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Integrating Chemical Information Instruction into the Chemistry Curriculum on Borrowed Time: A Multiyear Case Study of a Capstone Research Report for Organic Chemistry

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Ⓢ *Supporting Information*

ABSTRACT: To develop information literacy skills in chemistry and biochemistry majors at a primarily undergraduate institution, a multiyear collaboration between chemistry faculty and librarians has resulted in the establishment of a semester-long capstone project for Organic Chemistry II. Information literacy skills were instilled via a progressive research report, supported by a comprehensive modular virtual tutorial catered toward Rider University students, on the efficient use of *SciFinder* and related tasks for searching and using the primary literature. Over a six-year period, both the research report and the tutorial modules have been cyclically evaluated, assessed, and revised in order to meet our student learning objectives. This article describes the assessment-driven evolution of the research report assignment between 2010 and 2015, as well as student perceptions and learning outcomes. The technological development, feedback-driven revisions, and assessment of student learning outcomes of the *SciFinder* tutorial series have been included in a companion article in this *Journal*.

KEYWORDS: *Second-Year Undergraduate, Chemoinformatics, Organic Chemistry, Curriculum, Communication/Writing, Drugs/Pharmaceuticals, Learning Theories, Standards National/State, Student-Centered Learning*

■ INTRODUCTION

Writing Across the Curriculum

As described in a companion article in this *Journal*,[1] the impetus and efforts to incorporate instruction on the efficient and responsible practice of chemical information literacy into the undergraduate curriculum has become exceptionally urgent. Likewise, the practice of "writing across the curriculum"[2] has become an increasingly important technique through which to teach disciplinary writing and research conventions. While most undergraduate institutions offer a form of freshman and/or sophomore writing composition courses, students typically have been unable and unwilling to transfer their writing and research skills between their nonscience and science coursework.[3] Furthermore, composition instructors typically lack experience with discipline-specific writing and research conventions, which makes it essential to introduce these skills in upper-level coursework. The practice of writing in chemistry has been widely believed to force students to think qualitatively and affectively about quantitative problems, promoting student understanding and critical thinking.[4] Intentionally designed writing assignments enable students to grow from dualistic thinkers who accept textbook content as facts, into information seekers, who view the body of scientific knowledge as continually changing as a result of scholarly research.[5] Writing has been considered more than just a form of communication; it should be treated as a form of articulation, with a certain degree of comprehension,[6] mental organization, and idea refinement[7−9] required. To this end, this *Journal*[10−14] has published several articles pertaining to writing assignments in chemistry classes that have perceptibly elevated student engagement,[15] understanding, and critical thinking.

Instructional Objectives

This article and its companion piece[1] present a multiyear case study on the evolution of a research project for Organic Chemistry II that cost-effectively, efficiently, and sustainably (1) engages students in the techniques of searching and critically thinking about the primary chemical literature, (2) permits students to exercise and improve their scientific and technical writing skills, and in doing so (3) provokes interest in the course material, while (4) maintaining the challenging and rigorous curriculum standards of the course. The research project is composed of two components: a modular, semester-long capstone research report, described herein, which is complemented by a comprehensive online tutorial on chemical information instruction (CII) designed to assist students throughout their research process, described in a companion paper in this *Journal*.[1] These papers further intend to underscore the importance of the faculty−librarian collaboration toward effective assignment design, as well as the cyclical revision process that must occur toward maintaining relevance in assignments and instructional tools.[16]

■ PROJECT DESCRIPTION AND RATIONALE

Faculty and Student Population

In commencing efforts to incorporate writing and information literacy into the chemistry curriculum at Rider University, in academic year (AY) 2009−2010 the organic chemistry professor forged a collaboration with library faculty to execute a research assignment that would require companion instruction in chemical information literacy.

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While an ideal situation would be to integrate information literacy into a capstone seminar,[17−20] a multiyear discipline-specific seminar program,[21−23] or even lower-level courses specific for chemistry and biochemistry majors,[24−31] the addition of such a required course at Rider University would place tremendous burden on the Department of Chemistry and Biochemistry's resources, as the five full-time faculty are already tasked with one to two course overloads each semester. Furthermore, the high number of general education credits, when combined with the number of courses our department requires for an ACS-certified degree, provide little flexibility in our majors' schedules to allow for an additional course, especially to permit graduation within a four-year period. Lastly, the department graduates 5−15 ACS-certified chemistry and biochemistry majors per year, a small size which often prohibits upper-level courses from running.

Although Organic Chemistry II was originally chosen for CII because of the academic interests of the professor, it was perceived as an appropriate location in the chemistry curriculum due to its (1) relatively early exposure in the chemistry and biochemistry course sequence, and (2) limits on class size, with an overall student population rarely exceeding 30 across two sections. Since the Department of Chemistry and Biochemistry plays a substantial role in servicing the larger biology and premedical cohorts in addition to its own majors, an added benefit would be the (3) widespread exposure of a diversity of science majors to a comprehensive research and writing process. To this end, before the capstone research assignment could be implemented, it was first essential to modify the Organic Chemistry II course goals to not only reflect traditional skill adoption in electron-pushing arrow mechanisms, retrosynthesis, spectral interpretation, and the like, but to clearly indicate that by the end of the semester, students would be able to "efficiently search the primary chemical literature, and discern, interpret, and clearly communicate the relevant material in a research report" (Supporting Information). Only the concrete embedment of information literacy into the goals of the course would allow for subsequent backward design of relevant assignments and tools toward practicing and achieving these noncontent skills.

Pilot Assignment Design

Over the past several decades, writing has been integrated into the undergraduate chemistry curriculum in a diversity of formats. Even though the creation of an ancillary course strictly for discipline-specific writing[11,20,24,32,33] was not a viable option at our institution, the chemical literature has successful examples of writing via primary article summaries,[34−39] microthemes,[10,12,13] and short expository prompts to explain chemical phenomena[40−44,25] for consideration, although the faculty ultimately determined that an integrated, modular term paper[17,24,27,38,45] would be best suited to continually reinforce information literacy competencies throughout the semester. In 2010, the pilot term paper required that students choose a named reaction from an approved list and complete the following: (1) describe the overall transformation, (2) describe the historical significance of the reaction in industry or nature, (3) draw the complete electron-pushing arrow mechanism, and (4) provide two examples within the past five years wherein that reaction was employed. The assignment was complemented by a virtual tutorial, created by the science librarian, on searching the primary chemical literature using the various search functions of *SciFinder*.[46,47] Though CAS provides access to short tutorials on how to use *SciFinder*, we believed that developing our own set of Rider-specific modules was necessary to provide instruction beyond mere database navigation, for example, lessons on how to find resources using the Rider University Libraries catalog. The tutorial's objectives, technological considerations, and learning outcomes are discussed in an accompanying article in this *Journal*.[1]

As shown in Table 1, the modular assignments for this initial iteration of the term paper (denoted RR) included topic approval, submission of a primary literature source, rough draft, peer review, final draft, and a final self-assessment of their research and writing skills. Students were not held responsible for viewing or using the *SciFinder* tutorial throughout the semester, although their proficiency with the search engine and opinion of the tutorial's utility were evaluated as part of their final self-assessment. In keeping with the initial project objective to teach meaningful chemical information literacy and composition without compromising precious class time or material, only one modular assignment, RR#4 (peer review) was performed within a class period (Table 1).

Table 1. Evolution of Capstone Literature Assignment between 2010 and Its Most Recent Implementation in Spring 2015

Due Date	Spring 2010	Spring 2015
	Topic: Named reaction in organic chemistry	Topic: Disease area and pharmaceutical treatment
Week 3	RR#1: Topic approval	RR#1[a]: *SciFinder* tutorial self-assessment (Canvas[b])
Week 4		RR#2: Topic approval
Week 5	RR#2: Primary literature source	
Week 6		RR#3a: Primary literature source
		RR#3b: Biological pathway map
Week 7	RR#3: Rough draft	
Week 8	Spring break	Spring break
Week 9	RR#4: Peer review (in-class)	RR#4a: Primary literature source review
		RR#4b: Annotated bibliography
		RR#5: Preproposal peer review (in-class)
Week 11		RR#6: Rough draft (Turnitin[c])
Week 13		RR#7: Peer review (Turnitin[c])
Week 14		RR#8: Final draft (Turnitin[c])
Finals Week	RR#5: Final draft (paper)	RR#9: *SciFinder* final assessment and survey (Canvas[b])
	RR#6: *SciFinder* final assessment and survey	

[a]See Supporting Information for more detail on each modular assignment (RR). [b]Canvas is the Learning Management System subscribed to by Rider University, which enables the creation, administration, and automatic grading of online quizzes and surveys such as those assigned in the capstone assignment. [c]Turnitin is a plagiarism detection tool subscribed to by many academic institutions including Rider University. Utilities enabled and used throughout this assignment include online submission (for both rough and final draft), plagiarism detection and rating, anonymous peer review, instructor review and editing, and grading.

■ PROJECT EVALUATION AND REVISION

Over the six years in which this research report has been implemented, our team of faculty chemists and librarians have

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realized two critical aspects for successful implementation of the research report: (1) the assignment must be designed in a way that requires iterative usage of the chemical primary and secondary literature, as opposed to nonscholarly and often unreliable Internet resources, and (2) the virtual tutorial[1] content must be updated frequently to reflect the changes in appearance and searching capabilities in *SciFinder* and the Rider University Libraries system, as well as any shortfalls in students' chemical information literacy skills that continue to surface.[46] Both the research assignment and virtual tutorial are accordingly revised on a cyclical basis so as to ensure reinforcement of the course goals, ACS CPT guidelines,[48] SLA information competencies,[49] and learning objectives of the virtual tutorial. The revisions to the assignment design are described below, while those for the virtual tutorial are described in the companion manuscript.[1]

Cyclical Revisions to Assignment Design

There are two clear differences between the initial implementation of the research report (spring 2010) and its latest iteration in spring 2015 (Table 1). First, the assignment topic has evolved from having a purely chemical focus of one with a more biological and biomedical emphasis, which could be of personal interest to the wider audience of Organic Chemistry II patrons at our institution, comprised primarily of biology and biochemistry majors. The initial assignment was piloted without intentional development of topic choice, audience, and rhetorical form,[12,50] and course evaluations for the spring 2010 cohort largely suggested that the students did not have personal stake in their topics. Furthermore, at the time of their topic approval within the third week of the semester, students would have only been familiar with simple substitution, elimination, and alkene/alkyne addition reactions, so their limited knowledge of advanced mechanisms often forced them to choose named reactions in an uninformed manner. Even more troubling, it was discovered that despite the availability of *SciFinder* and the instructional tutorial, most students still did not use this tool to search for their primary resources. In retrospect, it appears most if not all of the assignment requirements could be fulfilled by performing a brief Internet search on a topic, without ever reading or critically evaluating a primary literature source.[46] For example, several less-than-authoritative Internet tools such as Wikipedia, Name-Reaction.com, and the Organic Chemistry Portal[51] provide electron-pushing arrow mechanisms, experimental considerations, references to original reports, and even citations for the modern use of a litany of reactions in organic synthesis. Thus, by spring 2015, following several cycles of significant revisions driven by the observations described vide supra, the capstone research report had evolved into a comprehensive grant proposal (Box 1) which intentionally identified a target audience, included a purposeful topic, and deliberately implied a rhetorical form, in alignment with the recommendations of Kovac and Sherwood.[12,50]

The second unequivocal difference between the first and last generations of the writing assignment (Table 1) is that the number of progressive assignments throughout the course of the semester has almost doubled. While some students each year perceive the due dates as too frequent, most appreciate the modular and iterative scaffolding which keeps them on track to efficiently complete their research report by the end of the semester. In spring 2015, the students were asked to evaluate the utility of each modular assignment with regard to both completing their final report, as well as receiving meaningful feedback from others (instructor and/or peers) that would help them improve their final submission (Table 2).

Box 1. Excerpt from Spring 2015 Background Description of the Capstone Assignment Given to Students on the First Day of the Semester*

Write a grant proposal for your spin-off company. While you are undoubtedly an expert synthetic organic chemist, your audience is comprised of the company CEO, CFO, vice presidents, and various executive board members who have a basic understanding of molecular structure, but not much more. In the proposal, you must:

(a) Defend the importance of the disease area that your biotech company will target, in terms of both (i) potential for global impact and thus capital, and (ii) feasibility for effective treatment based on the biological foundation for disease transmission and manifestation
(b) Provide rationale for the potency of the pharmacophore/class of small molecules that you plan on synthesizing as medicinal candidates toward this disease area
(c) Outline a clear synthetic route from commercially available starting materials to a known pharmaceutical within that class
(d) Demonstrate your understanding of two mechanisms from (c)
(e) Provide examples of the effectiveness of derivatives of this known pharmaceutical

Remember, your goal is to obtain millions of dollars worth of start-up equipment and chemicals *for free*. For your grant to be successful, you will need to validate and defend every single point. *Roche will not waste its valuable resources on a start-up company that will not be able to secure further capital, get off its feet, and eventually develop marketable, very profitable products.*

*A complete version of this assignment can be found in Supporting Information.

The RR assignments perceived by students as most pertinent were the preproposal (RR#5, Supporting Information), rough draft (RR#6), and peer review (RR#7, Supporting Information). This is unsurprising, as these were the only three formal writing assignments out of the nine leading up to the final draft submission. Furthermore, both RR#5 and RR#7 allowed opportunities for peer review. Since the initial 2010 implementation, peer review[12,52−55] has been demonstrated as essential element in the assignment design, not only because it parallels the scholarly submission process in chemical research, but also because it exemplifies what Vazquez[25] describes as "writing-to-teach": that meaningful learning can be achieved when students are forced to formulate, organize, revise, and expand upon their own understanding, so that they can effectively communicate a topic to their peers. Coleman[56] and Chin[57] have separately made the distinction between *summary* writing and *explanatory* writing, and it could be argued that preparing explanations, especially in the context of teaching peers, requires solid foundational knowledge and the complex synthesis of ideas,[58−60] while summarizing may be more superficial.

Although the students self-reported that the least helpful RR assignments were the submission of a primary article (RR#3), and the in-text review of that primary article (RR#4), these allowed the instructor to facilely assess student comprehension of

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Table 2. Spring 2015 Student Self-Perception of the Utility of Each Modular Assignment (RR) Prior to the Final Draft (N = 22)[a]

	Percentage of Students Perceiving Highest Utility with Regard to		
Modular Assignment	On-Time Completion of Research Report	Guided Feedback for Future Work	Percentage of Students Perceiving No Utility
RR#1: *SciFinder* tutorial and self- assessment	18	9	0
RR#2: Topic approval	9	9	20
RR#3: Primary literature source	18	9	50
RR#3: Biological pathway map	36	18	30
RR#4: Primary literature source review	36	18	40
RR#4: Annotated bibliography	27	0	30
RR#5: Preproposal peer review	45	45	30
RR#6: Rough draft	73	64	10
RR#7: Peer review	73	82	20

[a]Survey administered after submission of research report during Finals Week, with 22 respondents.

types of literature resources (primary vs secondary vs tertiary) as well as their ability to discern, extract, and ask pertinent questions regarding the information in those articles. It is also interesting to note that the *SciFinder* tutorial and assessment, RR#1, was not ranked of highest utility with respect to completion of the research report or receiving meaningful feedback (Table 2). Since the tutorial and assessment was due within the third week of the semester, and had no accompanying writing assignment, it is not surprising that students did not rank it highly with regard to time management nor feedback. However, RR#1 was the only modular assignment that was perceived by all students as a useful activity, underscoring the students' overall perceived value of the guided virtual tutorial in teaching them how to effectively use *SciFinder* and the Rider University Libraries system to pursue their research project.

In response to students' poor innate understanding of their proposed drug's role in disease treatment or symptom management, a biological pathway map (RR#3) has been added as a modular requirement for the capstone assignment. Students are required to synthesize information from various primary and secondary resources to construct a simplified concept map that traces their disease area from etiology to symptom manifestation. It was initially assumed that the Biology, Behavioral Neuroscience, Biochemistry majors, and postbaccalaureate premedical students (comprising greater than half of the students in Organic Chemistry II at Rider University) might fare better than nonbiological science majors, since these students would have already taken at least three requisite 100-level Biology courses, and many are concomitantly enrolled in Genetics (BIO 265). However, it was quickly discovered that biological science majors find this task just as difficult (and ultimately rewarding) as those pursuing Chemistry or other nonbiology majors, most likely due to their prior inexperience with concept mapping. Since 2013, many Biology, Behavioral Neuroscience, and Biochemistry faculty have voluntarily collaborated on this project by offering their expertise, to help students comprehend the causal relationships in their chosen disease areas.

It should further be noted that out of all nine assignment milestones, only the preproposal peer review (RR#5) requires significant class time (the anonymous peer review of the rough draft is conveniently set up as a homework assignment on Rider's Canvas learning management system with embedded Turnitin functionality). As the first formal writing assignment, the preproposal requires students to cogently synthesize the background information they have accumulated on their chosen disease area. For 40 min, students work in pairs and read their preproposals aloud to each other. The primary goal is to convince the reviewer—assuming the role of CEO of a pharmaceutical company—to dedicate research funding toward their chosen disease area. The reviewer evaluates their peer's proposal using a set of criteria (Supporting Information) and provides feedback on the argument's credibility and persuasiveness, which inherently requires primary literature citations. Such "transactional writing", defined by Beall[61] as having a specific purpose, has been proposed to form the foundation of meaningful learning.

Though this capstone research project was intentionally designed to maximize the quality, while minimizing the time, committed to chemical information instruction in the classroom, periodic attention is still required to be given in class to address the other two desired student learning outcomes of the assignment: to develop writing and communication skills that can be horizontally and vertically translated across their science coursework, and in doing so better engage students in the concepts of organic chemistry. We have discovered that even a few minutes of class time allotted to the capstone project nurtures student reflection, and the connections they make to the course material. Accordingly, on the dates when each RR assignment was due, students began the class with a guided freewriting exercise (Supporting Information).[15] For 5 min, students reflected about their experiences and wrote uninterruptedly any comments, questions, or revelations regarding that particular assignment. Following paper collection, the class would then participate in a 10 min discussion of their reflections. Similar to using journals in the science classroom,[9,62] while such "expressive writing"[61] activities might take a total of 15 min out of an hour-long period, they initiate valuable discussions about the research report and chemical information literacy; create multiple opportunities for formative feedback and student metacognition; maintain a consistent level of critical thinking, reflection, and engagement; and promote a healthy student-teacher dialogue which generates a comfortable and open classroom environment essential for student learning. Just as important, the frequent informal assignments iteratively instill the value of writing as a tool for learning science, and help to foster an overall cultural expectation of writing within science courses.

■ GRADING STRUCTURE AND WORKLOAD

Although the increased frequency of modular assignments and their related free-writing activities may perceivably escalate the instructor's burden for grading, many of these assignments merely warrant a grade for completion, or brief comments. To this end, all *SciFinder* surveys and quizzes, along with all RR assignments up until the rough draft, are graded on a basis of completion and adherence to provided criterion, usually with scores ranging from zero (not turned in) to three (completed and meets all criteria). Furthermore, the grade for the rough

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draft peer review (RR#7) is calculated as the average grade given by their two anonymous peer reviewers. While the instructor ensures the peer review grades are reasonable, the evaluation rubric (Supporting Information) is sufficiently robust that the graders' opinions typically match each other, as well as that of the instructor. In absence of the stress associated with quantitatively calculating grades, the instructor is able to focus on providing meaningful comments and feedback for each RR assignment. Thus, the only RR assignment in which the instructor intentionally grades is the final draft, which constitutes 40% of the overall research report grade (Supporting Information). Of course, in order for students to be provided with such frequent, meaningful feedback over the course of a semester, the class size must be limited to a manageable number. At Rider University, the class size for Organic Chemistry II is capped at 24, and the total number of students has rarely exceeded 30 across all sections. For such an assignment to be used in undergraduate courses at institutions with larger class sizes, multiple instructors or TAs would likely be required.

■ ASSESSMENT OF STUDENT OUTCOMES

Student Satisfaction and Self-Perception of Skills

Student feedback over the six iterations of this project has been overwhelmingly positive, with regard to both the writing component and the development of chemical information literacy. Of course, as with most courses that incorporate a significant amount of writing, there are always a few students who believe that the research report is too much work for a course that is already overwhelmingly difficult. Selected student comments between 2010 and 2015 include:

Learning about a disease that was so personally interesting to me was a really good opportunity and this project helped me to see the connection between biology and chemistry.

I learned that reading a patent is not as bad as I thought it would be, and I actually knew the majority of the chemistry, which was cool.

My previous understanding of drug activity in the body was very limited. Now I understand structure–function relationship⋯I did enjoy researching my project because it summarized everything we've been doing since first semester in a neat package. It was a great way to finish off the semester.

The research report was really interesting! It was so cool to be able to examine the synthesis of a drug and actually understand what was going on! It also let me see how organic chemistry is related to other subjects.

I learned much more about a disease that everyone I know has or can get.

The research report is a valuable experience; makes orgo "real". However, the semester-long progress drains away from the time that could be spent studying⋯

This was a good experience to do a research report. I feel like this was the first research report that I was actually interested in doing. Also the format of when the assignments were due was a good way to get people not to procrastinate.

I hated the research report. Too many due dates.

The background information was difficult and annoying to collect because it was spread out. Also the economic background was difficult because I don't really understand Medicare and how much of an investment is expensive for a pharmaceutical company.

Assessment of Effective Writing and Chemical Information Literacy Skills

Creating an appropriate assessment for students' writing, information literacy and searching capabilities was not a simple task. Most assessments to this end have been affective rather than summative. The average grades for the research report have remained between 80 and 83% between 2011 and 2015. Kovac and Sherwood[12] have drawn statistically significant correlations between students' grades on their writing assignments and overall course grade in a General Chemistry course, which they argued clearly indicates a connection between writing skills and critical thinking (although it can be questioned whether students who performed better on writing assignments were better at critical thinking or merely more diligent studiers). A cross-cohort linear regression analysis for Organic Chemistry II at Rider University was likewise performed, but instead comparing research report grades to exam averages. While no such correlation could be determined on an individual basis, there was a statistically significant direct relationship between each cohort's overall exam average and research report average (Figure 1). It is unknown if this is

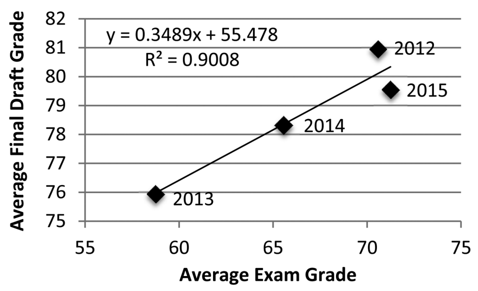

Figure 1. Cross-cohort correlation between average exam grade and average research report grade for 2012–2015.

representative of a corollary relationship between writing skills and critical thinking. Furthermore, these data are of no utility when assessing student writing skills, particularly transferability across science coursework, and methods for such analysis are being strongly considered for the future.

The chemistry faculty member has also incorporated strategies for quantitatively evaluating Organic Chemistry II students' chemical information literacy to determine the overall effectiveness of the virtual *SciFinder* tutorial,[1] as well as the writing assignment in practicing and developing those skills. These assessment efforts are described in the accompanying article in this *Journal*.[1]

Future Considerations

After six years of implementation, there are still aspects of the research assignment, virtual tutorials,[1] and assessment efforts that need to be improved. The greatest weakness evidenced by this report is the lack of quantitative evidence of student improvement in scientific writing and communication. Without participation in a multiyear, longitudinal calibrated peer-review process, it can be impossible to objectively and accurately assess the quality of student writing across cohorts. It is not surprising that the majority of articles in this *Journal* that have described chemistry writing assignments assess student outcomes via affective surveys and free-response prompts.[13,16,24,25,43–45,53,63] In the future, it may be prudent to implement an assessment such as Van Bramer's statistical analysis of writing scores across sequential drafts,[20] but even that assessment method fails to

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provide relevant information about the overall quality and transferability of student research and writing skills. Because the student papers for this research project have been archived since 2010, participation in a calibrated peer review would be feasible.

CONCLUSION

The relevant and effective incorporation of chemical information literacy into the undergraduate chemistry and biochemistry curriculum has been successfully accomplished in lower-level chemistry courses of mixed student populations. Without a specific course dedicated to chemical information instruction (CII) and/or scientific writing, a team of faculty and librarians have effectively removed the instruction of information literacy[1] and disciplinary communication from the classroom, while still being able to instill, reinforce, and monitor those skills via a capstone research report. A multiyear assessment of this process has clarified that the extent and quality by which these skills are imparted are dependent on assignment design, tutorial efficacy, and the germane link between the two. Specifically:

(1) The assignment topic should be relevant to both biological and physical science majors.
(2) The assignment topic must be engineered to warrant the use of a chemical searching instrument such as *SciFinder* over any other method.
(3) The assignment should enable critical thinking about the course material by requiring students to synthesize the information on various primary literature sources into a convincing and comprehensive research report.
(4) Periodic (but not overwhelming) class time must be dedicated to student-led discussions about the research report.
(5) Frequent modular assignments should be due throughout the semester to allow for the timely completion of the final written assignment, as well as to create multiple opportunities for formative feedback.
(6) The assignment and CII tutorials should be designed to allow for both formative and summative assessment measures, so that they can be continually updated to ensure that learning objectives are being met.

Faculty−Librarian Collaboration

Lastly, the authors feel it is prudent to highlight that the multilayered project described in this article as well as its companion piece[1] underscore the crucial collaborative relationship between chemists and librarians in promoting chemical information literacy.[64] The ongoing cooperation between faculty and librarians was and still remains essential for the constant revision and modernization of the assignment and its accompanying CII tutorial. The role of the faculty member is to create a relevant assignment that consistently engages students in the research and writing process to critically think, and ask challenging questions, about chemistry. The role of the science librarian is to impart his or her expertise with modern tools for searching the chemical literature, as well as to communicate the continually evolving SLA, ACS, and Association of College & Research Libraries (ACRL)[65,66] standards for chemical information literacy, to ensure that the writing assignment, tutorial instruction, and assessment strategies address the most relevant student learning outcomes. Finally, the emerging technologies librarian is fluent in the newest instructional technologies available for creating effective virtual tutorials as well as evaluating their impact on student learning.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00424.

Organic Chemistry II (CHE 214) course syllabus (PDF)
Research report assignment instructions (PDF)
Research report background description (PDF)
In-text primary literature review assignment RR#4 (PDF)
Preproposal assignment and evaluation guidelines RR#5 (PDF)
Examples of in-class free-writing exercises (PDF)
Peer review grading rubric (PDF)
Response to peer-review (PDF)
Research report grade form (PDF)

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Notes

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