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Improving information literacy through Wikipedia editing in the chemistry classroom: Lessons learned

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Abstract

Assignments in which students edit Wikipedia may help students learn about the complexities of information creation and production, while engaging them in researching and writing about topics related to class content. This chapter presents two case studies that illustrate how Wikipedia-based activities can be designed to achieve both chemistry and information literacy learning outcomes. In both examples, faculty partnered with a librarian to implement the Wikipedia editing assignments. Through these experiences, those

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involved learned about Wikipedia and its community, and identified promising practices for project requirements based on formal and informal assessment and observations. Reflections are offered on the value of using Wikipedia editing assignments and concrete suggestions for creating effective projects are offered.

Introduction

Wikipedia, the online encyclopedia, is the seventh most visited website in the world as of June 2016¹ and one of the leading sources of information for internet users.² University students are often told by faculty not to use or cite Wikipedia articles in assignments, often because of faculty concerns about the credibility of Wikipedia articles, which are written by multiple, anonymous volunteers and do not undergo traditional peer review.³⁻⁵ However, even if students do not cite Wikipedia in an assignment's bibliography, many are consulting it for academic purposes.⁵⁻⁸ Rather than discouraging students from using Wikipedia in their research, librarians and teachers can guide them to use it wisely. This chapter addresses how chemistry educators can engage students in the effective use of Wikipedia, focusing on improving their understanding of how its information is created, by designing assignments in which students edit and write Wikipedia articles.

By engaging students in writing for Wikipedia's worldwide audience, instructors and librarians can provide an opportunity to learn both subject content (in this case, chemistry) and information literacy (IL) skills simultaneously. As emphasized in the latest Framework for Information Literacy for Higher Education by the Association of College and Research Libraries (ACRL),⁹ engaging students in the process of creating information with the purpose of developing their IL competencies will help them succeed in the emergent information ecosystem and higher education environment. Wikipedia editing assignments are relevant to the six threshold concepts in the ACRL Framework, especially the second one, "Information Creation as a Process" and the fourth one, "Research as Inquiry," since the assignments require students to perform thoughtful searches for a variety of information resources, evaluate them, digest them, and then create new information appropriate for the general public to consume.

As research on the use of Wikipedia progresses, many scholars argue that educators should embrace Wikipedia — provide guidelines for using it in coursework, and consider creating Wikipedia editing assignments for further engagement — rather than discouraging or banning its use by students.^{2, 4, 6, 10-11} Multiple studies have documented the use of Wikipedia in college classes,

including contributing to it, for teaching information literacy.^{2, 12-13} Since 2008, several chemistry classes have explored the concept of using Wikipedia editing as course assignments.¹⁴⁻¹⁹ This chapter adds to this body of knowledge by providing two case studies describing in detail how librarians and chemistry professors from two universities engaged students in writing Wikipedia articles on chemistry topics. The designs of the projects are compared to reveal the flexibility and effectiveness of Wikipedia projects in delivering information literacy skills. These two case studies offer the educators' reflections on what students can learn from completing Wikipedia-based assignments designed to emphasize both chemistry and information literacy learning outcomes. The chapter also includes some lessons learned about designing Wikipedia assignments, including notes on what did not work well in early iterations of the assignments, and tips for writing effective Wikipedia assignments. The case studies also provide an example of integrating librarian involvement into a course, beyond a one-time instruction session, from assignment design to assessment.

Case Studies

The instructors for the classes described in these case studies assigned Wikipedia editing for a variety of reasons. In the first case study, the goal was to develop activities that would engage non-science majors in science writing for authentic audiences.²⁰ This goal supported a new university core curriculum, with required science courses for non-science majors. In the second case study, the objective was to enable students to digest advanced science concepts and communicate those to a general audience. Another goal of the second case study was to have students contribute to the public good while learning.^{4,16} In both case studies, an intention was to devise assignments and activities that would help students gain subject knowledge in chemistry while simultaneously improving their information literacy and communication skills. Both cases focused on improving the English-language edition of Wikipedia since they both occurred in U.S. classrooms.

Case Study 1: Wikipedia editing for non-science majors

The first case study provides an example of a Wikipedia editing activity for students not majoring in the subject matter being taught in the class. In this case, the discipline was chemistry and the course was composed of freshmen and sophomores who were not majoring in science. The activity was designed by a librarian and a chemistry professor at a private comprehensive master's university in the Pacific Northwest of the U.S. The class for which the

Wikipedia editing activity was designed as “Chemistry for Informed Citizens,” a new class offered as part of the university’s new core curriculum.²¹ The Wikipedia activity was repeated three times, in three consecutive ten-week-long academic quarters, in 2012. The class size during those quarters ranged from 16 to 32 students. Class met twice a week for two hours in a lecture space and once a week for a three-hour laboratory. For the library session, the class met for one of the three-hour lab sessions in the library’s instruction room, with laptops for hands-on work and tables set in clusters for group work.

In advance of the Wikipedia editing assignment, the professor created a list of Wikipedia articles from which the students could choose for their assignment. The professor started by exploring a Wikipedia-based list of chemistry articles needing expert attention.²² She evaluated a wide range of Wikipedia articles to find several that met three criteria: relevant to chemistry topics taught in class, in need of editing or expanding, and not too technical for first- and second-year students. Articles selected included, for example, “Humectant”²³ and “Food additive.”²⁴ The class self-selected into groups of 2 or 3 students, and each group chose a Wikipedia article (or a section of an article) from the list the professor provided.

The project was six weeks long, from introduction to due date. To help students build the skills needed, the professor and librarian designed several interim steps and scaffolding tasks. Table 1 describes these steps.

Table 1. Interim assignment steps in Case Study 1

Students completed the following tasks during the six-week-long Wikipedia editing project:

- Receive an introduction to Wikipedia and editing articles.
- Establish a Wikipedia editor account and associated sandbox page. (A sandbox page is a special type of web page on Wikipedia where people can practice editing Wikipedia; it is public but will not get confused with a formal Wikipedia entry.)²⁵
- Participate in a library session.
- Create an annotated bibliography of sources to use and cite in the article.
- Write an initial draft of revised articles on sandbox pages.
- Work with a classmate to create a new version of the article.
- Review other groups’ draft articles.
- Receive peer reviews from classmates and further edit the article.
- Publish to Wikipedia and monitor edits by later editors.

Early in the project, the instructor introduced students to the process of editing Wikipedia and the basics of participating in the Wikipedia community.

The librarian then led an in-class information literacy session that focused on providing students with the skills needed to find the reliable information that would help them write the Wikipedia article. The session included multiple modes of interaction and instruction, including structured small-group activities, short videos on relevant topics such as peer review, brief lecture and demonstration segments, and time to work alone or in pairs on searching for and evaluating resources. The librarian and instructor provided feedback and answered questions, especially during the portion of the class when the students were searching on their own or in pairs.

In the first iteration of this class, the library session focused on searching for primary sources in the scientific literature and secondary sources in the scientific or popular literature. For this class, “primary sources” were defined as documents such as scientific journal articles that provide data collected via scientific research performed by the authors. “Secondary sources” were defined as documents such as magazine articles (popular literature) or review articles (scientific literature) that summarize or interpret primary sources. However, as assessment and reflective work on the first iteration of the course progressed, it was noted that students needed to rely more heavily on tertiary sources (documents such as textbooks, science encyclopedias, and chemistry dictionaries, which summarize information from primary and secondary sources) and secondary sources for this project. It took a higher level of science expertise than these students possessed to understand, summarize, and synthesize information from primary sources into encyclopedic articles appropriate for Wikipedia, a tertiary source. In addition, with experience, the librarian and instructor gained a clearer understanding of the Wikipedia editing community, including the guideline, “Wikipedia articles should be based on reliable, published secondary sources and, to a lesser extent, on tertiary sources and primary sources.”²⁶ Thus, in the second and third iteration of the course, the librarian designed activities to teach students about finding, evaluating, and using secondary and tertiary sources from popular or scientific literature (rather than primary sources from the scientific literature) relevant to their topics and appropriate for citing in Wikipedia.

The librarian contributed to the class in several ways beyond the single in-class session. By knowing the professor’s list of acceptable Wikipedia articles for the class project, the librarian was able to add several relevant chemistry books (secondary sources) to the library’s collection, so that students would have easier access to them. These books covered such specific topics that they would not have been acquired had the librarian not known the content of the assignment. For example, the librarian selected “The Chemistry of Food Additives and Preservatives,” a 2012 e-book, to support the work on Wikipedia articles about food additives. In addition to acquiring relevant books and leading an in-person session, the librarian created an online guide providing links to useful resources including those used in the library session. A link to the

librarian's guide was placed in the course's web site. The librarian was also available to students who wanted one-on-one help with research for the Wikipedia assignment, via appointments, online chat, e-mail, or drop-in visits to the library. Finally, the librarian reviewed the final annotated bibliographies to assess the students' work and to inform future lesson plans for the library sessions.

After the library session, students submitted annotated bibliographies of the resources they planned to use in writing their article. The professor reviewed the bibliographies and provided formative feedback. Students then worked in groups on writing or editing their chosen Wikipedia article and submitted drafts for peer review within the class. Later, they published their work to a Wikipedia sandbox page, a special type of page that allows users to practice the process of editing Wikipedia.²⁵ In the first iteration of the course, students were graded on their sandbox submission and did not add their work to Wikipedia itself. In the second and third iterations of the course, the instructor had more experience with Wikipedia and felt more confident in the students' potential contributions to it, so the students were directed to move beyond the sandbox and publish their work to Wikipedia. This provided an authentic audience for their work.

Student learning was assessed formally and informally. In terms of chemistry knowledge, anecdotal evidence suggests that the students, who were not science or chemistry majors, understood more about their selected chemical topic, but this suggestion was not tested directly. One of the ways this was noted was through poster presentations, in which students were required to teach classmates about their topic. In all three iterations of the course, every student in the course could correctly define the chemistry terms associated with their Wikipedia article to other students in the course. This evidence is significant because these students researched rather obscure topics like humectants and surfactants.

With respect to information literacy outcomes, the librarian reviewed the annotated bibliography assignments turned in after the library session in the first iteration of the course. Careful reading of each bibliography revealed that after the library session, 76% of students were able to correctly identify 3 sources from the scientific literature (such as a peer-reviewed journal or a scientific book). Additionally, 48% could accurately determine if the 3 sources were primary, secondary, or tertiary sources. These two skills are fundamental to a basic level of information literacy, especially with respect to science information.

Case Study 2: Wikipedia editing for chemistry graduate students

The second case study covers two graduate-level chemistry courses at a large, doctoral Research I university in the Midwest of the U.S. In 2008, one of

the authors, a chemistry professor, introduced a collaborative Wikipedia editing project to a class focused on physical organic chemistry. The project was designed to enhance students' understanding of advanced chemistry concepts and improve their ability to communicate science to the general public. From 2008 to 2014, the Wikipedia project was used almost continuously in this course, as well as in a different course on the synthesis of macromolecules. Both classes met three times per week for a one-hour lecture. Class sizes ranged between 11 and 45 students, with graduate students from multiple departments and some senior undergraduate chemistry majors enrolled. The librarian liaison to the chemistry department supported these Wikipedia assignments starting in 2011. Because the two classes in this case study targeted similar student populations and both covered advanced chemistry topics, the strategies in designing the Wikipedia editing project and interventions to help students were similar. Thus, the two classes are discussed as one case study, in contrast to the first case study, which discussed one class.

Table 2 lists sample learning outcomes expected from completing the Wikipedia editing assignment.

Table 2. Sample learning outcomes of the Wikipedia editing assignment in Case Study 2

<i>Learning Outcomes</i>
<ul style="list-style-type: none">• Evaluate the quality of the existing Wikipedia article• Identify and evaluate relevant sources to cite• Find appropriate media to use or reuse• Handle copyright /ethics issues properly and avoid plagiarism• Understand subject knowledge relevant to the selected topic• Write about scientific matters with the general public as the audience• Recognize bias in Wikipedia and in one's own writing• Provide peer reviews and respond to reviews from classmates and the broader Wikipedia community• Format articles with Wikipedia markdown syntax• Consume Wikipedia content with a critical eye in the future

The details of this Wikipedia assignment have been published previously¹⁶ and are summarized in Table 3 below. The length of the project ranged from 5 to 8 weeks, depending on the academic term in which it was assigned. A sample timeline and students' work from a recent implementation are publicly available on the Wikipedia course page.²⁷

Table 3. Summary of Wikipedia assignment in Case Study 2

Tasks and requirements completed by students:

Task:

- Create or substantially improve a Wikipedia article on a chemistry-related topic, invoking concepts learned in class.
- Work in groups of 2 or 3.

Requirements:

- Sandbox draft (20 points) and final post with response to reviewers (60 points).
 - Add a minimum of 3 sections, including an introductory paragraph, to the Wikipedia article.
 - Add a minimum of 3 original figures and/or schemes.
 - Add a minimum of 8 appropriate references to diverse sources.
 - Consider the general public as the audience.
- Review each others' work before the article is posted to the main space of Wikipedia articles (20 points).

Unlike the students in the first case study, the students in these graduate classes were not given a list of Wikipedia articles from which to choose. Instead, they were required to propose topics that were related to the chemistry course material and that were not adequately covered in Wikipedia, for example, those articles classified as “stubs” in Wikipedia.²⁸ A brief description of an editing plan was also required for each proposed topic. To write such a plan, students needed to critically evaluate the current Wikipedia article and then identify the gaps in the content coverage by using their previous knowledge of the discipline as well as newly acquired concepts from the class. To provide direction, the instructor and the librarian suggested that students review a list of topics from the WikiProject Chemistry²⁹ group, which provides a list of “open tasks” identifying articles needing improvement. Examples of “before” and “after” articles modeling what was expected were also provided to students as a handout posted on the course web site. The instructors then selected topics from the list of student-proposed topics, based on the relevance of the topic to the class as well as how reasonable their editing plans were within the class timeframe. Topics selected included “Biodegradable polymer”³⁰ and “Physical organic chemistry.”³¹ More topics edited by students in these classes are linked on two course pages on Wikipedia.³²⁻³³ Allowing students to propose Wikipedia articles for editing assignments works better with students majoring in science because of the higher level of science knowledge required at the start of the project.

In the implementations after 2012, students received an overview of Wikipedia community dynamics and were introduced to editing basics during a library workshop given by the science librarian. Other topics covered in the

library workshop included finding and evaluating sources, copyright issues, and other IL topics. Table 4 outlines the content covered in the workshop.

Table 4. Outline of Library Workshop on Wikipedia Editing in Case Study 2

<ul style="list-style-type: none">• Discuss what makes a good Wikipedia article<ul style="list-style-type: none">○ community “peer review”○ encyclopedia writing style○ searching for and evaluating sources○ citing sources○ copyright issues• Learn editing basics<ul style="list-style-type: none">○ creating usernames and sandboxes○ basic formatting○ how to add references○ how to add images○ moving content from sandbox to article• Special editing tips for chemistry-related content• Where to find help

Similar to the previous case study, students published drafts to their Wikipedia sandboxes for peer review from their classmates, the instructor, and the librarian. They then published their work on Wikipedia. Thus, their work receives ongoing “peer review” from the Wikipedia community.

The extent of interactions between the students in this case study and the Wikipedia community varied depending on the topics. For example, among the 14 articles students edited for the Winter 2014 implementation,³² only two articles (“Polybenzimidazole fiber” and “Star-shaped polymer”) received comments from the broader Wikipedia community between 2014 and 2016; while six articles from the Fall 2013 implementation received comments in that same time frame.³² Some feedback has been very positive and encouraging, such as this comment from a Wikipedia user:

“I have this page on my watchlist so I have just seen the recent changes to the article. What an outstanding improvement. I can’t make out who has done what, but anyway it has worked out well and has been very successful. In the past there have sometimes been rather unhappy examples of Wikipedia editing being used for educational purposes. In this case it looks to me the article has become both informed and accessible.”³⁴

Most Wikipedia edits contributed by students in this case study remained intact. However, since the feedback from other “Wikipedians” (volunteers who edit Wikipedia) was mostly posted after the classes ended, most students did not address the comments. In fact, this is one of the most popular criticisms in the Wikipedia community regarding students editing Wikipedia as course assignments, as illustrated in the following comment from the “Talk” page of one of the articles edited by students in this case study:

“History shows us that students who are tasked with creating such essays are unlikely to ever edit again. What we have is a snapshot of the mostly primary literature that looks very good today, but what about its relevance in 5 years time? Who is going to tend this article? I guess one could say that an obsolete review is better than none. I would argue that it is possible to write content that is less time-sensitive [sic].”³⁵

In contrast, the “Polyfluorene” article from the 2011 implementation received an extensive review from the community and the students responded to some of the questions and comments professionally.³⁶ Overall, the interactions between the Wikipedia community and students are often unpredictable, but can be productive when both parties are engaged.

Assessment of student learning in this case study focused on chemistry content knowledge, communication skills, and student reflections on the experience of editing Wikipedia. Student feedback submitted via optional, anonymous end-of-term course evaluations across five implementations of the class between 2008 and 2014 (56 responses in total) was analyzed. Course evaluation data was collected anonymously without direct interaction with the students. The university’s Institutional Review Board (IRB) does not consider this work human subjects research and determined that IRB review was not required for it. Analyzing this feedback showed that on average, 73% of students considered editing Wikipedia for the course as a positive experience, while 7% considered it a negative experience and 20% considered it a good experience overall but had some reservations. Students reported that they: (1) gained a greater understanding of their chemistry topics, (2) learned how to communicate science concepts to the public, and (3) were able to connect to classmates and learn together. A few students reported that they improved their literature search and analysis skills. The students recognized their growth and the benefit of doing public good. A few representative statements are listed here.

“The wikipedia project and the proposal project were my favorite parts of the course. It was challenging, (relatively) comprehensive independent research on topics I found interesting.”

“The wikipedia project is certainly a great thing to have in the upper-level chem classes!! I wish that all the departments would do this to help Wikipedia become more useful for educated levels. I will say that I did not enjoy doing it, mainly because I have no computer skills whatsoever and the demo in class was very limited.”

Two common complaints from those students who had negative responses were that the project was too time-consuming and that working in teams can be challenging. The students did not have an opportunity to choose their partners. Assigning teams was a pedagogical decision made by the instructor to ensure the diversity of groups. Some students recognized that teamwork is necessary due to the complexity of the project. For example, a few students reported that:

“The wikipedia project is neat because there is a tangible product at the end, but it is a disproportionate amount of effort compared to the actual material learned, especially as the pool of course-related topics shrinks after every year.”

“The Wikipedia project was a lot of fun and I enjoyed getting to make an impact on something so global. Working in pairs/groups could have been frustrating or difficult for some students, but it would probably be a very difficult project to do alone, so I think keeping it in pairs or groups is a good idea.”

It was also observed that fewer students reported lacking guidance on editing and the research process in later implementations, which can be attributed to improved guidelines, sample finished products, the in-class library workshop and other learning materials. The concerns about “the pool of course-related topics shrinks after every year” also appeared less often in the more recent implementations.

In one of the earlier implementations of the project, the revised Wikipedia articles appeared to be much more engaging for general readers than the original articles, according to independent analysis of the final Wikipedia articles by a faculty member affiliated with the Department of English Language and Literature, the School of Education, and the Writing Center.¹⁶

Students in these classes were able to make substantial contributions to Wikipedia. Some of their articles were accepted as “Did You Know?”³⁷ articles, which were featured on the Wikipedia home page and received more than a thousand visits within one day. For example, the article, “Physical organic chemistry,” was visited 1381 times on the day it was featured as a “Did You Know?” article.³⁸ The success of the project in these classes inspired other

university instructors to adapt the Wikipedia editing assignment for other courses in science, social science, humanities, and engineering departments. The librarian supported many of these classes and more examples of the courses are linked on the librarian's Wikipedia user page.³⁹

Reflections and Discussion

Writing for an encyclopedia like Wikipedia has some qualities in common with the process of writing for academic audiences, as opposed to writing a traditional assignment, whose audience is often one professor assigning a grade. First, students publishing articles to Wikipedia will engage with the community of active contributors to Wikipedia, who possess a range of perspectives and agendas, and who can share their feedback with the students. In this way, the process of writing for Wikipedia is somewhat similar to presenting at academic conferences, where authors share academic writing with a community of practice and receive feedback from multiple people in that community. This worldwide audience for students' writing may also increase student motivation when writing for Wikipedia for a class.^{4,16} Second, by participating in the process of writing for Wikipedia, students are able to contribute to a scholarly conversation that may be otherwise inaccessible to them. This aspect of writing for Wikipedia reflects the "Scholarship as a Conversation" threshold concept of the ACRL information literacy framework.⁹ Finally, writing for Wikipedia requires citations, clarity, and accuracy, which is similar to academic writing requirements. However, Wikipedia articles do not require an argument, which is usually part of academic writing. Instead, students write an overview of a topic after digesting the concept, with the general public as the audience. Focusing on this type of writing may serve as an effective scaffold, by allowing students to master some of the fundamental skills of academic writing without having to construct arguments, a higher-level skill.¹⁴

By writing for Wikipedia, students may learn more about the nature of science. Wikipedia content changes over time, in a way that is somewhat similar to the process of scientific knowledge creation. The Wikipedia community adds knowledge to the encyclopedia as it is discovered, and debates knowledge as it comes into question. Like science, Wikipedia may appear to be static, but in reality both scientific knowledge and Wikipedia content continuously change.

Students writing for Wikipedia may learn about the process of creating information resources, including Wikipedia itself, a source they probably use regularly. This relates to the "Information Creation as Process" threshold concept in the ACRL information literacy framework.⁹ Students writing or editing articles can actively gain an in-depth understanding of Wikipedia's distributed authorship model, instead of just being told by an instructor that anyone can edit Wikipedia. Students in both case studies in this chapter

experienced first-hand the process of writing for Wikipedia, including both positive and negative moments. For example, some of the students' contributions to Wikipedia were criticized or overwritten by established "Wikipedians." Ultimately, this process is similar to science, with new knowledge changing our understanding over time, and somewhat similar to the academic world, in which peers comment publicly on each others' work.

Lessons learned

By repeating Wikipedia activities over time, the educators in these two case studies were able to learn about designing effective Wikipedia-related assignments based on their assessment of student learning as well as their informal observations of the activities and interactions with the students. Applying an iterative design approach, they updated the Wikipedia assignments over time, based on their new knowledge. For other educators considering incorporating Wikipedia editing assignments in their courses, some of the lessons learned from these two case studies may be helpful.

The first lesson learned is that Wikipedia truly is a community. Instructors and students editing Wikipedia must understand that even though Wikipedia can, in theory, be edited by anyone, it is not just anyone participating independently and blindly. Rather, Wikipedia consists of a community of about 76,000 active "Wikipedians" for all language editions of Wikipedia (30,000 of which are active "Wikipedians" for the English-language version of Wikipedia).⁴⁰ Like any community of people, Wikipedia's community includes personalities, politics, and bureaucracy. The people who are active in the community care deeply about their work, and they might be critical of changes made to their articles, or of new editors' interactions with the established community. For instructors creating Wikipedia assignments, some tips related to this point include:

- In selecting articles to edit, instructors should look at the "Talk" pages for articles under consideration.⁴¹ Evaluate how recently edits have been made and which users made them. Instruct the students to mention on the "Talk" page that they will be working on the article for a class project.
- Use Course pages provided by the Wiki Education Foundation⁴² (previously Wikipedia Education Program⁴³) to organize students' work and act as a portal for the class to communicate with the community.

- For graduate students or advanced undergraduates majoring in the discipline taught, consider having them analyze Wikipedia articles and select several to propose editing. For first- or second-year students, or non-majors, supply them with a list of articles appropriate for the assignment.

The second lesson learned is that, like any community, Wikipedia has a culture to understand and norms to follow. Just as scholars learn about an intellectual community before engaging with it by publishing or presenting, students should not expect to enter this community without learning about the expectations for doing so. In both case studies described here, it took more than one implementation for the activity to run smoothly. Before designing these Wikipedia editing activities, the authors of this chapter were not active editors in the Wikipedia community. However, the Wikipedia projects improved over time as the authors gained experience as editors, learned more about the culture of Wikipedia, and edited the assignments accordingly. Tips related to this point include:

- Instructors should have a good understanding of the Wikipedia community. Participating in editing or partnering with an experienced editor before bringing students into the Wikipedia community is ideal. A good starting point is to go through the Training for Instructors provided by WikiEdu.⁴⁴ At least one instructor in the instruction team should have actually edited some Wikipedia articles and interacted with the community by the time the class starts.
- Instructors should teach students to follow Wikipedia style guidelines.¹⁶ Use, for example, the WikiEdu Training for Students,⁴⁵ Wikipedia Manual of Style,⁴⁶ Wikipedia Manual of Style for Chemistry,⁴⁷ and most importantly, the Five Pillars of Wikipedia.⁴⁸
- Students need to be reminded of the established norm requiring writing for a general audience, using language easily understood, and taking a neutral point of view.⁴⁸
- Choose articles with topics that seem to have a low potential for controversy. In an early iteration of the activity in the first case study, the “Preservative” article was too controversial, and got too much attention from the Wikipedia community. Also, it may be more difficult for students to provide a neutral and balanced perspective on controversial topics.¹⁴

- Teach students to add one paragraph at a time, not multiple paragraphs. Also, recommend that they add an “edit summary,” which shows up in the revision history of an article, explaining to the community why they are adding the new paragraph.

The final lesson learned is about sources. As described in the first case study, the information cited in Wikipedia articles should come from a range of sources, not only primary sources published in the scientific literature.¹⁶ In fact, secondary sources (books, review articles, magazine articles) often represent the best option to cite when writing for Wikipedia. Because Wikipedia is an online encyclopedia, a tertiary source, citing only primary literature could make an article’s content too current and therefore quickly outdated. Citing more sources tested by time reduces the risk of sharing incorrect information in Wikipedia. In addition, Wikipedia’s guidelines specify that its content should not contain original research, including new “analysis or synthesis of published material that serves to reach or imply a conclusion not clearly stated by the sources themselves.”²⁶ When only primary sources (original research) are cited in a Wikipedia article, the article itself may come too close to original research, which is not appropriate for this tertiary source. For instructors creating Wikipedia assignments, some tips related to sources include:

- Teach students how to find and use reference sources for citing in Wikipedia. Reference sources are also useful for comparison, considering students are writing a reference source when writing for Wikipedia. Also, help students understand the verifiability and reliability of a source in the Wikipedia context.^{49,50}
- Break the big task of writing/editing an article into smaller pieces to allow time for formative assessment on tasks such as source selection from the librarian and/or instructor on the early stages of the project.¹⁴

How to incorporate Wikipedia editing into a class

This chapter describes two approaches to designing an assignment leading students through the process of editing chemistry-related Wikipedia articles. Instructors who want to do similar full-fledged, multi-week class projects may find these examples, and tips above, useful. However, instructors and librarians may also want to design shorter, more focused assignments/activities that encourage students to engage critically with Wikipedia, without actually publishing a full Wikipedia article. Examples of such smaller-scale activities, which could also serve as scaffolding activities to help students develop the skills needed to write an article, include:

- Analyze Wikipedia articles for strengths and weaknesses. The assignment format could be a short proposal explaining why an article needs improvement and what the approach would be for improving it.
- Research information sources to add citations of reliable sources to existing Wikipedia articles. The assignment format could be an annotated bibliography. If appropriate, the students could actually add the citations to Wikipedia.
- Write a draft of a Wikipedia article and submit to class for peer review feedback without publishing to Wikipedia. This eliminates the need to teach students about setting up an editor account and sandbox page, using the Wikipedia markup language, or following best practices for adding content to Wikipedia such as adding one paragraph at a time.
- Provide structured peer review feedback to fellow students on draft Wikipedia articles.

Instructors and librarians interested in creating activities related to editing Wikipedia should consider connecting with the Wiki Education Foundation,⁴² which provides support and resources for educators. The program also includes example lesson plans and ways to integrate the instructor and the course into the Wikipedia community.

Conclusions

This chapter offers reflections on the pedagogical possibilities of having students write for Wikipedia, an online reference source read by millions of people. The case studies illustrate how a variety of assignments engaging students in editing Wikipedia can be used to achieve both chemistry and information literacy learning outcomes for a variety of students. Working together, chemistry faculty and librarians can design creative, engaging Wikipedia-based assignments that help students understand the complexities of information creation and production, as well as the nature of science, while engaging them in researching and writing about chemistry topics.

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