Wikipedia Writing Assignments: a One-year Pilot Program in Chemistry Classes at Mahidol University

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Abstract

We discuss a pilot implementation of Wikipedia writing assignments in three chemistry courses at the Mahidol University International College. Thirty eight out of 70 undergraduate students opted to write articles relating to their classes on the English Wikipedia as an alternative to a paper-based exam. As part of the assignments, 64 articles were created or improved by the students, but other voluntary contributions, during and after the courses, were also significant. Preliminary results collected over one academic year (September 2014 – December 2015) confirm that our current practice not only benefits student learning but also promotes 21st century learning (i.e. student-centered learning) and contributes to the free knowledge movement. Students' motivation to participate in a Wikipedia assignment and the difference in course outcomes from those who took a paper-based exam are also discussed in the paper. Our practice may be transferable to chemistry or science courses in other settings.

Keywords: *Wikipedia, Alternative assessment, Undergraduate chemistry course, Writing assignment, Scientific writing, Web 2.0 movement, Student volunteerism*

Introduction

Wiki is a Hawaiian word for "quick". It was first used to refer to a user-editable website, WikiWikiWeb in 1995 by Cunningham (2014). Today, the term also represents the software engine and the markup language of the user-editable website itself. Within just two decades after its introduction, wiki has been adopted by many sites and has become an indispensable part of the internet. In particular, the Web 2.0 transition, the change from static to dynamic web pages with user-generated content, has been made possible through the adoption of Wiki platform.

A wiki website may be viewed as having three components, the software engine, the community constitution, and the users. First, the engine is the technical backbone of the website and services the interaction of users with the system through a web browser. The second part of a wiki site is the community constitution, or the common set of rules governing the contributions and interactions of the users. The constitution is at the heart of the site and may vary greatly depending on the purpose of the site and whether involved stakeholders are allowed to set the rules. Lastly, users and contributors are the most valuable aspect of a wiki website. All content is created, removed or revised by them. As depicted in Figure 1, various wiki platforms may be used by diverse audience groups in different disciplines for multiple levels of interaction. However, the existing body of literature concentrated on certain domains in the map only.

Wikipedia and Its Place in Education

The most popular wiki and the seventh most visited website on the internet is Wikipedia. Introduced in 2001, the English Wikipedia is the largest internet encyclopedia in terms of both its content and access. Smaller and more specialized wikis exist for encyclopedic and many other purposes, for example, Chem Wiki (Allen et al., 2015). The most visible research is on the use of English Wikipedia for study materials in higher education. According to recent surveys from three anglophone countries, US, UK and Australia published by Halverson, Siegel, and Freyermuth (2010), Judd and Kennedy (2010), Knight and Pryke (2012), Lim (2009, 2013), Selwyn and Gorard (2016), it was revealed that students undoubtedly read

Wikipedia for general information and for their study despite disapproval and discouragement. In the UK, Knight and Pryke (2012) reported that 74% of the academic and 75% of the student groups use Wikipedia. However, it is ironic that 77% of the student body in the same study were instructed not to use Wikipedia by those who do use it. There is a consensus that recommending students against the online tide of Wikipedia is rather futile and efforts should be made towards efficient and critical use of the website (Knight & Pryke, 2012; Lim, 2009, 2013; Selwyn & Gorard, 2016; Vilensky & Steenberg, 2015). Selwyn and Gorard (2016) pointed out that Wikipedia can be particularly useful for students who are non-native English speakers, and this should be explored further.

Several studies (Giles, 2005; Casebourne, Davies, Fernandes, & Norman, 2012) compared the English Wikipedia favorably to other commercial encyclopedias. Being a high-quality comprehensive encyclopedia is not a definitive guarantee for its suitability in the teaching of all disciplines to all audiences. However, we see a reassurance for chemistry in an increasing number of articles comparing presentation of the pedagogy or definition in the English Wikipedia with textbooks or citing it as a source or resource (Blonder et al., 2013; Blonder & Sakhnini, 2012; Bodner, 2007; Delgado, 2015; van der Kolk, Hartog, Beldman, & Gruppen, 2013; Matta, Massa, Gubskaya, & Knoll, 2011; Weinhold & Klein, 2014). These show acceptance and popularity of the English Wikipedia and put it alongside its textbook counterpart.

With reference to the framework in Figure 1, there are limited examples of Wikipedia assignment programs for chemistry or STEM disciplines in general at university level. At the same time when psychology and sociology initiatives were launched, only two papers describing group Wikipedia assignments for undergraduate general chemistry (Martineau & Boisvert, 2011) and graduate organic chemistry (Moy, Locke, Coppola, & McNeil, 2010) were published. A recent article by Walker and Li (2016) was still based on Ann McNeil Chemistry classes at University of Michigan (Moy et al., 2010). Recently, there was preliminary discussion at the American Chemical Society for Wikipedia projects, but there are no initiatives similar to the ones for SAH disciplines yet (American Chemical Society 2015; Davenport 2015; Wikipedia: Meetup/Boston/American Chemical Society Wikipedia Edit-a-thon: Notable Chemists and Chemistry 2015).

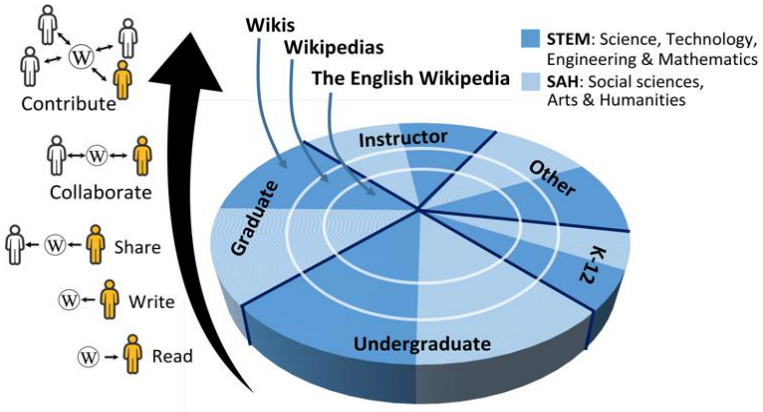


Figure 1. Uses of Wikis in Education: Wiki Platforms, Audience Groups, Disciplines and Levels of Interaction

In this exploratory study, we aim to examine the impacts of implementing Wikipedia writing assignments as a non-compulsory alternative to paper exams in three undergraduate chemistry courses. Students' contributions were monitored and tabulated. Comparisons were made between the students taking the Wikipedia assignment and those taking a paper exam. Students' performance and learning outcomes of both groups were also measured and discussed.

Methodology

Theoretical Framework

It is important to make sure that a Wikipedia assignment is an appropriate means of assessment and contributes positively to student learning. Contributing to Wikipedia (Walker & Li, 2016; Moy et al., 2010; Martineau & Boisvert, 2011; Konieczny, 2007, 2012, 2014; Obar & Roth, 2011) is an emerging area of research. Therefore, it can be a rewarding educational exercise for students (Yun, Lee, & Jeong, 2016). There are many skills that students (and instructors) can learn from Wikipedia contribution such as research, writing, and collaborative working skills (Brailas, Koskinas, Dafermos, & Alexias, 2015) and students' contribution will help educate many other people long after the class ends, unlike other short-lived web resources (Markwell & Brooks, 2008). Wikipedia is also a rich ground to develop critical analysis skills (Martineau & Boisvert, 2011). As suggested by Walker and Li (2016), students are expected to receive the following advantages according to the 'Framework for Information Literacy for Higher Education Association of College and Research Libraries' (Association of College and Research Libraries, 2015):

1. By creating information or knowledge for the general public, students develop a creative process, or "an understanding that their choices impact the purposes for which the information product will be used and the message it conveys."

2. By having to peer review, criticize and evaluate the existing Wikipedia articles, students learn to value user-generated content and contributions made by others.

3. By seeking for information to represent the overall picture of a particular topic, students develop ability to utilize divergent (brain storming) and convergent (selecting the most appropriate source) thinking when searching.

4. By having to translate academic literature for the general public and using an appropriate style of writing, students make scholarly contributions at an appropriate level to suit a broader audience.

5. By letting the students do extensive literature research, looking into primary, secondary, and tertiary resources, and summarizing a topic comprehensively, students synthesize ideas gathered from various kinds of sources.

Considering all the benefits and skills that students may acquire, the Wikipedia assignment is used as an alternative assessment to examination and hence is an individual assignment. It may seem radical to change examinations into a writing assignment, but according to Wolf, Bixby, Glenn, and Gardner (1991), this may not be "a new mode" but "a rediscovered mode" of assessment.

Implementation

The Wikipedia assignments were implemented as an individual non-compulsory alternative to a final exam. Students were allowed to choose an article of their choice with the assistance of the instructor. A list of suggested articles as well as examples from other classes were given as a guide.

The Wikipedia assignment was implemented in three undergraduate chemistry courses, ICCH 444 Environmental Chemistry, ICCH 224 Integrated Laboratory Techniques in Chemistry I (two different sections, S1 and S2), and ICCH 336 Computational Chemistry, in the following terms:

Table 1. Courses with Wikipedia Assignments

Subject	Trimester	Date	# Students Taking Wiki	# Students Taking Exam
ICCH 444	2014-15T1	Sep to Dec 2014	8	0
ICCH 224 (S1)	2014-15T3	Apr to Jul 2015	10	5
ICCH 224 (S2)	2014-15T3	Apr to Jul 2015	0	15
ICCH 224 (S1)	2015-16T1	Sep to Dec 2015	5	8
ICCH 224 (S2)	2015-16T1	Sep to Dec 2015	8	4
ICCH 336*	2015-16T1	Sep to Dec 2015	7	0

Note: *Five of these students were in ICCH 444, and we have counted them twice for the total number of participants.

The Wikipedia tasks for each subject are tailor-made to fit the objectives of the course and are set term by term. Students were informed on the first day of class that a Wikipedia assignment would be available as an alternative assessment. The instructor took his time to explain and demonstrate how a Wikipedia assignment works. During the first few weeks, students had to make their decision whether or not they wanted to participate in the pilot program. Participating students were asked to create an account on the English Wikipedia, complete the online student training, and choose a prospective article to write or improve. The instructor also regularly checked student online record to see if the training was complete, and reminded the student to redo the missing online interactive exercise. Online training is based on wiki mark-up language. It was compulsory for students to learn it at this stage, though they were allowed to use any tools including the VisualEditor for their contribution later. Students were assigned to edit, upload, and make contributions directly onto Wikipedia. Their contributions were subject to further independent scrutiny by other Wikipedians, which gave students an opportunity to practice working collaboratively and communicating with the general public. This process also mimics the rigorous peer review of the science literature, a process which they are likely to face in their future career. Student contributions were evaluated according to the quantitative and qualitative requirements of each course. (See the next section.) Assessment is made of three components: text, media upload, and references. Text and references are standard components of the encyclopedic content, but media are not usually compulsory. However, we see media upload as an important part of our assignment because (1) most of our students are non-native English speakers, and so diagrams, drawings, photographs and videos may be a better way to communicate the scientific content, (2) the uploaded media can be used all across Wikimedia projects, and (3) not only can an image say a thousand words, but students need to read a thousand words to successfully create a media file on the Wikimedia Commons, a central repository of freely licensed media files for all Wikimedia sites.

The assignment is likely to lead to full marks for those who complete it. However, there are milestones that had to be completed by the deadline or else the student would be required to take a normal paper exam.

Survey, Monitoring and Program Evaluation

Wikipedia Education extension on the English Wikipedia allows instructors to create a course page and keep track of student usernames and their nominated Wikipedia articles. Separate course pages were written for each course in each term. On a course page, the public can see the course description, timeline and grading criteria of the Wikipedia assignment in addition to a list of usernames and nominated articles.

A voluntary exit survey was administered to students online via *Qualtrics*. All students in the courses except one of the authors (A.S.) were invited to complete the survey. For ICCH 224 (2015-16T1) and ICCH 336 (2015-16T1), surveys were completed in class after a practical examination and presentation respectively. For the other two sections, a link to the survey was sent out to students in December 2015. The survey consisted of three parts. Inspired by Allen et al. (2015), the first part was Barbera, Adams,

Wieman, and Perkins (2008)'s Colorado Learning Attitudes about Science Survey modified for use in chemistry (CLASS-Chem). The CLASS-Chem was designed to measure students' attitudes towards chemistry and the learning of chemistry. Any differences in attitudes between students taking Wikipedia assignment and paper exam, if they exist, should be identified by the survey. The second part was an open-ended question for students to share their reasons for taking a Wikipedia assignment or paper examination. These two parts were compulsory for all survey respondents. The last part was comprised of questions adapted from Pence and Pence (2015) and Martineau and Boisvert (2011) for students taking the Wikipedia assignment only.

Unlike Moy et al., (2010) and Martineau and Boisvert, (2011), the instructor allowed individual students to work directly on Wikipedia without instructor approval or *Turnitin*, an online originality checking service. It is therefore straightforward to monitor students' activities and overall contributions (pages, uploads, edits, and bytes) by using Wikipedia Education Program extension and *Wikimetrics* (metrics.wmflabs.org). Student final grades were also analyzed to understand the impact on course outcome.

Instructor/Reviewer Preparation

It is recommended that instructors in the Wikipedia Education Program have a basic understanding and familiarity with Wikipedia (Walker & Li, 2016). Online instructor training is available and Wikipedia's online community support is required to get a user approved as an instructor to use Wikipedia Education extension on the website. T.L. has been a Wikipedia editor since 2006. He started by using the English Wikipedia to help with his university assignment and contributed his translation to the Thai Wikipedia voluntarily. T.L. was elected a sysop on the Thai Wikipedia in 2009 and has had to battle with poor contributions from school work since then. He briefly experimented with the use of Thai Wikipedia as a learning resource for Thai language students at the Australian National University in 2010. It was not until he attended the Wikimania 2014 conference in London where he received pamphlets from the Wikipedia Education Program that he reconsidered offering Wikipedia assignments to his class at Mahidol University.

We did not enforce peer review because students in general are inexperienced with Wikipedia and our class size was small enough for the instructor to manage. This is in line with some Wikipedians' expectations (Smokefoot, 2016). Novice users on Wikipedia usually do something wrong and receive warning messages or a ban on their account resulting in their leaving Wikipedia. It is commonly accepted that the retention rate of new users on Wikipedia is low, and various solutions are being tried. Wikipedia Education Program is probably part of the solution. Having said so, to make our practice scalable, we instead relied on a volunteer from previous cohorts of students. Currently, after one academic year of the program, there is only one alumnus of our class (A.S.) approved as a campus ambassador, an official volunteer who provides face-to-face training and support on campus, on the English Wikipedia. Our deployment of Wikipedia assignments may be slow, but as the number of volunteers grows organically, the practice can increase sustainably within the institution.

Results and Discussion

Student's Contribution to Wikipedia

All students who chose to work on the Wikipedia assignments were new to writing for Wikipedia. Their Wikimedia accounts were created during the first few weeks of their class and we analyzed online public records of these accounts to understand their behavior and contributions. As part of the class assessment, they contributed to 64 articles on the English Wikipedia (see the next subsection for lists of articles contributed as part of the study). Students worked on text and/or illustration of their nominated articles to achieve the target set by the instructor. "Laboratory water bath" (Figure 2) is an example created by one of us (A.S.) in June 2015. As of 9 May 2016, the article received an average view of 241

per day and has been visited more than twenty thousand times since its creation.

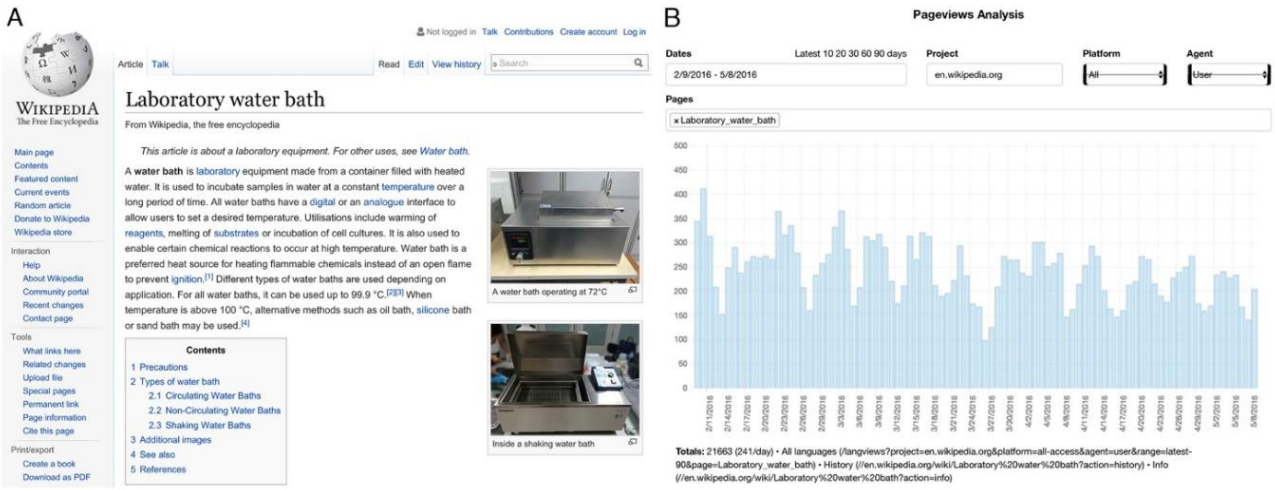


Figure 2. A Wikipedia Article from ICCH 224: "Laboratory Water Bath" (A) and Number of Views (B)

Wikimetrics results represent collective contributions of all students. Even though students were assigned to contribute to the English Wikipedia, we tabulated the results from all Wikimedia projects which include Wikipedia in other languages and other sister projects in order to represent all students' contributions. For the number of uploads, however, only uploads to Wikimedia Commons were counted. Deleted pages were excluded as per default setting of Wikimetrics tool.

Significantly higher contributions were made between September and December 2015 (Figure 3) because two Wikipedia assignments were administered in the same trimester along with student voluntary contributions to Wikipedia. In total, 44 new pages were created and 1,136 edits were made on all Wikipedia projects. On Wikimedia Commons, 311 articles were uploaded. We note that deleted pages were negligible as we warned students that pages on Wikipedia may be deleted. However, the number of deleted articles was as high as 95. Though we discouraged too many uploads, some students uploaded a new file to a new page rather than uploading an improved file as a new version of the existing file. It was our instruction to students to clean up their low-quality and unnecessary uploads, and it resulted in significant deletion statistics. Student contributions in terms of bytes are discussed in the next section.

We note that there are a few limitations in Wikimetrics. The total pages created included redirects created by students. A redirect is a page that contains no content itself but directs readers to another page. Redirects serve to keep links to a page after it has been renamed or moved. Byte count also included Wikipedia formatting syntax (for examples, internal and external links, font face, and table syntax), which enhances reading experience but is generally invisible. There was also intended inclusion of non-class contributions, as we wished to see if students continued to volunteer on Wikipedia even after the assignment was over. Results clearly show that voluntary contributions of a few students became significant. One of the authors (A.S.) works on anatomy articles, and several students participated in Wikipedia Asian Month, a campaign to improve the Wikipedia content about Asia. This explained a relatively high number of pages created as shown in Figure 3 (27 articles in November 2015).

It is encouraging to see that the overall student contributions were more than double the class requirement, and a few students not only continued to contribute to Wikipedia online but also volunteered in other events of the Wikimedia movement. However, as the retention rate of users is usually extremely low, it may be premature to draw a conclusion regarding the retention rate from this small pilot study.

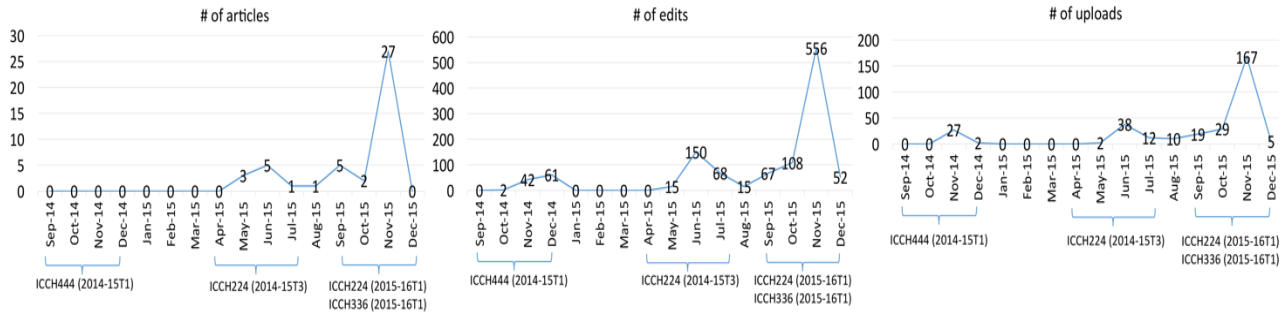


Figure 3. Number of Articles Created, Edits, and Media Uploaded by Month between 1 September 2014 and 13 December 2015

Articles by Students

Article names are listed below by course/term and by alphabetical order. Asterisk (*) indicates a new article.

ICCH444 (2014-15T1) *Hydrogen Sulfide, Hydroxylapatite, Industrial waste, Osteosarcoma, PTT Public Company Limited, Saltcrete, Toxicology, Waste treatment technologies* ICCH224 (2014-15T3) *Alcohol burner*, Chemical storage*, Filtration, Glass rod, Graduated cylinder, Laboratory safety, Laboratory water bath*, Spatula, Universal indicator, and Watch glass* ICCH224 (2015-16T1) *Blue bottle (chemical reaction), Burette clamp*, Emergency eyewash and safety shower station*, Filter paper, Laboratory rubber stopper*, Laboratory scissor jack*, Napthalene, Rubber bulb*, Sublimation (phase transition), The chemical traffic light*, Test tube rack*, Test tube holder*, Utility clamp*, and Vanishing valentine experiment**

ICCH336 (2015-16T1) Midterm and final are indicated by superscript 1 and superscript 2 respectively. *2- Ethyl-1-butanol[1], 2,4-Dimethyl-6-tert-butylphenol[1], Carbocation[1], Complete active space perturbation theory*[2], Fenfluramine/phentermine[1], Fukui function[2], Hordenine[1], Hydroxyethyl cellulose[1], Hydroxylapatite[1], Infrared spectroscopy[1], Isoflavane[1], Journal of Chemical Theory and Computation[2], Metoclopramide[1], Mitragynine[1], MOLPRO[2], Monoiodotyrosine[1], N-Acetylglucosamine[1], N-Methyltyramine[1], NAPQI[1], Nikethamide[1], Nucleophilic substitution[1], ORCA (Quantum Chemistry Program)[2], Phenacetin[1], Polypropylene[1], Polystyrene[1], Pople diagram*[1], PQS (chemical)[2], Propargyl alcohol[1], S_N1 reaction[1], Trimethobenzamide[1], Tripelennamine[1], TURBOMOLE[2], and Valnoctamide[1]*

Bytes Added by Students

Figure 4 shows that 691,598 bytes of text were added to Wikimedia projects during the study period. These contributions, however, are not restricted only to the English Wikipedia. The majority were added to namespace 0 or Wikipedia mainspace (233,872 bytes), followed by namespace 2 or userspace (211,895 bytes), odd namespaces or talk pages (119,690 bytes), and other namespaces (116,501 bytes). Bytes added to namespace 0 accounted for the texts that students added to the articles. Bytes in namespace 2 were the amount of bytes added to personal user space. It was higher in the first half of the trimester when students had to create user pages during the online training. As part of the training, messages were also automatically posted on each student's user page and talk page. The messages were recorded under the student account, thus resulting in the number of bytes and edits. Moreover, it was suggested that students draft the assignment on their sandbox (individual user space) prior to submission. After the submission, students blanked their sandboxes resulting in the negative numbers of bytes added to namespace 2 in July and December 2015. The amount of communication on Wikipedia was measured by the number of bytes in odd namespaces or talk pages of Wikipedia. The added bytes mainly came from

student trainings, the template which students were asked to put on the talk page of each of the articles they contributed, and also from responses to comments given to them on talk pages by other Wikimedians and the instructor.

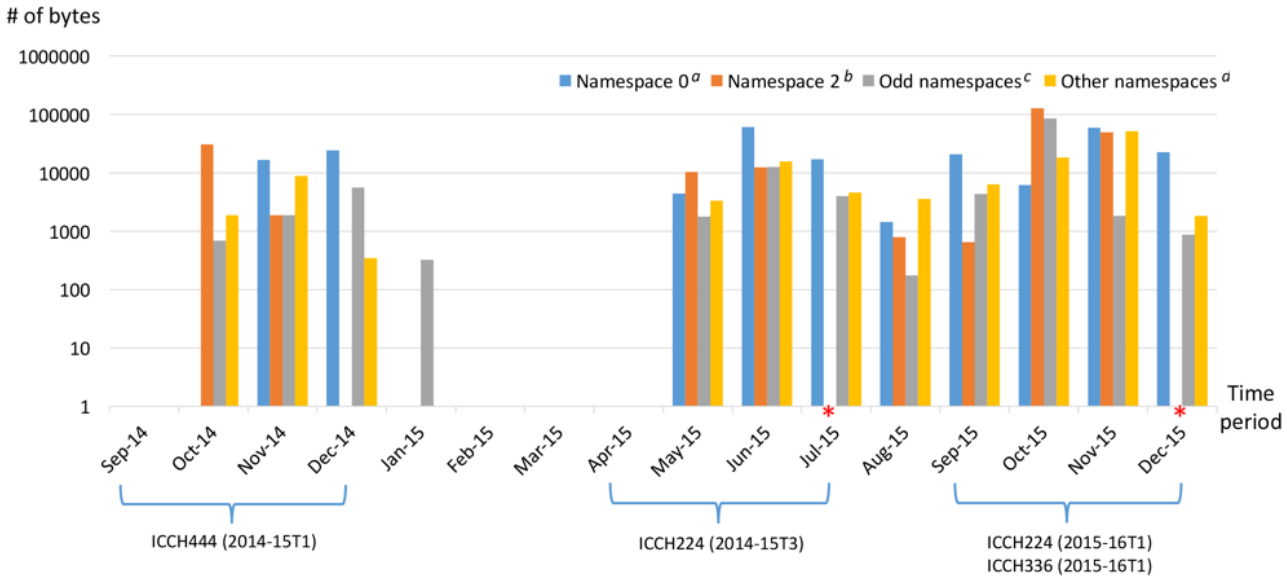


Figure 4. Number of Bytes Added to Wikimedia Projects in Logarithmic Scale by Month between September 1, 2014 and December 13, 2015

[a] Namespace 0 refers to main/article pages of Wikipedia.

[b] Namespace 2 refers to user pages that students created as a part of the online training or as a draft for the assignment.

[c] Odd namespaces refer to talk namespaces including namespaces 1, 3, 5, 7, 9, 11, 13 and 15. They indicate the amount of communications on Wikipedia.

[d] Other namespaces include namespace 4, 6, 8, 10, 12 and 14, which are namespaces for Wikipedia, File, MediaWiki, Template, Help and Category respectively.

*Negative sum of bytes in Jun 2015 and Dec 2015.

Arrangements for Each Course

Detailed implementations for each course are explained below:

ICCH 444 Environmental Chemistry: Links to Wikipedia articles were posted on the course learning management system as a supplementary reading, since textbooks are usually behind the latest development in the field. Wikipedia articles are also a good resource for specialized topics not included in the course textbook. The articles were a subject of homework and discussion during class. The Wikipedia assignment was given as an alternative to the written final examination. The requirement was that a student must contribute ten sentences and ten references to a related Wikipedia article. The assignment was 40% of the final grade (30% for the work and 10% for a presentation).

ICCH 224 Integrated Laboratory Technique in Chemistry I: The Wikipedia assignment was given as an alternative to the written final examination. The requirement was that a student must contribute five sentences, two media files, and one reference to a Wikipedia article describing a compound, a reaction, some equipment or a technique. The assignment was 20% of the final grade.

ICCH 336 Computational Chemistry: Links to Wikipedia articles were posted on the course learning management system as part of reading assignment. Wikipedia serves as a technical dictionary for most key terms and concepts, as software manuals can be unnecessarily complicated. The Wikipedia

assignment was given as an alternative to the written midterm (30%) and final (30%) examinations. The requirement for midterm was to create and upload three media files for uses in Wikipedia articles (90% of the 30%) and a collaborative contribution to a common article "Pople diagram" (10% of the 30%). The requirement for the final was to contribute 15 sentences, 4 references and one media file (90% of the 30%) and a presentation (10% of the 30%). Seven out of seven students chose to work on Wikipedia assignments.

Students' Attitudes towards Chemistry Education

The CLASS-Chem survey serves as a measurement of students' attitudes towards learning chemistry. A total of 36 students from the three classes answered the online survey. Out of the 36 students, 26 were in the Wikipedia assignment program. The CLASS-Chem results are shown in Figure 5. Scores were normalized to a 5-point scale, where a score of 5 indicates strong agreement while a score of 1 indicates strong disagreement with expert opinion. On average, the total score (± standard deviation) of each respondent for Wiki and non-Wiki group were 122.31 ± 14.77 and 133.20 ± 13.64, respectively. Two different questions between Wiki and non-Wiki groups were questions 16 and 34, with the differences being 0.9 and 0.8, respectively. For question 16, the statement was "I study chemistry to learn knowledge that will be useful in my life outside of school." There was a stronger agreement among those taking the Wikipedia assignment, with the average score (± standard deviation) being 4.0 ± 0.83 points as opposed to 3.1 ± 1.1 points for students who took the paper-based exam. Question 34 was "Learning chemistry changes my ideas about how the world works." Those taking the Wikipedia assignment scored 0.8 points higher for this question with a mean score (± standard deviation) of 4.0 ± 0.73 points, as opposed to 3.2 ± 1.23. χ^2-test gives *p*-values of 0.12 and 0.09 for questions 16 and 34 respectively. Fisher exact test yields similar *p*-values. Therefore, statistically speaking, the CLASS-Chem results do not show any significant difference between the two groups of students. Although the difference was not statistically significant, it may be perceived as a trend which should be explored in future studies.

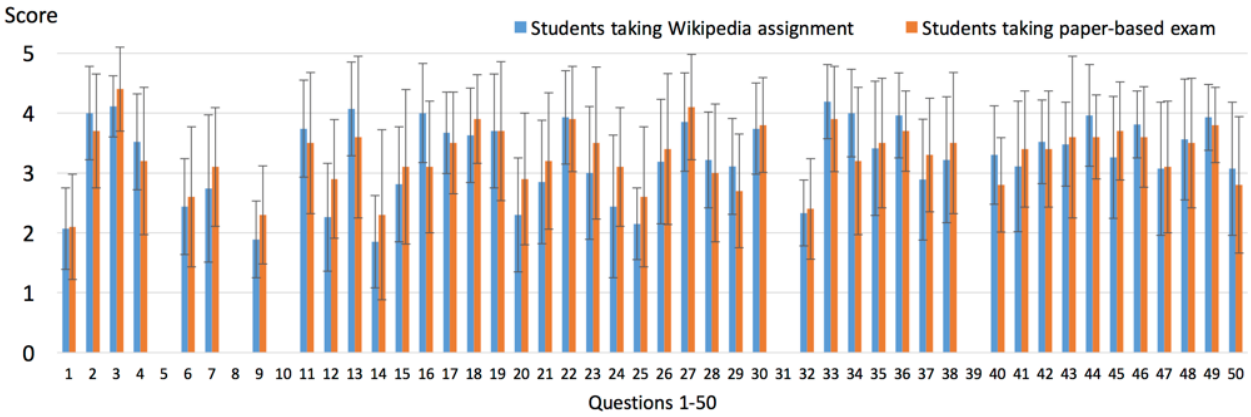


Figure 5. CLASS-Chem Results of Students Taking Wikipedia Assignments and Students Taking Paper-based Exam Scores were normalized to a 5-point scale, where a score of 5 indicates strong agreement while a score of 1 indicates strong disagreement with expert's opinion. Questions number 5, 8, 10, 31 and 39 were not scored and not included in the survey.

Motivation to Participate in the Wikipedia Assignment

We also administered a compulsory open-ended question in the survey to ask for reasons why one chose the Wikipedia assignment or the paper exam. For those taking the Wikipedia assignment, responses can be grouped into three categories:

New interesting challenge: (5 students)

"I want to have an experience on creating a Wikipedia page of my own..." "It was something new, I have always wanted to contribute and this was an opportunity to do so." "It challenges me to read and find new information that I don't know before." "Because I want to try something new other than taking a test." "I find it interesting and I have never experienced something like this before."

Contribution to society: (3 students)

"It helps to do something that people can use later on, rather than just an exam." "I chose Wikipedia because it not only benefits myself, but also benefits other people." "I feel like it's a way to contribute rather than just a mere assignment."

Ease of the task compared to exam: (3 students)

"...Wikipedia is an easy program to publish, and it allows everyone to look at it easily..." "Because it would be less time-consuming than studying for finals..." "...my final exam schedule this term is cluttered."

For those taking the paper exam, responses can be grouped into two categories:

Time consuming: (5 students)

"I did choose it the first time, but I didn't have time to complete it." "I felt it was a lot of work … that I needed to do research and I had other subjects to do already." "I did choose at first but it seems like I didn't have enough time..." "I feel like I don't have enough time for the assignment, considering the other classes I take this trimester." "There was other work from other subjects. If I chose the Wikipedia assignment, I would not be able to do it very efficiently."

Exam is not too difficult: (4 students)

"I think it is easier for me to take the exam." "I think the written exam should be easier than the wiki assignment." "I'm afraid that it will be harder than the conventional final exam." "My friends told me that the exam was not that hard."

It is clear that students' participation in the program is a choice of convenience, adventure and altruism. According to Cho, Chen, and Chung (2010) and Wagner and Prasarnphanich (2007), altruism or the enjoyment of helping others can be regarded as a positive motivator towards knowledge sharing. Time constraint might also be an important factor that could have discouraged students to take the Wikipedia assignment. We observed in class and in the survey that the peer pressure and peer recommendations played a significant role in student decisions.

Survey Results and Raw Scores

The results of the questionnaire for students taking the Wikipedia assignment are shown in Table 1 on the following page. For each statement, a score of 4 indicates a strong agreement and a score of 1 indicates a strong disagreement. Mean score for each statement is in the last column, and 4 methods of communications regarding the assignment were also listed. It is clear that the assignment led to a positive impact on student's learning, and students who took the assignment agreed that the assignment aided their understanding of the topic covered. Our results are in line with the findings of Pence and Pence (2014) and Martineau and Boisvert (2011) who formulated the survey questions.

Students' Grades

Scores from ICCH 224 Integrated Laboratory Technique in Chemistry I for 2014-15T3 and 2015-16T1 of students were analyzed to see the differences between students taking Wikipedia assignments and paper exams. Since all students in ICCH 336 and ICCH 444 chose to participate in the Wikipedia assignment, scores from those two courses therefore were not included for the analysis. Figure 6 on the following page showed that there was no significant difference in the letter grade between students participating

in the Wikipedia assignment and the paper exam in all sections of both trimesters (χ^2 p-value ≥ 0.1173). Figure 6 shows raw scores of the two groups, the cumulative score before the Wikipedia assignment/exam, and the total score. The raw scores show a general tendency that students taking Wikipedia assignment have higher total scores, but the difference is statistically significant only in section 1 of 2015-16T1 term (t-test p-value = 0.0165).

Table 2. Students' Responses to Wikipedia Assignment Surveys Adapted from Pence & Pence (2015) and Martineau & Boisvert (2011)

Questions	Strongly Agree	Agree	Disagree	Strongly Disagree	Mean[c]
Having completed this course, I now have extensive experience with Wikipedia[a]	10 (37%)	16 (59%)	1 (4%)	-	3.33
Being able to select our own topics was a good idea[a]	16 (59%)	11 (41%)	-	-	3.59
The Wikipedia were an effective way of incorporating outside topics into class[a]	7 (26%)	19 (70%)	1 (4%)	-	3.22
I prefer to have my work spread out evenly over the trimester/Having the Wikipedia work spread out through the semester was better than one large assignment due at the end[a]	12 (44%)	13 (48%)	1 (4%)	1 (4%)	3.33
When I prepare written work, I edit it extensively before I turn it in/I edited the Wikipedia work more than I usually edit my work[a]	6 (22%)	19 (70%)	2 (7%)	-	3.15
I prefer to have a single large assignment due at the end of the trimester/I would have preferred to write a term paper instead of doing Wikipedia[a]	3 (11%)	5 (19%)	11 (41%)	8 (30%)	2.11
I value the opportunity to learn new technology[a]	14 (52%)	13 (48%)	-	-	3.52
I enjoy the opportunity to explore outside topics related to class in depth/Incorporating outside topics makes a course more interesting[a]	13 (48%)	14 (52%)	-	-	3.48
Did this assignment help you to better understand the topic covered?[b]	7 (26%)	20 (74%)	-	-	3.26
Did the reviewing process help to understand the importance writing a structured text and using a proper terminology in Chemistry?[b]	3 (11%)	24 (89%)	-	-	3.11
Did the reviewing process help to improve the overall scientific quality of your texts?[b]	4 (15%)	22 (81%)	1 (4%)	-	3.11
Did you learn something new about Wikipedia (organisation, rules, author's rights, etc)?[b]	21 (78%)	6 (22%)	-	-	3.78
Are you proud of the contribution you made to the collaborative knowledge?[b]	14 (52%)	13 (48%)	-	-	3.52
Would you recommend this assignment to the future cohorts of students?[b]	11 (41%)	16 (59%)	-	-	3.41
After completing this assignment and in the context of your topic, do you trust the content of Wikipedia?[b]	7 (26%)	18 (67%)	2 (7%)	-	3.19
Methods of communication on the Wikipedia assignment[d]					
Face-to-face		67%			
Email		48%			
Within Wikipedia		22%			
Text messages		15%			

Notes: [a] Questions adapted from Pence and Pence (2014)

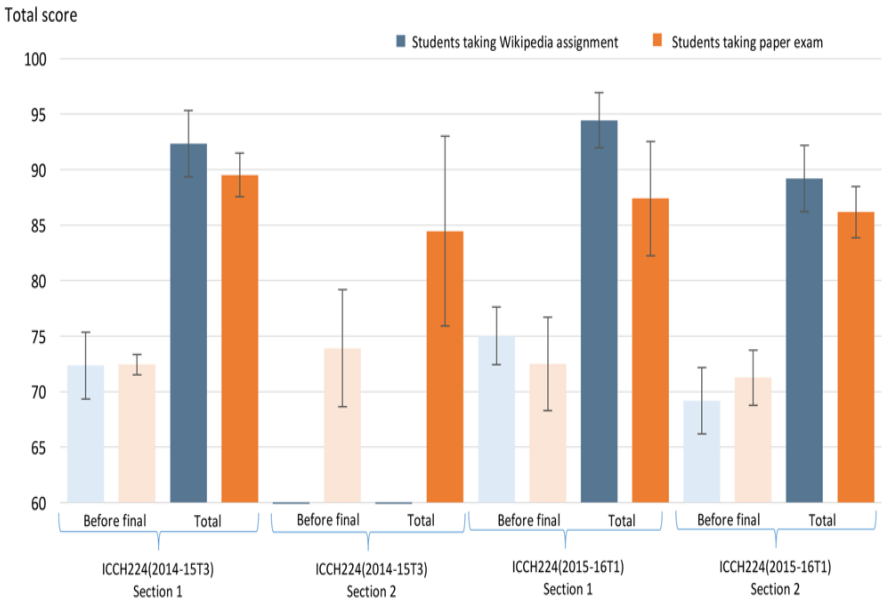
[b] Questions adapted from Martineau and Boisvert (2011)

[c] Normalized to 4-point scale where a score of 4 indicates strong agreement and a score of 1 indicates strong disagreement.

[d] Students were asked to list all means of communication they used. Therefore, the total percentage is expected to exceed 100%.

Students who took the Wikipedia assignment scored slightly better (Figure 6). This is not surprising, as Richardson (2015) also found that the assessment by coursework or by a mixture of examinations and coursework is more likely to lead to higher scores than assessment by examinations alone. Our results could be explained in several ways. Course workload for students in the Wikipedia program was evenly distributed throughout the whole trimester; therefore, students had more time on the assignment. This is shown in the answer to question 4 in our survey (Table 1) that 92% preferred not to have a single large

assignment at the end of the trimester. We also observed students' online records on Wikipedia during the implementation of the assignment, and we noticed that students typically took five active days to finish the Wikipedia assignment. Another reason is that activities on Wikipedia were monitored regularly, and students were given comments and feedback many times. Therefore, students in the Wikipedia program had a better opportunity to improve their work when compared with those taking the traditional exam. Johnston (1994) suggested that the higher scores obtained reflected students' higher level of attainment, and assignments also allowed students to demonstrate a broader range of skills than examinations. It is also believed that a lesser number of longer tasks might resemble more of real-life applications, and therefore engage deeper forms of learning (Thomlinson, Challis, & Robinson, 2010).



Term	2014-15T3				2015-16T1			
Section	1		2		1		2	
Group	W	E	W	E	W	E	W	E
A	9	2	0	7	5	4	4	0
B+	1	3	0	7	0	1	4	3
B	-	-	0	1	0	2	0	1
C+	-	-	-	-	0	1	-	-
Total	10	5	0	15	5	8	8	4
χ^2 p-value[a]	0.1485		n/a		0.3066		0.1173	
t-test p-value[b]	0.9553		n/a		0.2531		0.2626	
t-test p-value[c]	0.0809		n/a		0.0165		0.1093	

[a]grade received, [b]raw score before final, [c]total raw score, W: Wikipedia assignment, E: paper-based examination

Figure 6. Raw Scores of Students Taking the Wikipedia Assignments and Students Taking Paper-based Exam and Comparison of Their Scores

Wikipedia Community Feedback

Wikipedia is an online collaborative platform to develop encyclopedic content. Editors of an article on Wikipedia may hold very different views, and conflicts are inevitable. Communications between editors through Wikpedia's talk pages (also known as discussion pages) is the main mechanism to resolve an issue or reach a consensus. As part of the training, students are encouraged to participate in discussions on Wikipedia and respond properly to comments and concerns from other community members. However, we note that Wikipedia positive-feedback channels and practice are relatively new and uncommon in the community. A careful average student usually had only an automatic welcome message on their talk page. An outstanding one had an invitation to join a Wiki-project or a complimentary message on their talk page. However, for most newcomers, they are likely to do something wrong, have their edits reverted, and receive a warning message. In a study by Patten and Keane (2012), students became discouraged when their edits were deleted by faceless critics or without reasons. Depending on the severity of the issue, students may resolve the conflict by themselves, discuss it with the instructor, decide to change the article, or withdraw from the course. We did have many instances of topic change in the middle of the trimester or even at the last minute, and one case of withdrawal from the course. These are not new phenomenon and may be regarded as "acculturative stress" according to Brailas et al. (2015).

As Wikipedia editors, we perceive the community feedback as a necessary and healthy part of the

assignment, and always warn students in advance that certain actions will draw a reaction. We also acknowledge that there are some Wikipedians opposing the use of Wikipedia as a platform for education assignments (Smokefoot, 2016), and they sometimes wrote to us to express their concerns regarding our students' work. Our response was that we strive to do better, and would advise students to pick a topic wisely. T.L. always encourages students to pick a "stub" page (short article with no or few references) and develop it into a better one. There are several advantages in this approach: the pre-existing page usually passes notability criteria (i.e. Wikipedia administrator will not delete the entire page.), the student gets a sense of structure and is mainly required to provide data and information, and people can see positive contributions by comparing the article before and after the student's work.

Conclusion and Implications

We explore impacts of online Wikipedia Assignment as a non-compulsory alternative to paper exams in three undergraduate chemistry courses. The Wikipedia writing assignment involved close supervision by the instructor throughout the 12-week trimester. Students received feedback from the instructor, peers, and anonymous general public. Online students' product is comparable to about 78 pages of text and 64 pages of photos, assuming 3,000 bytes per page and 5 photos per page. These articles are used every day by the public, and one isolated example shows as many as twenty thousand views since article creation. Even though students taking the Wikipedia assignment received slightly higher raw scores, there were no statistically significant differences in letter grades. An exit survey and course evaluation showed that most students were satisfied with this alternative assessment approach. As many institutions, including Mahidol University, are embracing the lifelong learning agenda in the 21st century, there are driving forces for educators to rethink their assessment methods. The Wikipedia assignment is aligned with the 21st century learning framework for most of the 3Rs (reading, writing, and arithmetic) and 4Cs (creativity, critical thinking, communication, and collaboration), and also supports pedagogical strategies like flipped/blended classroom and student-centered learning. Our model of implementing the Wikipedia writing assignment may be transferable to other chemistry or STEM courses in a similar context.

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