Reading Science: Digital Humanities and General Chemistry

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Abstract Scientific papers often present challenges to undergraduate readers. This paper reports on research to explore whether Voyant, a digital humanities text analysis tool, might help students become more proficient and independent readers of scientific articles. Students taking Honors General Chemistry 2 were introduced to Voyant. For the study, they read, analyzed, and summarized a scientific paper without the use of Voyant to establish a baseline measure of their skills. They then read, analyzed, and summarized a second scientific paper with the aid of Voyant, and a third one without Voyant again. For the first article, the students earned an average of 7.6 points out of 10. For the second article, they gained a point, reaching an average of 8.7. For the third article, students maintained the gain with an average of 8.6 points. In addition, thematic coding of answers to open-ended survey questions posed after the second article confirmed reports by eleven out of fourteen students that Voyant had helped them; however, for the third article, only four missed the assistance of Voyant. In conclusion, Voyant was found to be a helpful temporary aid for reading scientific papers.

Keywords Voyant, Digital Humanities, General Chemistry, Scientific Papers, Undergraduate

1. Introduction

Scientific articles present a gateway to fascinating STEM (science, technology, engineering, and mathematics) fields and allow students to gain current information about research. An emphasis on encouraging students to engage in research outside the classroom during their undergraduate education has been reported as a path to greater student persistence and retention [1]. In addition, researchers report that students who do such research have greater success in graduate school than their less experienced classmates [2]. By reading scientific articles, students engage with the background of their future fields and current projects. In addition, in the classroom, students frequently need to read some scientific articles when writing their research papers.

However, reading scientific literature can be daunting to an undergraduate student, because there is usually a gap in reading level between the classroom textbook and scientific journal articles [3]. In addition, extensive scientific background and vocabulary are referenced and assumed. Finally, there is a level of uncertainty in reading current research that results from not understanding the entire article, because scientific articles frequently report on complex techniques and equipment [3]. In order to assess the grade levels of the articles that I asked my students to read for this study, I employed the Flesch-Kincaid Readability Grade Level test through Microsoft Word. This method considers the average sentence length and the average number of syllables per word in a calculation [4].

In an attempt to make the process reading scientific articles faster for students, I decided to apply Voyant, a tool of the digital humanities, toward the reading of scientific articles in the classroom. In 2013-2014, I had been a participant in the professional development seminar initiated by Provost Paul Arcario, the Provost's Learning Space, which that year focused on the digital humanities. Voyant software can be used for any text that is in digital form and, therefore, can be used across the disciplines. In the fall of 2014, I introduced the tool to my classes with the goal of promoting transferrable skills such as finding the main idea, defining vocabulary, and being comfortable with possible uncertainty. My students had a very positive response to the use of Voyant. The purpose of this article is to determine whether Voyant, a free online digital humanities tool, can serve as a sort of "training wheels" to spur students into becoming effective and independent readers of scientific articles.

2. Literature Review

2.1. Reading Scientific Articles in the Science Classroom

Science educators have reported including scientific journal articles in the curriculum for a variety of reasons: guiding students in summarizing; teaching scientific writing

and enhanced problem solving; and increasing the interest level of the class. Several papers have been written about using scientific journal articles to teach writing [5-8]. Some papers offer help in reading and summarizing journal articles [9-11]. For instance, students taking a third-year Introduction to Chemical Research course at Annapolis State University in Boone, North Carolina were given excerpts from scientific articles and asked to pick a key sentence that summarized each paragraph. They then created a PowerPoint slide with a key sentence as the title. The supporting sentences were used to write bullet points. Students were surveyed and they said that this technique helped them in "finding keywords and concepts, understanding the author's point, and determining how to organize and evaluate information for a presentation" [9]. This is a creative approach to reading papers in science, although the students were not given an entire paper and the papers were chosen so that the students did not have to deal with technical jargon [9].

Another type of summarizing method was introduced in the literature as KENSHU, the Japanese word for "research understanding" [10]. This method was adapted from a top Japanese national university and involved translation of articles, summarizing, and presenting. The students worked in pairs on science articles with an experimental procedure [10]. Alternatively, students in an Analytical Chemistry class were given prescreened articles and were asked questions about them. The author specifically chose analytical science papers with experimental data. The students reported that these papers helped them with exams and gave them more exposure to scientific literature [11]. Lastly, some articles report the process and benefits of incorporating journal reading into the curriculum to increase interest in the course [12, 13].

2.2. Reading in Other Disciplines' Classrooms

Summarization itself is a reading strategy for increasing comprehension of texts [14]. Friend presents this strategy as having "four defining features: (a) it is short, (b) it tells what is most important to the author, (c) it is written 'in your own words,' and (d) it states the informa- tion 'you need to study'" [15]. Spörer, Brunstein, and Kieschke (2008) taught readers four strategies for increased comprehension: "summarizing, questioning, clarifying, and predicting" [16]. They also reflected on the positive effects of asking students to teach each other. McNamara (2009) expands on these strategies to include: "1) comprehension monitoring, 2) paraphrasing, 3) elaboration, 4) logic or common sense, 5) predictions, and bridging [inference]" [17]. Finally, Liu, Chen, and Chang (2010) reported the use of computer-assisted concept mapping as a technique for increasing reading comprehension with English as a Foreign Language (EFL) students [18].

3. Voyant Software

This paper differs from the literature reviewed above in that it reports on the use of a computer program that generates in minutes a word analysis of an assigned article for students to refer to while reading the article. Voyant software, available free online, analyzes the scientific article or articles and generates a word cloud, a word frequency list, a graph of frequent words, and a presentation of keywords in sentences. Students can quickly see themes and difficult words in context. For students who speak English as a second language, seeing the words in context can be particularly helpful. Using Voyant in this way has not been reported in the literature, but it has been used to analyze medical survey responses [19].

Voyant, which is found at http://www.voyant-tools.org, is a text analysis tool used in the digital humanities. The digital humanities is a new and thriving field which looks for patterns in texts by way of what is called "distant reading." Literary scholar Franco Moretti's view of distant reading is described as "understanding literature not by studying particular texts, but by aggregating and analyzing massive amounts of data" [20]. Voyant is a distant reading tool. There is some controversy in the Humanities with regard to this type of study of large amounts of data made available by the digitization of vast numbers of books [21, 22]. Since participants in this study also had to read the paper, the controversy is avoided. An example of work done with distant reading is Ana Mitric's (2007) essay on "Jane Austen and Civility: A Distant Reading." [23]

In addition to reading scientific papers for research outside the classroom, students must read scientific papers as part of the general chemistry curriculum because they need to use journal articles to write their own research papers. As professional scientists, students will need to read scientific papers for a living. The present study explores whether the Voyant tool will help students become more proficient with reading and summarizing scientific papers.

4. Methods

Voyant analyzes an article cut and pasted from a PDF or HTML document, generating a word cloud, a word frequency list, the printed article, a graph of word frequencies, and the words in their context sentences. The word cloud simply displays words in sizes that represent their relative frequencies within the text of the article. The graph of the word frequencies provides a picture of where the chosen words appear in the article. Finally, the words in their context sentences allow students to see how important words are used in a sentence in the article. These features potentially help students interpret the major themes more quickly based on word frequency. In a study by Dooling and Lachman, they found that students who received the theme before reading a passage had better recall and comprehension of the material [24]. Students can also look up difficult words and see how they are used in various sentences within the article, in order to gain context for the words. However, the program does not change the language

of the sentences to make it easier to interpret. In order for the program to be most useful, it is very important to click on the gear-shaped icon to filter out repetitive words such as "the," "a," and "and." Click on the box for stopwords in English and on the box to apply a stopword list globally. I booked a computer classroom for my students when I introduced Voyant and made sure that all the students were able to get the Voyant analysis to work.

In my experience with General Chemistry I and II students at LaGuardia Community College, I have found that there is a gap between reading the textbook and diving into the literature. For this exploration, fourteen students in the Honors General Chemistry II course in spring 2016 read an article without Voyant, wrote a summary, and answered some survey questions. Next, the students read an article with Voyant, wrote a summary, and answered survey questions. Finally, students read another paper without Voyant, wrote a summary, and answered survey questions. The articles were checked in Microsoft Word for grade level to make sure that they were comparable; the three articles had a Flesch-Kincaid readability grade level of 13.3, 13.4, and 13.5 respectively. Students received a rubric of expectations for each article summary assignment. The surveys were analyzed with thematic coding, that is, searching for common themes in the survey responses.

5. Results and Discussion

5.1. First Article

The first article, summary, and survey were designed to get a baseline estimate of the students' abilities in summarizing articles. The first article was titled "Use of Human Urine Fertilizer in Cultivation of Cabbage (Brassica olera- cea): Impacts on Chemical, Microbial, and Flavor Quality" [25]. This article had a reading level of grade 13.3. Of all the articles, it was probably the easiest because it had fewer unfamiliar scientific terms than the other two articles. I chose an article about cabbage because the other articles are related to cabbage. In particular, red cabbage contains anthocyanins, which are natural dyes that we discussed throughout the course in our research projects. In a survey after the first article summary assignment, I asked the students about their process of crafting the summary. I asked them if creating the summary was difficult, and why or why not. My Honors students achieved a fairly high baseline score of 7.6 points out of 10 for the first summary. Six of the students reported using highlighting as a technique for drawing out the main ideas. Two read the paper and used the Internet to help them with difficult terms. Three mentioned outlining the article. As for the question of difficulty, nine students said the article was not very difficult. One student commented, "It was not that difficult. The article was really interesting to me and so that allowed me to engage it well. Overall thought it was a good fair article." Five students said that the article was difficult. One student compared it to SAT

questions: "Yes, because the article was almost like the passages that are offered in the English section of the SATs and those long passages requires a lot of analysis in order to decipher it into one's own words and understanding. Especially since this article felt more longer." One student used an interesting term—"filtered out"—to describe his process of summarizing. He reported, "It wasn't that very difficult. There was a lot of technical details and the important parts had to be filtered out."

5.2. Second Article

For the second article, which they read with Voyant, the students achieved an average of 8.7 out of 10, which reflected a gain of one point over their average score of 7.6 for the summaries they had written without Voyant. The second article was titled "Anthocyanins Contents, Profiles, and Color Characteristics of Red Cabbage Extracts from Different Cultivars and Maturity Stages" [26]. This article had a reading level of 13.4. In their work with the second article, eight students improved, three students stayed the same, one student did worse, and two students did not hand in the second summary. The students were asked about their process of crafting the summary, whether the process was difficult, whether Voyant had helped in any way and, if yes, in what ways. Eleven students reported that Voyant had helped them write the summary. In general, students suggested that they could find the keywords and focus of the article more quickly: "Voyant helped me get to details faster and easier." The majority of the students found Voyant helpful for the second article, but four students felt that it had not helped them. Some of them preferred their highlighting method over using the software. Some of the students misunderstood and thought I was asking them to use Voyant as a substitute for reading the article: "I did not like not being able to physically read the article. What usually helps me is reading and manually highlighting an article, while also being able to write and scribble notes in the margins. Voyant did help in finding sections quicker but I would not use it alone." None of the students reported that they could write the summary without reading the article in detail. Voyant was not viewed as an effective substitute for reading the article.

5.3. Third Article

Finally, for their summaries of the third article, read without Voyant, the students achieved an average of 8.6 points out of 10. Students gained a point with the use of Voyant, and kept that gain without Voyant for the third article. The third article was titled "Influence of Steviol Glycosides on the Stability of Vitamin C and Anthocyanins" [27]. This article had a grade level of 13.5. For the third article, three students improved, four stayed the same, five did worse, and two did not hand in the summary. The most extensive number of improving students was seen after the second article, but this result could have been due partially to the students becoming more comfortable with the

assignment. Since this was an Honors class, the students were relatively strong readers to start with, having averaged a baseline 7.6 out 10. Some of them had techniques for reading articles that they already felt comfortable with. Regarding the third article, students were asked if they missed Voyant, and four said yes, and eight said no. It was interesting that many of the same students who said that Voyant helped after the second article were convinced they did not need it for the third article. One student said, "No, I did not [miss Voyant]. Although it may have been helpful, I can do just as good without it." One student thought there were too many keywords to sift through: "Voyant was not [used] during crafting the summary because there were too many keywords and it was necessary to read the whole text and understand." Some students did not want to bother with Voyant, if it meant they still had to read the whole article. One student used Voyant for the third article despite my instructions, and said, "Yes, I used Voyant because it gave clear idea of terms mostly used and also separates the main points." Although there was not the same jump in improvement and actually five students did worse with the third article, the students maintained nearly the same average as the second article.

Based on these results, we can conclude that Voyant helped some students with their summaries but was not necessary for the third article. Students made gains with Voyant and kept their gains without Voyant for the third article; by then, the majority felt comfortable without the aid of Voyant. I think that the major benefit of Voyant is that it saves time by distilling the article into keywords and placing those keywords into their context sentences. Some students who are less than experienced readers might not have the persistence to wade through the article to distill those keywords on their own. Less experienced readers might see greater gains than my Honors students. This study also revealed that some students had methods such as highlighting the article, that they felt more comfortable with and preferred.

6. Conclusions

This paper explores whether utilizing Voyant can help students become more independent and proficient scientific readers. Using Voyant to read scientific papers was evaluated by compiling point totals for summaries and analyzing answers to survey questions with thematic coding. A majority of students said that Voyant was helpful for reading the second article, but a majority of students also said they did not need Voyant for the third article. In reading and summarizing the third article, students retained the gains made in reading the first and second articles. Students who are weaker readers might see greater gains than my Honors students. Whether this is so is an important question that I want to explore in future research. In conclusion, student reports found Voyant to be a helpful temporary aid for summarizing research papers.

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