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About the Journal

Founded in 2013, the Journal of Teacher Action Research (ISSN: 2332-2233) is a peer-reviewed online journal indexed with EBSCO that seeks practical research that can be implemented in Pre-Kindergarten through Post-Secondary classrooms. The primary function of this journal is to provide classroom teachers and researchers a means for sharing classroom practices.

The journal accepts articles for peer-review that describe classroom practice which positively impacts student learning. We define teacher action research as teachers (at all levels) studying their practice and/or their students' learning in a methodical way in order to inform classroom practice. Articles submitted to the journal should demonstrate an action research focus with intent to improve the author's practice.

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MAINTAINING SCIENTIFIC LITERACY IN A DIGITAL AGE: THE TRANSITION OF A HIGH SCHOOL BIOLOGY CLASS FROM PAPER TEXTBOOKS TO DIGITAL TEXT RESOURCES

Lisa Catalano Gizas

West Morris Central High School

Abstract At the start of the 2017 school year, administrators at the high school where I am a teacher, implemented a switch from paper textbooks to free, digital resources (that include texts) for all incoming freshmen students. Both my 9th grade on-grade-level Biology students and I unexpectedly found ourselves at the dawn of the Digital Education Age. For me, that meant the elimination of paper textbooks from my curriculum, and therefore the loss of the primary resource I had that students used to practice and develop close technical reading skills. All of the studies that I have read on reading show that students lose literacy when reading on a screen versus paper. However, this paper will describe the journey of my students and me as we developed and implemented digital reading strategies to maintain the level of scientific literacy that former students were capable of reaching through the use of paper textbooks. Most agree that modern education is swiftly moving in the digital direction. This paper is a call to secondary teachers who must recognize that the emphasis on content memorization is diminishing while the emphasis on scientific literacy is expounding, that relying on videos and interactives to teach content ignores the student's need to practice scientific literacy skills, and that teachers of any level or subject must use digital reading strategies to train students to read mindfully in order to combat the significant dip in literacy the digital world presents.

Keywords: teacher action research, textbook, scientific literacy, digital text

Introduction

Although "literacy" is defined as the ability to read and write, "scientific literacy" is defined in part as someone who can "read articles with understanding of science in popular press and engage in social conversation about the validity of conclusions" (National Science

Education Standards, 1996). In this present time period, scientific literacy may be one of the most important skills a person needs to develop in order to have success in their personal life and their career. As Neil deGrasse Tyson states: “Part of what it is to be scientifically-literate, it's not simply, 'Do you know what DNA is? Or what the Big Bang is?' That's an aspect of science literacy. The biggest part of it is do you know how to think about information that's presented in front of you” (Gardinier, 2017). Wolf (2018) noted that traditional paper textbooks were set up to foster thinking, but digital content is not. If members of our society, especially leaders of our society, do not develop the ability to think about information presented to them, then, as Mr. Tyson states, “...you are not a participant in the future of the world” (Gardinier, 2017).

In order to both reduce the annual budget and to justify the district’s 1:1 technology initiative, the Board of Education overseeing the school where I work decided that beginning in the 2017-2018 school year, no new print textbooks would be purchased, and none should be given out to either the freshman or sophomore classes (those with chromebooks). Teachers were instructed to only use digital textbook resources. The Science Supervisor at the district specifically directed science teachers to begin using the CK-12 resource created by the CK-12 Foundation (CK-12 Foundation) and the specific use of the Biology text on that site (Brainard et al., 2017).

I immediately questioned this initiative from a standpoint of scientific literacy. I regularly use many online resources in my classroom as content-specific supplements to the paper textbook and noticed a trend among students to not read any digital articles they were assigned. For example, if I assigned an online article and gave a homework sheet to go along with it, students scanned the questions on the homework sheet and looked for keywords. They used shortcuts, primarily the “find” shortcut (“CTRL + F”), which prompted the computer to scan the entire article for that single keyword. Then, the student just read a few sentences around that keyword to find the answer to the question. More often, students avoided reading the article, and had a difficult time discussing it in class the next day. These kinds of shortcuts were not possible with printed material, and students had been more likely to read their paper textbook and were more successful in discussing what they read when they came to class the next day. My deep concern was that by eliminating the only Board-approved resource I had that promoted scientific literacy and replacing it with something online that is so easily “searchable,” students were going to lose their scientific literacy skills.

And therefore, I have come to the genesis of my question. In this changing educational climate, how could I use the mandated CK-12 online textbook in such a way that scientific literacy was not lost? How could I best use this resource to encourage comprehension of big ideas and overarching concepts? In short, how could I ensure that students are *reading* the entire passage? As many other schools across America are experiencing similar change, I believe this question is on the minds of many teachers, and those at the start of this journey will benefit from my experience.

Literature Review

Traditional Reading Strategies Do Not Translate To Digital Media. In 2007, Wolf published "Proust and the Squid," a history of the science and development of the reading brain from antiquity to the twenty-first century. Her core observation was that "human beings were never born to read," and that reading is not genetically acquired, it is a human invention that must be taught (Wolf, 2007). The responses she received to the book overwhelmingly carried one theme: the more reading moved online, the less students seemed to understand. She explored this theme in her follow-up book, noting that the strategies employed for deep reading, and developing a connection to the material, are not to be found in digital media. She aptly titled this book, "Reader, Come Home," encouraging a return to paper books (Wolf, 2018).

Differences Between Print Text and Digital Text. The following contemporary research echoes Wolf's findings. For example, Anne Mangen's group noted that reading involves the ergonomics and haptics of the medium - the tangibility of paper versus the intangibility of something digital. The screen seemed to encourage more skimming behavior, and people read more quickly (and less deeply) than when paper was used. Online reading with embedded links, videos, and interactives had such an overload of information that people read more quickly (and less deeply) to compensate (Mangen et al., 2013). Ziming Liu (2005) found that on screen, people tended to browse and scan, to look for keywords and to read in a less linear, more selective fashion. However, on paper, readers concentrated more on following the text. Skimming online lead to the inability to stop and draw one's own conclusions. Dyson (2004) described how online readers became fatigued easily by the constant need to filter out hyperlinks and other distractions, and that the eyes themselves became fatigued from the constant shift in screen layouts, colors, and contrasts. From these experts, Konnikova (2014) found digital reading to be superficial and exhausting.

Comparing Comprehension (Paper versus Digital). In my classroom, I was focused on how the newly implemented digital biology textbook would compare to the print one in both comprehension and literacy. Mangen (2013) did a study by asking one group to read a short story on paper, while another group read it digitally. They were then asked to place a series of events from the story in chronological order. The print group fared significantly better than the digital group, leading her to conclude that the physical materiality of the paper resource mattered for basic comprehension.

Attention To Reading Tasks (Paper versus Digital). As far as online resources fostering deep scientific literacy, it may come down to a student's self-control. To read an assignment on paper, a student must monitor themselves only once - to pick up the book and open it. To read an assignment digitally, with so many distractions, the monitoring and self-regulation cycle happens over and over. It is predicted that those students who cannot easily focus their attention will experience diminished levels of comprehension and literacy when reading online (Konnikova, 2014).

Why Is Digital Reading Popular? In my research of the literature, I could not find any counter arguments that would give evidence for digital reading being better for student comprehension. So with expert consensus being that reading digitally is not as beneficial for a student as paper was, why is education trending in this direction? In research done by Wallis (2017), she noted that when students were asked if they read better in print or digital media, they would overwhelmingly respond that they did better in digital media. She found this very odd as her research showed they were not "reading better." Wallis argues that the students are equating “reading better” with “reading faster” and assuming that because they were reading faster that they understood it better.

Digital Reading Strategies. Without having ever learned any digital reading strategies myself, I only thought to apply those which had been successful for me on paper, and which I found to be easily available on the CK-12 website - coded highlighting and annotation. Schwartz (2016) wrote in, “Strategies To Help Students ‘Go Deep’ When Reading Digitally,” ways that students can utilize the tools available in a Google Doc. It is important to note that he makes the students do the work of coded highlighting, annotation, and outline development, rather than using a computer program that will do that for the student (Schwartz, 2016). This is exactly similar to doing what can be done on paper (although not in school-issued books), but was done digitally, and was very effective. For my work here, I aimed to follow Hess’s initiative - use available reading strategies, and make the students do the work when reading.

Methodology

Participants. In the 2017-2018 school year, I was in my sixth year teaching at a small rural, non-diverse public high school in New Jersey. It is one of only 18 public International Baccalaureate World High Schools in New Jersey (Iborganization, 2018). In 2018 the school ranked within the top 20 high schools in New Jersey (Schlager, 2018). I taught three sections of on-grade-level freshman Biology for a total of 58 students, the majority of which had a variety of accommodations for learning differences. All of these students received a chromebook, and this was my first time not assigning a paper textbook to these classes, as per my school board’s decisions.

Question. With the elimination of the paper textbook and the adoption of the digital online textbook, my research question is clear: How could my students and I (as their teacher) use reading strategies in a digital Biology textbook to enhance comprehension while maintaining scientific literacy?

Data Tools. Before looking at the CK-12 site, I sent out a survey to the 140 teachers in the district to gauge their level of comfort in assigning and using digital textbooks. I was hoping to find some respondents who would be able to guide me through my own switch to this new resource. I next set out to survey my sixty incoming freshmen Biology students, to discover whether they preferred print or digital textbooks and to let their responses guide my education and implementation of new digital reading strategies.

I kept a journal throughout the research, and interviewed my supervisor, the CEO of the digital textbook assigned to me, and spent numerous hours with my co-teacher refining the resource and ensuring that the students would have a beneficial reading experience. With daily collaboration and reflection, I was able to develop a reading experience that I felt maximized the skills of scientific literacy.

Finally, I wanted to compare test scores from 2016 (paper textbooks) with 2017 (digital text resources) to ensure that students being given the new digital medium could perform as well on assessments as prior classes.

Results and Discussion

Twenty-seven teachers responded to the teacher survey, representing a roughly equal distribution of grades taught (33.3% 9th grade teachers, 29.6% 10th grade teachers, 22.2% 11th grade teachers, and 14.8% 12th grade teachers). My first question to those teachers was, "Have you replaced your paper textbook with a digital textbook?" The results are shown in Figure 1. This figure indicates that two-thirds of teachers have or will be switching to digital textbooks, while one-third do not plan on doing so now or ever.

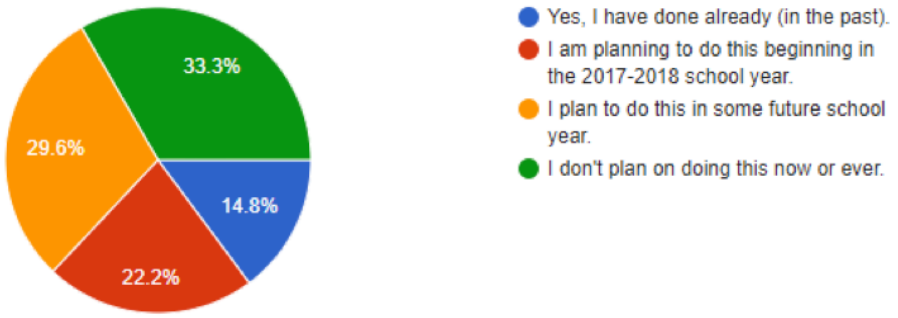

Figure 1: Teacher responses to the question, "Have you replaced your paper textbook with a digital textbook?"

Sixteen teachers responded to the survey that they were switching to digital textbooks that year, as I was, or planning to switch in some future year. I was most interested in the responses from this group. Most in this group responded that they were making the switch because their "supervisor told them to." This group reported that digital textbooks have many advantages including ease of access, interactives, and videos. When asked which medium provides the best level of literacy for students, the majority of this group felt the level of literacy would be the same, no matter which resource is used. Thirty-eight percent of respondents in this group reported that they have no idea what kind of digital reading strategies they should be modeling or teaching. As this was the crux of my research question, I found this incredibly jarring, and an indication that administrators don't fully understand the impact of their decisions on the students, as they aren't adequately

preparing the teachers for actually using the new resource. As a high school Biology teacher, I had never modeled or taught reading strategies, and it appears that most teachers at my high school have not done so either, and certainly not in a digital format. I still believed that being scientifically literate was an essential skill, but I realized I would be navigating the digital reading strategies world without peer support.

Student Preparedness. I surveyed my students before introducing them to the CK-12 textbook resource to be used in this class. The results are shown in Figure 2. This figure indicates that 36.7% of students prefer paper, while 35% preferred digital, and the remaining 28.3% were undecided or do not use textbooks.

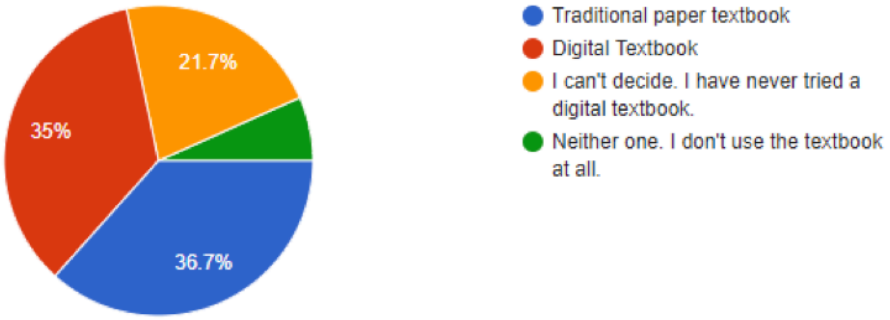

Figure 2: Student responses to the question, "Do you prefer a traditional paper textbook or do you prefer a digital textbook?"

Students were about evenly split between preferring either the paper textbook or the digital textbook. In the group that preferred paper textbooks, one comment was, "I enjoy reading while not using the screen, and turning the pages is just a good feeling, feels more accomplishing when you finish a reading." This group also felt very strongly about their dislike for digital textbooks, commenting "they suck," "because I stink with technology," "technology hates me," and "because I always work better on paper." Many students felt that looking at a computer too long gave them eye strain or a headache. They overwhelmingly felt that they were more scientifically literate when using paper textbooks, and 20 out of 22 students have already been taught and regularly use reading strategies such as highlighting, annotating in the margin, and taking notes with their paper assignments.

In the group that preferred digital textbooks, they responded that, "there is no need to flip page after page after page," "because my backpack cannot fit any more books," and "I've never liked just having one resource to look through, with digital I can look through many different resources and compare." This group did not like paper textbooks because, "they are too heavy and get lost," "it takes forever to find stuff," and "it is really obnoxious and big and it makes me dread wanting to read it." Not surprisingly, this group thought that text presented digitally maximized their scientific literacy, and 16 out of 21 used the same on-paper reading strategies as the previous group.

Armed with the information that I would be making the switch to the CK-12 resource essentially on my own and knowing my students had used reading strategies with paper in the past, I made it my goal to figure out how to best use the CK-12 digital textbook resource to enhance my student's comprehension of Biology content, and enhance their scientific literacy.

Unpacking the Resource: Problems. On September 1, 2017, I began working with the CK-12 resource. The previous year's textbook was the Holt *Biology* textbook (Johnson and Raven, 2004) and lessons can be compared to what is found in the CK-12 resource. If I were to just use the link provided, I find, as I noted in my journal of September 1, 2017, "the link takes me to a web page that contains so much reading that if I were to print it out, it would be 16 pages! There is so much reading, and so many concepts introduced at once, and more depth than I can go into in an on-grade-level class that I think it is too much for my students to handle." This resource bills itself as an on-grade-level resource, but I found that the depth, breadth, and length of this reading was far beyond what my students can handle. In addition, the link provided would allow students to highlight and annotate as they read - but without a CK-12 account, their work would not be saved. And what is the point in that?

A Review of Previous Practice. In my past years as a teacher utilizing paper textbooks, I was able to ensure students were deeply reading the resource by assigning short sections (approximately three pages) to read, and assigning a worksheet of my own design that asked questions about what they had read. The feedback I got from students and other teachers was that the worksheet forced students to slow down and carefully read the textbook. Students who did this work were fully prepared to participate in discussion the following day. After being assigned a digital textbook to use, and reviewing the relevant literature about the lack of scientific literacy with this type of media, I set about to radically change my approach to reading homework.

Unpacking the Resource: Solutions. After about 20 hours of working with the CK-12 resource, I had my first unit ready to assign to the class - text reading only, in chunks, capable of being highlighted, annotated, and saved. I worked with the resource until, to the best of its ability, it would provide the reader with all of the tools necessary to read deeply. I limited the distractions as much as possible by assigning small chunks of text to read. Following the directions on the CK-12 website, I created a digital classroom so that my students could save their digital highlighting and annotations. Unfortunately, this new look meant that it took my students seven clicks to get from our class website out to the CK-12 text reading. It was so confusing my co-teacher made a checklist for the students. On the back of the checklist, I put the coded highlighting key I wanted the students to use: yellow for vocabulary, green for concepts, and blue for examples. One positive aspect is that once the students finish their coded highlighting assignment, the program collates all of the colors at the bottom - creating a vocabulary list, a concepts list, and an examples list. The bad part is that as the teacher on the CK-12 site, I can only see a checkmark when students "Turn In" their reading. I cannot see what they highlighted.

I guided the students through their first reading assignment during class time. Students were able to log on, follow the checklist, and read the selection while highlighting only the relevant information. In my journal, I noted that students who initially preferred a paper textbook were excited that they could highlight because paper textbooks were expected to be returned in the condition they were handed out in, and marking one up was seen as a bonus.

I felt confident enough to ask my students to do this work in the future as a homework assignment. I set up the digital reading sections in advance, and assigned the reading to the students. However, without the resource easily accessible, the percentage of students doing the work started to plummet (see Figure 3). This figure indicates that 95% of students did their "Science Goals" reading assignment, but only 64% completed the "Scientific Investigation" reading assignment.

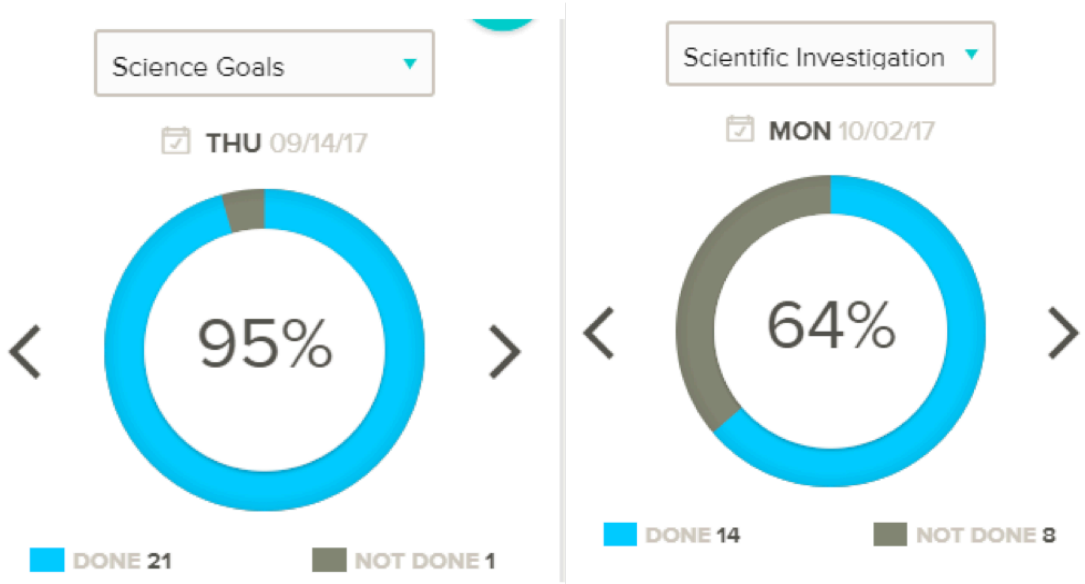

Figure 3: Percent of reading assignments "turned in" for two readings: "Science Goals" and "Scientific Investigation" (CK-12 Foundation).

A way to address this loss of literacy came unexpectedly in November. I was out sick and designed a substitute lesson that could only be completed if the homework reading had been done. When I returned to class, I asked students to fill out an exit pass letting me know if they ran into problems doing the work because of unpreparedness. I found that students were very quick to recognize the role that reading played in their academic success, as they were unable to contribute when unprepared, but more so, they felt the negative emotions from their peers as they were unable to pull their weight in the group activity. Thirty-nine percent of students admitted to not doing their reading, and their responses ranged from the knee-jerk, "I didn't know we were supposed to read the online textbook," to the more deep and reflective, "We didn't use it. But we'll start!"

Final Impressions. I ended my research time with the one piece of data I was most concerned about - student success. In late November, I conducted a survey of my students to see how they felt about their reading skills and ability to be successful in my classroom. At the beginning of the school year, I had asked my students which type of media they preferred for reading, and after three months of using the CK-12 resource, I asked the same question again. Figure 4 shows the responses to both questions. This figure indicates that students preferring to read digitally jumped from 35% in August 2017 to 69.8% in November 2017. Of 34.8% of students not using digital textbooks in August, now preferred them in November.

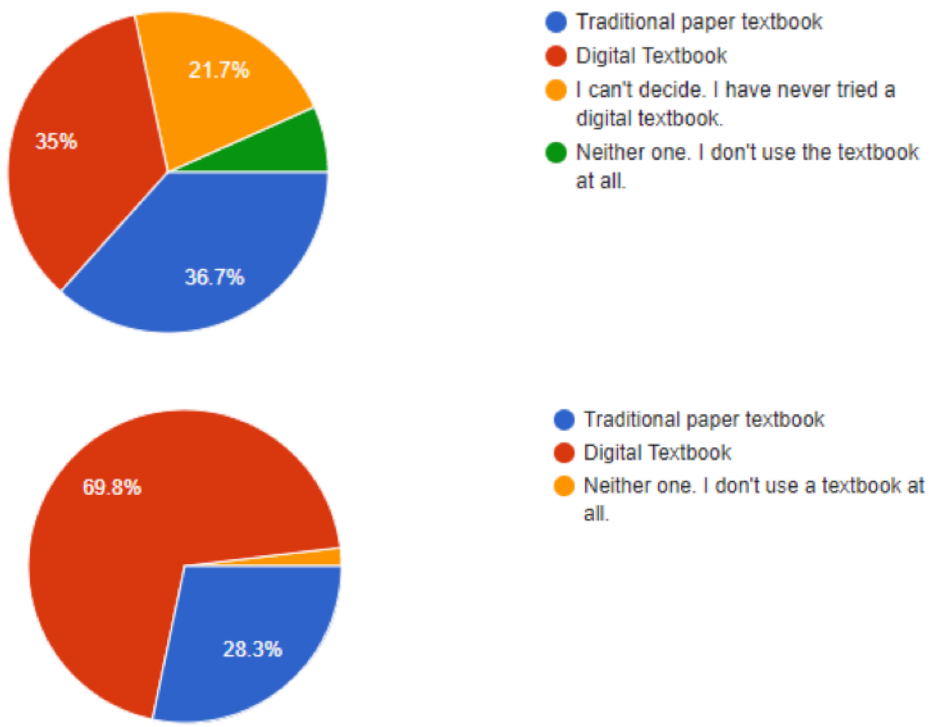

Figure 4: The change in student preference for text reading from August 2017 to November 2017.

The responses indicate that the number of students who preferred a paper textbook to a digital textbook had dropped from 36.7% in August to 28.3% in November, while digital preference nearly doubled from 35% in August to a staggering 69.8% in November. The Chi-Square test for statistical significance was used to evaluate the results and with a X^2 value of 32.52 with one degree of freedom, I can conclude that the differences in these numbers represents a true change in student preference ($p < 0.05$). However, the question was answered based on student preference for text media (i.e., what they thought they liked best). I recalled from Wallis's (2017) research that psychologically students equated reading faster on a screen with reading better, when in reality they were retaining less information than if they had read the same text in print. To explore whether this was happening with my class, I compared my current year students' average test scores across the three tests

that they have taken so far this year with the previous year's student scores. Of course, the unit incorporated lecture notes, activities, experiments, projects, and demonstrations as well, but all resources used were the same as last school year - with the only change being the textbook. The test used was exactly the same. See Tables 1, 2, and 3 for a summary of test scores across three periods of Biology. Table 1 shows that there was no significant difference in the test scores of any period over two years ($p < 0.01$). Table 2 shows that there was no significant difference in the test scores of any period over two years ($p < 0.01$). Table 3 shows that there was no significant difference in the test scores of any period over two years ($p < 0.01$).

Table 1: The average "Themes of Biology" test scores for each period of Biology in two school years (total point value of test equals 80 points).

	Period 1	**Period 2**	**Period 7**
Average Test Score For 2016-2017 School Year (Paper Textbook)	67.5	62.2	65.8
Average Test Score For 2017-2018 School Year (Digital Textbook)	63.3	67.3	76.1

X^2 value = 2.29; df = 2; $p < 0.01$

Table 2: The average "Inorganic Chemistry" test scores for each period of Biology in two school years (total point value of test equals 55 points).

	Period 1	**Period 2**	**Period 7**
Average Test Score For 2016-2017 School Year (Paper Textbook)	43.1	41.4	41.3
Average Test Score For 2017-2018 School Year (Digital Textbook)	39.1	40.8	41

X^2 value = 0.38; df = 2; $p < 0.01$

Table 3: The average "Organic Chemistry" test scores for each period of Biology in two school years (total point value of test equals 70 points).

	Period 1	**Period 2**	**Period 7**
Average Test Score For 2016-2017 School Year (Paper Textbook)	59.2	59.5	54.4
Average Test Score For 2017-2018 School Year (Digital Textbook)	54.5	59.1	53.2

X^2 value = 0.40; df = 2; $p < 0.01$

Here again, the Chi-Square Test of Statistical Significance was used to evaluate the results. On each test, and for each period of Biology, I am confident that there is essentially no difference between the test scores of these two groups. The students' perception of doing well with digital media is accurate - they are doing at least as well as their peers who were taught with a print textbook. There has been no loss of literacy skills in my classroom, despite the switch to digital textbooks.

Figure 4 clearly shows that 34.8% of my students who initially did not feel successful with a digital textbook by November were using the digital textbook effortlessly and felt successful. I wanted to explore some of the reasons that brought about that change. First, I asked the group that preferred the CK-12 resource what it was that they liked about CK-12 that made it better than their previous paper textbooks. Twenty-two out of the thirty respondents in this group chose "highlighting" as the main improvement over paper textbooks, for example writing, "it's easy to get to the article, and the article is all together. no turning pages, no getting lost, easy highlighting, automatic notes. It makes the whole studying process 100X easier, and much faster, and less boring than a traditional one." The other eight students chose different features as being their favorite, which are probably more reflective of their individual learning needs, with one student noting, "I like that if you don't know a word and it is used but there is no definition you can click or hover over it to get the definition," while six more chose the embedded videos and full-color pictures as being their favorites.

Conclusion

I began this work because I was asked to remove the one resource from my classroom that allowed children to learn through the printed word. Paper textbooks were replaced with a digital resource that was heavy on dynamic content and embedded quizzes, but this change proved to be a challenge when trying to assign reading in a meaningful way. To minimize homework time, I eliminated a guided reading sheet as was past practice and stepped outside of my comfort zone spending considerable time researching and implementing

digital reading strategies - strategies that would encourage my students to read deeply and to extract meaning. Limited to only the CK-12 resource, I learned to manipulate the content to assign small reading passages, and coached my students on the techniques of digital coded highlighting and annotation. Their responses indicate that they saw these digital reading strategies as a benefit over paper textbooks, and their test grades indicate that they are performing at least as well as last year's paper textbook users. As a secondary teacher, I never thought I would have to teach literacy in my classroom, but that is just what I must do in order to encourage students to think for themselves and to draw independent conclusions from data presented to them in order to become the best leaders of tomorrow.

The implications of this four-month research project begin where this project leaves off. As I went through this project, it became glaringly obvious that if students are going to be scientifically literate in a digital society, secondary teachers are going to need to be trained to teach digital reading strategies (Shanahan and Shanahan, 2008). It is so easy to turn to a video when a student has difficulty reading, but that is exactly the student who needs the reading practice. Instead of taking the easy way, secondary teachers like myself must commit to learning new digital reading strategies (such as highlighting, annotation, text-to-speech, etc…), and consistently teaching and modeling them for the students until they can be as successful through their digital reading as they once were through paper reading. When reading, belief is suspended while integration of knowledge occurs. When watching videos, belief is automatic. We, as teachers, must encourage students to think for themselves and to draw independent conclusions from data presented to them in order for them to become the best leaders of tomorrow. The question that emerges from this research is, how is it best to teach these strategies in a digital age?

About the Author

Lisa Catalano Gizas is in her seventh year teaching Biology and Advanced Placement Biology at West Morris Central High School in Chester, New Jersey. In this role, she is a four-time winner of the annual BASF Science Education Grant. She graduated from the University of Texas at Austin with a BS in Microbiology, and has earned a MS in Biology from Rutgers University and an MEd in Educational Leadership and Instruction from The College of New Jersey. She has previously worked as a research technologist in the fields of cancer research, neuroscience, and immunochemistry. As an adjunct college professor, she taught Microbiology and Human Biology. She would like to thank Charlie, Maria, and Damian for their support of this action research. Email: lgizas@wmrhsd.org.

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