READING ONLINE MATHEMATICS TEXTBOOKS

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Abstract:

This study explores how students read from an online mathematics textbook. The particular textbook that we are exploring is *Precalculus: Pathways to Calculus,* which was developed at Arizona State University as part of a redesigned precalculus course that focuses on developing students' ability to reason conceptually about functions and quantity. We are interested in understanding the way students read their mathematical textbooks so that research informed activities can be developed and incorporated into online textbooks to increase comprehension and retention. In order to investigate authentic student reading habits as closely as possible, we used nonintrusive screen capture software to measure activities such as scrolling, latency, and browsing, as students completed their regular reading assignments in a study hall setting. Other data sources include brief surveys, assessments and interviews. Interventions include reading instruction and embedded activities with feedback and sequences of hints that are intended to promote deeper engagement with the text.

Introduction

Many would agree that reading is critical for gaining understanding within a discipline, and that students will not reap the full benefits of their studies if they skim through (or worse yet, ignore) their reading assignments. Even in quantitative disciplines such as mathematics, teachers may assign readings from the textbook with the intent of having students come to class more prepared and giving them exposure to more material than can be taught in the time allotted to class meetings. However, few teachers would be so naïve as to believe that students actually read the text, and often complain about the unpreparedness of the students for instruction. On their part, students complain about how hard it is to read mathematics textbooks, perhaps because they lack appropriate reading strategies that might remedy the situation. Indeed, even first-year undergraduate who are good general readers do not read mathematics textbooks well (Shepherd, Selden & Selden, 2009).

One solution to the problem of getting students to read mathematics texts effectively, despite their deeply instilled poor reading habits, is to harness technology. Online mathematics textbooks are a fairly recent (and increasingly popular) addition to the available set of instructional resources. In contrast to physical textbooks, online texts have affordances for interactive and responsive engagement. In particular, online texts can include activities that foster effective reading through embedded tasks that provide feedback and hints. The purpose of this project is to begin to understand how readers interact with an online mathematics textbook in a quasi-authentic setting, and to study the effects of some scaffolded online activities intended to help students monitor their comprehension of what is read.

Literature & Theoretical Perspective

Reading involves both decoding and comprehension. On the comprehension side of the coin, research has identified several strategies that good readers employ as they engage with a

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text (Flood & Lapp, 1990; Palincsar & Brown, 1984; Pressley & Afflerbach, 1995). Of course, these strategies depend on the individual reader, the reader's goals, and the material being read. Mathematics textbooks, in particular, are "closed texts" in the sense that they seek to elicit a well-defined, "precise" response that is not open to differing interpretations from readers (Weinberg & Wiesner, 2011). Yet, many students have not been taught how to read their mathematics textbooks, and do not read them as intended. For instance, authors of mathematics texts include expository material to help students develop a deeper understanding of the mathematical concepts. Yet, despite the fact that an overwhelming percentage of students claim to read their mathematics textbooks for understanding, few students report attempts at reading the expository sections (Weinberg, in press). Our research addresses how students who *are* making an attempt to read their textbooks engage in this process, and how they might be better supported in their endeavors.

Our theoretical perspective is aligned with the view that reading is an active process of meaning-making in which knowledge of language and the world are used to construct and negotiate interpretations of texts (Flood & Lapp, 1990; Palincsar & Brown, 1984; Rosenblatt, 1994). In helping students navigate mathematics texts, we advocate reading strategies that stem from the Constructively Responsive Reading framework (CRR) that was developed in reading comprehension research (Pressley & Afflerbach, 1995). These strategies are intended to help students maximize their construction of knowledge from texts. In addition, we place an emphasis on *cautious reading* (Shepherd, Selden & Selden, under review) that helps students minimize inappropriate interpretations of their mathematics texts by detecting and correcting errors, misunderstandings, and confusions. Taken together, CRR-based strategies and cautious reading advocate encouraging students to carefully read expository text and check the correspondence between the inferences they have drawn and the author's intent, and discouraging students from forging ahead without carrying out and evaluating their performance on tasks provided by the authors.

Motivation, Framework and Research Questions

Standard "online" textbooks from the major textbook publishers look like the printed book. The pages are the same as in the printed version and have active links to videos, demonstrations, and similar problems to examples. The first author has had some experience with this type of online textbook in both a traditional precalculus and college algebra course. When the students were given reading instruction it appeared students were not likely to stop and monitor comprehension by "doing" any of the interactive activities.

The course from which volunteers were drawn uses an online text, *Precalculus: Pathways to Calculus,* which was developed at Arizona State University and was designed to foster students' ability to reason conceptually about functions and quantity (Carlson & Oehrtman, 2009). *Precalculus: Pathways to Calculus* textbook is only online. It does not look like a traditional book put into an online text with pages identical to the printed textbook and added activities. Instead, interspersed with the reading are questions to the students. The questions are asked and then the student is invited to interact with the text, signaled with the following line:

Think about it for a moment and then <u>access this link to see our answers.</u> (See Figure 1)

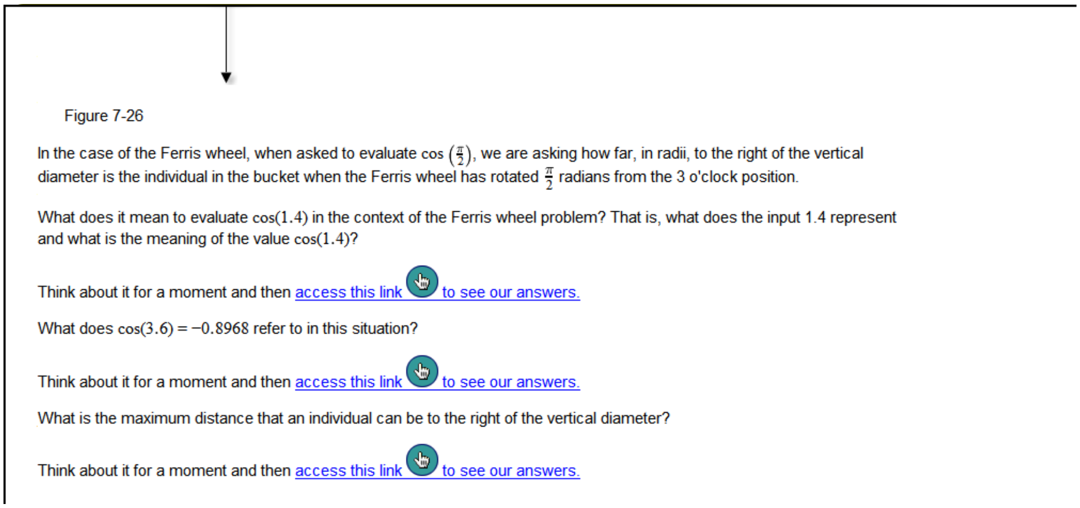


Figure 7-26

In the case of the Ferris wheel, when asked to evaluate $\cos\left(\frac{\pi}{2}\right)$, we are asking how far, in radii, to the right of the vertical diameter is the individual in the bucket when the Ferris wheel has rotated $\frac{\pi}{2}$ radians from the 3 o'clock position.

What does it mean to evaluate $\cos(1.4)$ in the context of the Ferris wheel problem? That is, what does the input 1.4 represent and what is the meaning of the value $\cos(1.4)$?

Think about it for a moment and then access this link to see our answers.

What does $\cos(3.6) = -0.8968$ refer to in this situation?

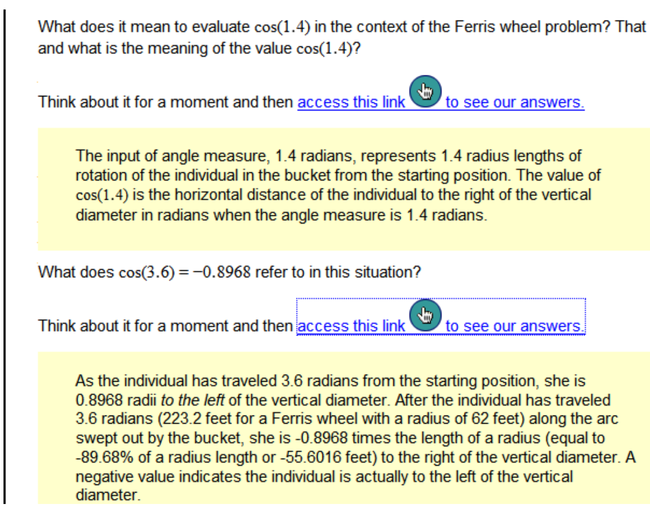
Think about it for a moment and then access this link to see our answers.

What is the maximum distance that an individual can be to the right of the vertical diameter?

Think about it for a moment and then access this link to see our answers.

Figure 1: Example of questions posed to reader in Pathways online precalculus book.

Readers are invited to think about an answer, then open the link that gives a "drop down" box with an explanation. (See Figure 2)



What does it mean to evaluate $\cos(1.4)$ in the context of the Ferris wheel problem? That is, what does the input 1.4 represent and what is the meaning of the value $\cos(1.4)$?

Think about it for a moment and then access this link to see our answers.

The input of angle measure, 1.4 radians, represents 1.4 radius lengths of rotation of the individual in the bucket from the starting position. The value of $\cos(1.4)$ is the horizontal distance of the individual to the right of the vertical diameter in radians when the angle measure is 1.4 radians.

What does $\cos(3.6) = -0.8968$ refer to in this situation?

Think about it for a moment and then access this link to see our answers.

As the individual has traveled 3.6 radians from the starting position, she is 0.8968 radii *to the left* of the vertical diameter. After the individual has traveled 3.6 radians (223.2 feet for a Ferris wheel with a radius of 62 feet) along the arc swept out by the bucket, she is -0.8968 times the length of a radius (equal to -89.68% of a radius length or -55.6016 feet) to the right of the vertical diameter. A negative value indicates the individual is actually to the left of the vertical diameter.

Figure 2: Example of explanations available to students.

These interruptions in reading this particular online textbook lead us to ask some questions.

1. How do students interact with this type of request to engage with the material?
2. Do students interact more with this type of activity request?
3. Does how students engage with these activities help them with self monitoring of understanding?

The questions with drop-down box answers are essentially passive activities—students do not have to do anything to get the answer besides just click to open it. We suspected that students might not engage with these more passive activities as fully as they should. What if we could create active "interruptions" of a similar type? We created several activities of this second type (which we affectionately called "flashlettes") using authoring tools that were developed by the Open Learning Initiative at Carnegie Mellon University. We then were able to insert these activities and created a modified text that was the same except some of the questions with drop down answers were replaced by flashlettes. (See Figure 3 and 4)

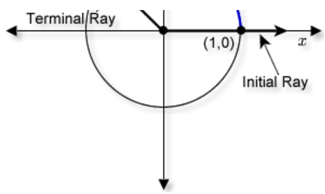


Figure 7-26

In the case of the Ferris wheel, when asked to evaluate $\cos\left(\frac{\pi}{2}\right)$, we are asking how far, in radii, to the right of the vertical diameter is the individual in the bucket when the Ferris wheel has rotated $\frac{\pi}{2}$ radians from the 3 o'clock position.

THE COSINE OF AN ANGLE MEASURED IN RADIANS **Hint**

Now, let's look at a different angle. What does cos(3.6) = -0.8968 refer to in this situation?

a) As the individual has traveled 3.6 radians from the starting position, she is 0.8968 radii *above the horizontal diameter.*

b) As the individual has traveled 3.6 radians from the starting position, she is 0.8968 radii *below the horizontal diameter.*

c) As the individual has traveled 3.6 radians from the starting position, she is 0.8968 radii *to the right of the vertical diameter.*

d) As the individual has traveled 3.6 radians from the starting position, she is 0.8968 radii *to the left of the vertical diameter.*

oli step 2 of 2

Figure 3: Example of a flashlette as it appears in the modified text—matches the second question in Figure 1.

What is the maximum distance that an individual can be to the right of the vertical diameter?

Think about it for a moment and then access this link to see our answers.

EXAMPLE 8. THE FERRIS WHEEL AND THE COSINE FUNCTION

Given that the input of the function $l = g(\theta) = \cos(\theta)$ defines the distance, in radians, the individual has traveled counterclockwise around the Ferris wheel from the 3 o'clock position, how many revolutions has the individual traveled if θ (the angle of rotation of the individual) varies from 0 radians to 5π radians?

Think about it for a moment and then access this link to see our answers.

MEANING OF THE COSINE GRAPH **Hint**

When graphed, what does a point on the graph of $l = g(theta) = cos(theta)$ represent in the context of the Ferris wheel problem above?

a) It represents the **horizontal distance** of the individual **to the right of the vertical diameter** (in radii) as a function of the number of radians the individual has traveled counterclockwise around the circumference of the Ferris wheel from the 3 o'clock position.

b) It represents the **vertical distance** of the individual **above the horizontal diameter** (in radii) as a function of the number of radians the individual has traveled counterclockwise around the circumference of the Ferris wheel from the 3 o'clock position.

oli part 1 of 2 next

Figure 4: Example of a flashlette that shows not all passive activities replaced.

These flashlettes had in addition, scaffolded tasks that provided students not only with right/wrong feedback but also a sequence of hints, progressively leading to a correct response. For instance, the hint sequence, accessed from the green Hint corner, for the activity shown in Figure 3 was:

1. As the individual has traveled 3.6 radians, she will be a certain distance from the

vertical diameter.

2. If the entire circumference of the circle is 2pi or approximately 6.28 radians, then will she be to the left or right of the vertical diameter after traveling 3.6 radians?
3. If she is to the right of the vertical diameter, the value of cos(3.6) will be positive. If she is to the left of the vertical diameter, it will be negative.
4. As the individual has traveled 3.6 radians from the starting position, she is 0.8968 radii to the left of the vertical diameter.

Because we were able to present both the regular online text and a text modified with these more active flashlette interruptions we were able to consider some additional questions:

4. Would students interact differently with the flashlettes?
5. Would the interaction with the flashlettes be more effective in student self monitoring of understanding?

The theoretical framework that we are using for this research is the Constructively Responsive Reading (CRR) framework of Pressley and Afflerback. It is essentially a constuctivist approach to reading for comprehension that has good readers actively engaging with the material read and includes monitoring comprehension and integrating what is read with prior knowledge among other strategies and activities. Observations of students reading their standard mathematics textbooks (Shepherd, Selden & Selden, 2009) leads us to believe most students don't know how to engage effectively as they read mathematics textbooks, when they read them at all. In addition, it does appear that mathematicians do learn how to read and engage with mathematical text—we might call this *cautious reading* and this seems to go beyond the CRR framework.

Our major research questions, thus, are:

- How are students interacting with the Pathways online precalculus text?
- How effective are their apparent reading strategies to the learning of students from this online textbook?

Research Methods

The participants were 36 students enrolled in sections of a redesigned precalculus course at a large southwestern university. The course used the online text, *Precalculus: Pathways to Calculus* (Carlson & Oehrtman, 2009) discussed above. Students were recruited to volunteer for participation in seven Study Hall sessions once weekly of approximately 1.5 hours each. To encourage participation the teachers of the 10 sections using the Pathways curriculum were asked to give participants a small amount of extra credit. Not all 36 students completed all 7 weeks. (See Table1)

Number of students	Number of weeks completed
12	7
7	6
5	5
1	4
3	3

4	2
4	1

Table 1: Number of weeks of participation/number of students

During the Study Hall sessions, students were asked to complete their current reading assignment on the computers provided. Paper for scratch work was provided and collected. Copies were provided to the students if they wanted their scratch work. The students generally read the section(s) to be covered during their next class period. Some teachers were a section or so ahead of other teachers so four of the weeks, students read from different sections based on where they were in their class. (See Table 2.)

Week	Group	Module/Section	Title
1	Both	Mod 4 Sec 6	Logarithms and Solving for Exponents
2	Both	Mod 5 Sec 1 & 2	Example of Polynomials & Exploring Co-varying Quantities Qualitatively
3	A (ahead)	Mod 5 Sec 8 & 9	Exploring the Growth of Power Functions & Quadratic Functions
3	B (behind)	Mod 5 Sec 6 & 7	Evaluating and Interpreting Values of Polynomial Functions & Roots, Maximum Values, Minimum Values and Graphing Polynomial Functions
4	A	Mod 6 Sec 5 & 6	Strategy for Determining Horizontal Asymptotes & Strategy for Determining Vertical Asymptotes
4	B	Mod 6 Sec 3 & 4	Long-run Behavior: Horizontal Asymptotes & Vertical Asymptotes
5	A	Mod 7 Sec 3	The Unit Circle and Trigonometric Functions
5	B	Mod 7 Sec 2	Angles and Their Measures
6	A	Mod 7 Sec 7	Evaluating Trigonometric Functions and Solving Trigonometric Equations
6	B	Mod 7 Sec 5	The Cosine Function
7	Both	Mod 7 Sec 6	Period, Amplitude, and Translations of the Sine and Cosine Functions

Table 2: Material covered by reading each week.

In order to investigate authentic student reading habits as closely as possible, nonintrusive screen capture software was used to measure activities such as scrolling, latency, and browsing. In addition, prior to and following their reading of the text at each Study Hall session, students completed short mathematical assessments (a pre- and a post-test) based on the relevant text material. Other data sources included brief surveys addressing reading habits, and, for most students, admissions testing scores (SAT/ACT) as a control for mathematical and reading preparedness (See Table 3).

	Average Math	Avg Read/Verbal	N

ACT	24.1	24.8	15
SAT	510	535	22

Table 3: SAT/ACT average scores (Seven students had both scores reported.)

Also, half of the participants were randomly assigned during the final four Study Hall sessions to a version of the text in which some of the questions with pop-down solutions (e.g., hidden answers) were replaced with the flashlette activities. Finally, during the last three weeks, a total of 13 students were interviewed as to their reading activities and asked to step the interviewer through what they had done as the read the section of the textbook they read that day.

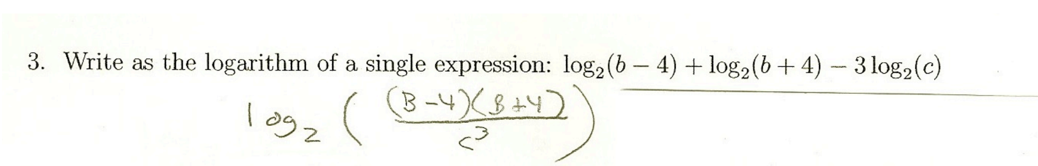
Analysis Methods

We will discuss the analysis started (some complete, some only partially complete) so far related to (1) the pre and post-tests, (2) the screen capture videos, and (3) interviews. Analysis has not yet begun on the initial survey on reading habits or the scratch work.

Pre/Post Tests. The Pre and post tests had from 4 to 12 questions, matched with only numbers or expressions slightly changed. Each question was scored on a 0—4 point scale where:

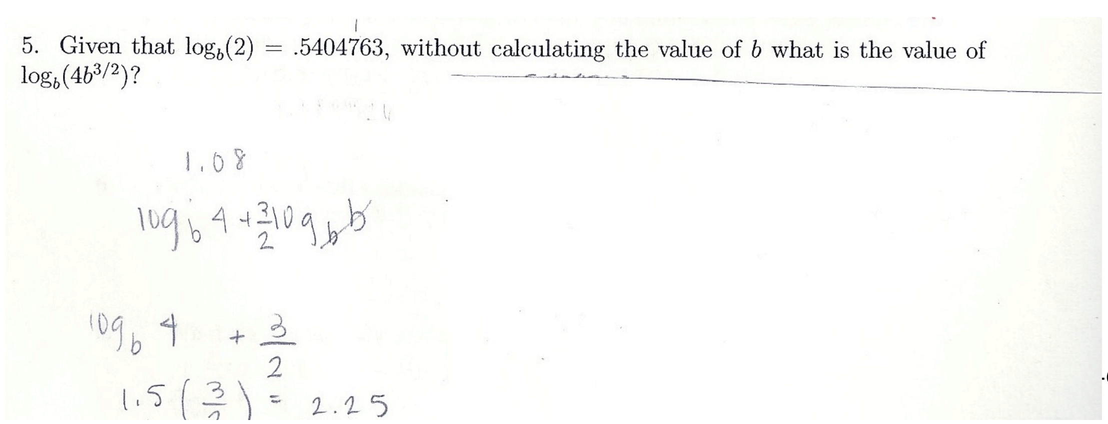
- 0 = no work (or useless work)
- 1 = some work shown, but little understanding (of what was read) demonstrated, incorrect application of material read
- 2 = some work shown and some understanding demonstrated, incorrect/incomplete application
- 3 = work demonstrates minor mistakes, correct understanding of most of what was read.
- 4 = correct work, correct understanding demonstrated

Here are two examples of scoring.


3. Write as the logarithm of a single expression: $\log_2(b-4)+\log_2(b+4)-3\log_2(c)$

$\log_2\left(\frac{(B-4)(B+4)}{c^3}\right)$

The above work received a score of 4.


5. Given that $\log_b(2) = .5404763$, without calculating the value of b what is the value of $\log_b(4b^{3/2})$?

1.08

$\log_b 4+\frac{3}{2}\log_b b$

$\log_b 4 + \frac{3}{2}$

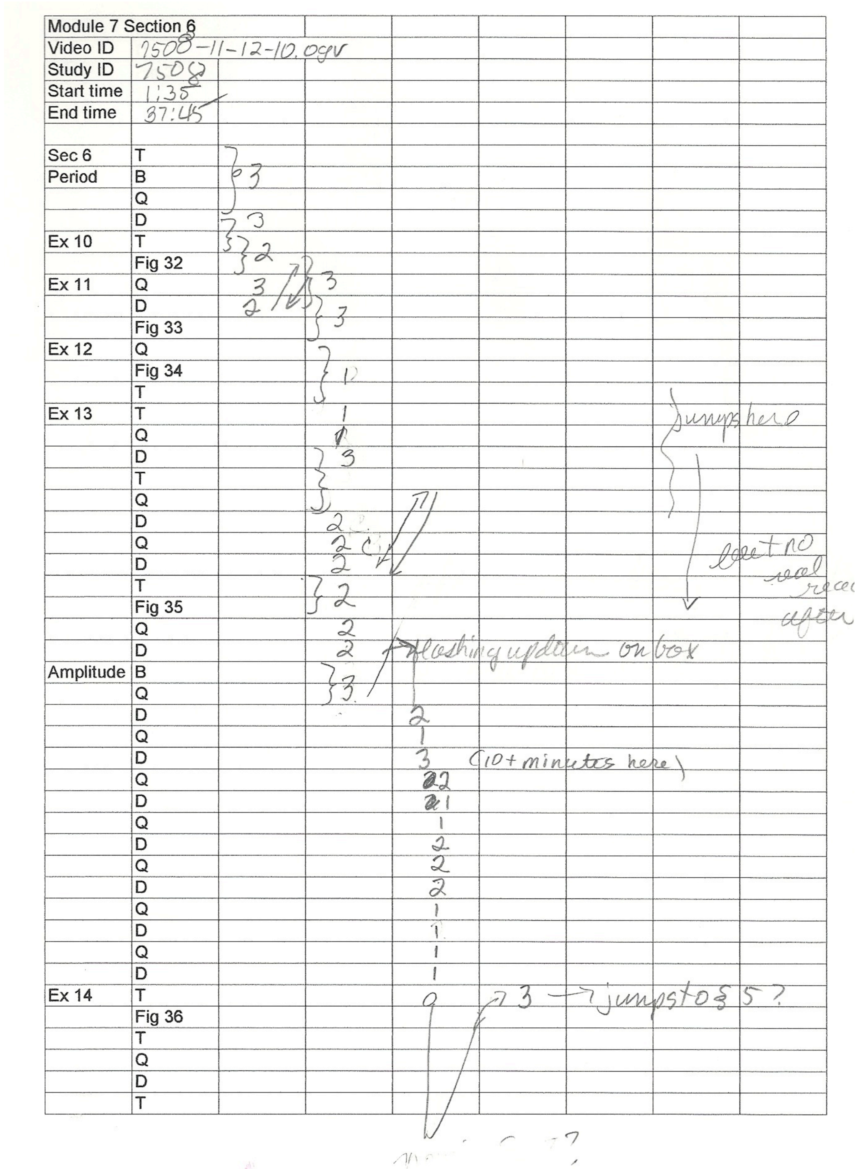
$1.5\left(\frac{3}{2}\right) = 2.25$

The above work received a score of 2.

Screen Capture Video. The goal of the screen capture video was to attempt to record how students actually scrolled through and read the text. In the videos where there were no flashlette activities, each type of object (text, boxed text, figure, question, drop down box for answer) was coded according to the apparent amount of time the student spent on it.

0 = skipped
1 = scrolled quickly through/scanned
2 = scrolled as though reading
3 = long pauses in the scrolling

In addition, if there was cursor movement a “C” was added to the number code. Arrows were used to indicate where students scrolled to in the text. Brackets were used to indicate text on a page when it was difficult to tell where the student’s attention was. An example coding sheet is shown in Figure 4.



Module 7 Section 6				
Video ID	7508-11-12-10.ogv			
Study ID	7508			
Start time	1:35			
End time	37:45			
Sec 6	T			
Period	B	3		
	Q			
	D	3		
Ex 10	T			
	Fig 32	2		
Ex 11	Q	3	3	
	D	2		
	Fig 33		3	
Ex 12	Q			
	Fig 34		1?	
	T			
Ex 13	T		1	jumps here
	Q		1	
	D		3	
	T			
	Q			
	D		2	
	Q		2	
	D		2	
	T		2	
	Fig 35			
	Q		2	
	D		2	flashing update on box
Amplitude	B		3	
	Q			
	D			2
	Q			1
	D			3 (10+ minutes here)
	Q			2
	D			1
	Q			1
	D			2
	Q			2
	D			2
	Q			1
	D			1
	Q			1
	D			1
Ex 14	T			0 → 3 → jumps to § 5?
	Fig 36			
	T			
	Q			
	D			
	T			

Figure 4: Example of coding for video screen capture. Arrows indicate student returning to previously encountered text or scrolling ahead.

Coding on videos where flashlettes appeared contain additional coding as to whether the opened answer was right (R) or wrong (W). (See Figure 5)

Question	2		
Answer	W	W	R
Feedback	1	2	

Figure 5: Example of additional coding for flashlette activities. Here the student

appeared to read the question, chose an incorrect first response (W), skimmed the feedback (1), chose a second incorrect response (W), read the feedback (2), and then chose the correct response (R).

Interviews: Interviews have been summarized but not yet been transcribed. Interesting comments were noted.

Results and Observations

After each reading session the students were asked to complete an After Reading Survey (ARS). One of the questions on this survey was for the student to rate his/her understanding of the section he/she just read. (See Figure 5).

i. 1 = I don't understand anything I just read.
ii. 2 = I understand a little, but not very much.
iii. 3 = I understand about half of what I read.
iv. 4 = I understand most of what I read.
v. 5 = I understand what I read perfectly.

Figure 5: Rating scale students used to rate understanding of material just read.

Not unexpectedly, students' beliefs about their level of understanding were often overestimates. For instance, in Week 4, the pre and post-tests had 6 questions for the section on Long-run Behavior: Horizontal Asymptotes & Vertical Asymptotes. A student had scores of 1,1,0,3,0,0 on the pre-test and 1,1,1,2,1,1 on the post-test yet rated his/her understanding as a 4 indicating the student felt he/she understood most of what he/she read. This is similar to findings by Chi, et al. (1989) that poor students were less aware of not understanding than good students.

If we use the student perception of understanding as a measure of how difficult the students felt the sections were to read/understand, then not all sections read appear to have the same level of difficulty—students "understood" some sections better than others as indicated in Table 4 below.

Looking at the self-rating column there seem to be two distinct categories of understanding. There are 5 sections with ratings of 3.8 or higher (which we might categorize as "easier" for the students feel like they understand), and 6 sections with ratings of 3.1 or lower which we might categorize as "harder" for students to fell like they understood), and no ratings in between. This should be useful feedback to the authors as to which sections students find more difficult to understand.

Module/Section (Week)	Average Self rate understanding	N
M4 S6 (1)	4.3	31
M5 S1&2 (2)	3.8	33
M5 S6&7 (3)	3	8
M5 S8&9 (3)	2.7	1

		9
M6 S3&4 (4)	3.1	9
M6 S5&6 (4)	4.2	1 9
M7 S2 (5)	4.1	7
M7 S3 (5)	3.8	1 7
M7 S5 (6)	2.8	4
M7 S7 (6)	2.7	1 3
M7 S6 (7)	2.9	1 9

Table 4: Student self-rating of understanding by section read

Analyzing the pre- and post-test scores by looking at the change from pre to post score by question we have the data summarized in Table 5 below. The Treatment Group is the group of students that viewed the text with the flashlette activities, the Control Group is the group of students who viewed the text without the flashlette activities during the last four weeks of the study. During the first three weeks of the study, all students viewed the text without flashlettes.

Post – Pre	First 3 weeks (All)		Last 4 Weeks (Control)		Last 4 Weeks (Treatment)	
	Count	Percent	Count	Percent	Count	Percent
+4	24	6.2%	7	3.4%	38	12.0%
+3	38	10.0%	33	15.9%	20	6.3%
+2	41	10.6%	24	11.6%	34	10.8%
+1	89	23.1%	26	12.6%	56	17.7%
0	162	42.1%	92	44.4%	147	46.5%
-1	29	7.5%	17	8.2%	14	4.4%
-2	1	0.3%	3	1.4%	4	1.2%
-3	1	0.3%	5	2.4%	2	0.6%
-4	0	0%	0	0%	1	0.3%

Table 5: Count of numbers of matched pre-/post-test question point improvement

An initial observation is that the reading did not harm the students. Just under 50% of the students in each group showed an increase between pre and post-test scores and over 40% showed no change. No change does not necessarily mean the student made no progress, because a pre and post-test score of 4 (indicating understanding) would have resulted in a zero in the table above. In fact, 63 of the 162 no change scores in the first 3 weeks came from pre and post-test scores of 4. Similarly in the last 4 weeks, 95 of the 239 no change scores came from pre and post-test scores of 4. The percent of questions where the scores dropped is small, and mostly appears in drop of one point. This was mainly due to minor errors where the pre-test and post-test had similar understandings, but the post-test showed a minor calculation error. For example, when the sample scoring example that received 4 points was given above, the post-test for the same person had the following work and received a score of 3 because the final exponent on c should have been 3 instead of 2.

3. Write as the logarithm of a single expression: $\log_2(b-4) - \log_2(b+4) - 3\log_2(c)$

$$\log_2 \frac{(B-4)}{(B+4)c^{2}}$$

There will be more analysis done when these scores are integrated with the screen capture video where we hope to capture some measure of apparent student engagement.

2457-10-22-10.ogv

Module 5 Sections 1 & 2		
Study ID	2457	
Start time	1:~~00~~12	
End time	6:43	
Intro	T	0
Sec 1	T	3
	B	3
Ex 1	Q	3
	D	2c
	T	0
Sec 2	T	2
Ex 2	T	2
	Fig1	2
	Q	2c
	Fig 2	
	D	1
	Fig 3	
Ex 3	T	1
	Fig 4	
	T	2c
	Q	
	Fig 5	
	D	1
	Fig 6	
Ex 4	T	2c
	Fig 7	
	Q	
	Fig 8	
	D	1
	Fig 9	

Figure 6: Example of a coding where a student just reads straight through.

From the screen capture videos, we can see different reading techniques. Some students seem to just read straight through the material. Some students go back frequently to re-read material. Many students scroll to the end of reading apparently to see how much further there was to read. Figure 6 shows what a coding some one more or less reading straight through the material might look like. Figure 7 shows a student going back in the material, rereading or reviewing material previously encountered.

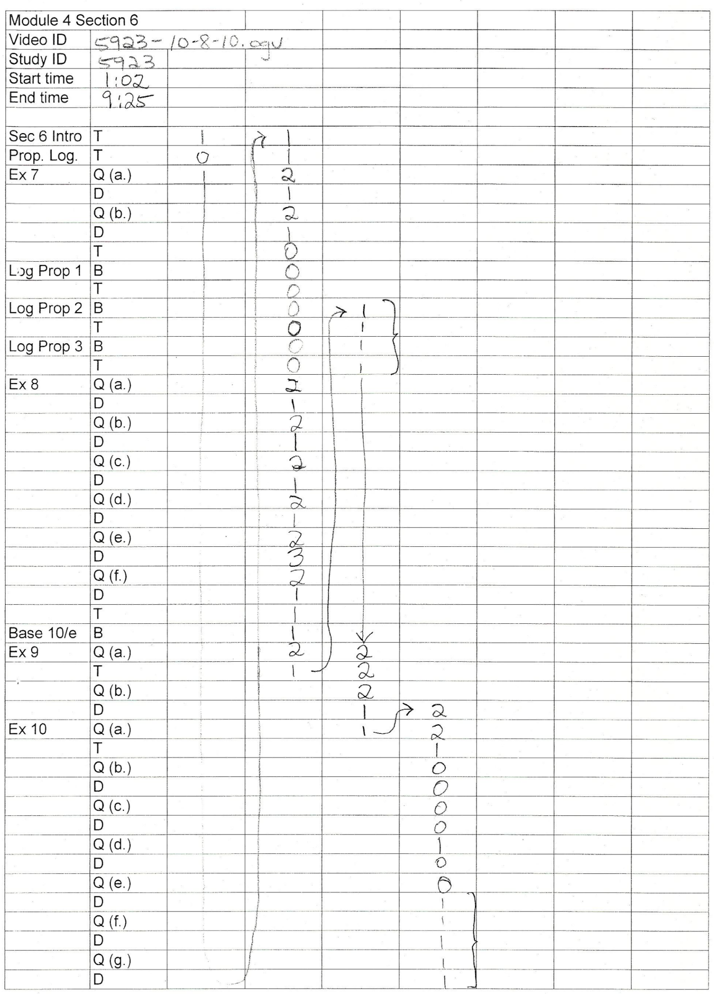


Figure 7: Example of a student who both scrolled to the bottom of the section and went back to re-read a few times.

We have observed that students may read less carefully when they believe they understand the material. Further analysis here is needed. We also believe we will be able to give a rough estimate of how long students are willing to read carefully at a single sitting. In Figure 7 when the student reaches Example 10, the student clearly begins skimming and does not pay close attention to the remaining text or participate in the questions in the text.

There were different approaches to answering flashlettes. So far, using open-ended axial coding (Strauss & Corbin, 1990), five different approaches have been identified, although the actual number of each is still being determined. These are described in Figure 8.

Reading approach	Typical coding

Skipping	Question	0		
	Answer			
	Feedback			
Gaming (guessing at answer until correct)	Question	1-2		
	Answer	W	W	R
	Feedback	0	0	
Got it! (or Lucky Guess)	Question	2		
	Answer	R		
	Feedback	0		
Using Feedback	Question	2		
	Answer	W	W	R
	Feedback	1	2	
Re-reading	Question	2B		
	Answer	R		
	Feedback	1		

Figure 8: Typical codings for the flashlettes

Finally, interviews were conducted with 13 of the students. Five were in the control group, eight were in the treatment. Although the interviews have yet to be transcribed, 12 of the 13 students stated they did not usually read the section before or after it was covered in class, even though each stated that when they did, what went on in class made more sense. Although we wish this were different, it is not different from what happens with standard textbooks.

Maybe the most interesting observation to come from the interviews is that students are quite willing to work, on their own, a calculation type problem (e.g. What is the maximum distance right of the vertical diameter?—see Figure 1), in either the control or treatment group, but questions which required an explanation (e.g. What does it mean to evaluate cos(1.4) in the context of the problem? –see Figure 2) students were unwilling to pause and think about, much less try to formulate an answer. They claimed they usually just opened the answer (in the drop down form), then read back through the response. We hope to quantify this behavior as we complete our analysis of the current data.

We have some preliminary answers to our major research questions. To the

question,
How are students interacting with the Pathways online precalculus text? They are interacting with the text when they read it, but their interaction is still not particularly effective in understanding the concepts covered.

To the question, How effective are their apparent reading strategies to the learning of students from this online textbook? Their strategies are not as helpful as one would hope, but there is hope that in developing activities that will help students work toward more interaction with "explain" type problems, new reading strategies can be developed to help students monitor their understanding better.

Implications for Further Research & Teaching

This research project is a preliminary step for identifying and constructing activities that promote effective reading strategies and that can be embedded in online mathematics textbooks. At this stage, we are restricting our activities to multiple-choice questions. There is a need for research that identifies statistically valid response choices that capture common student errors and ways of thinking so that appropriate sequences of hints can be designed. For instance, certain incorrect answers might be best addressed by posing hints that promote cognitive conflict with that particular way of reasoning.

We would also like to explore how students who rely on embedded scaffolded tasks to read their textbooks effectively can be graduated to the adoption of their own reading strategies that are consistent with reading for understanding. To address this issue, both the timing and manner in which the activities are faded need to be investigated.

Finally, this research has implications for how teachers can connect with the reading aspect of their students' instruction. At present, in order to check whether students have completed a reading assignment, many teachers resort to giving quizzes during (valuable) class time on the relevant material. Online texts can be designed to capture and log student actions, and so provide indicators of whether (and how) students are completing their reading assignments.

Summary

At the heart of our project is the goal of helping students become more effective readers of introductory level mathematics texts. In order to achieve this goal, we are harnessing the affordances of technology, and exploring the ways that activities can be embedded within online textbooks. Although the goal of these activities is to foster reading with understanding, we do not anticipate that they will produce "cautious readers." Instead, our much more modest hope is that we can help students turn over a new page in the way they interact with their textbooks.

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