ASSISTments Interactive Qualifying Project: 2013-2014

A Randomized Controlled Trial Comparing Video versus Text: Video Tutoring in High School Mathematics Assignments Using ASSISTments

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Abstract

The present Interactive Qualifying Project (IQP) performed at the Worcester Polytechnic Institute used the ASSISTments educational software platform to develop high school mathematics problems and tutoring as well as design and perform a randomized study to determine whether students learn better when they are exposed to video tutoring compared to receiving the same tutoring via static text. While most results were statistically insignificant, the trend exists that students who were struggling to understand a topic did benefit more from viewing the video tutoring. From this study we may suggest that video tutoring will benefit students who are struggling with a concept, and text tutoring is more efficient and beneficial to be used as a re-learning tool.

Acknowledgements

We would like to thank our advisors for their invaluable help with the success of this Interactive Qualifying Project. Professor Neil Heffernan was instrumental in helping us understand the data and its trends. Cristina Heffernan guided us through the creation of content within ASSISTments, and the determination of the overall goal of our study, and the design of our randomized study. Lastly, Korinn Ostrow helped us with her experience in creating the ASSISTments content, finding and synthesizing relevant background research, and, extracting our data. Again, we thank you all for making this Interactive Qualifying Project possible.

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Introduction and Background

ASSISTments is a free public service of WPI, where teachers from around the United States, and eventually the world, can assign problems and math skill building sets to their students. The videos used for this study are hosted and played through Youtube.com. However, some schools block Youtube and related video sites, so any embedded videos in the study problem sets may not load properly in these specific schools' settings. Speakers or headphones are also necessary for the videos' information to be clearly expressed. So, if these problem sets were completed in school or using a school computer, there is a greater chance that students were not able to see the videos.

In the motivational video study (Ko and Htet, 2013), students were given problem sets to see if they would work better if they are shown motivational videos after getting a problem wrong in ASSISTments. The final conclusion was that motivational videos had a positive effect on students, helping them to persevere and work to complete their assignments when they would normally give up.

The wheel-spinner study (Beck and Gong) looks into whether students are actually capable of "mastering" the skills that they are practicing in ASSISTments' "skill builders." From the data presented, it appears that students exhibit a learning curve, and approach a point where they never master the skill that they are working on. The beginning of this process occurs around the fourth to sixth problem the students have been exposed to. It is safe to assume that after this mark, students will take a very long time to master the skill if at all.

Main study - Text vs. Screen Capture Video in Scaffold Explanations

This study compares student's mastery when working through problem sets. The control condition receives text-based scaffold tutoring and the experimental condition receives video-based scaffold tutoring. First, students will be given an introductory video to determine if they are capable of receiving video hints, validating a "controlled" experimental structure. This means that if they indicate that they are not able to view videos, they will still perform the exercises, but will not be considered for our study. Then, students will be randomly placed in one of two categories, control or experimental, via Assistments' "ChooseCondition," and will be given those specific problems. The problems for each category will be exactly the same, the only difference will be their tutoring style, text or video. The setup for the problems will be a "scaffold" format, automatically bumping students to the tutoring content if they get the problem wrong. In these problem sets, the complete, problem-specific worked solution will be given in as the tutoring. The students will be randomly assigned to one of the following groups:

- Control Condition - When a student fails to answer a question correctly, a scaffold will appear that provides a text explanation working out the entire problem. The solution to the problem will appear at the bottom of the explanation. (Figure 1.)
- Experiment Condition - When a student fails to answer a question correctly, a scaffold will appear with a video that contains the worked out solution to the problem with the answer being displayed at the end of the video. Subsequent hints are given so that students who are unable to view the video at this point can put in an alternate answer to the question and proceed. (Figure 2.)

The results desired for this study are:

- Fewer instances of tutoring required by the experimental group after watching the video.
- Fewer instances of tutoring required by the experimental group throughout the skill builder after watching a tutoring video.
- Experimental group to develops mastery (3 problems answered correctly in a row) with fewer exercises than the control.
- Data showing significant differences between students who excel in mathematics (high prior knowledge) versus those who do not (low prior knowledge) when placed in either experiment or control conditions.

The following study includes the Assistments problem sets PSAJPW6, PSAJVPW, PSAJVP8, PSAJ4YN, PSAJ4ZU, PSAJ43P, and PSAJEQW. Links to these problem sets can be found in Appendix B.

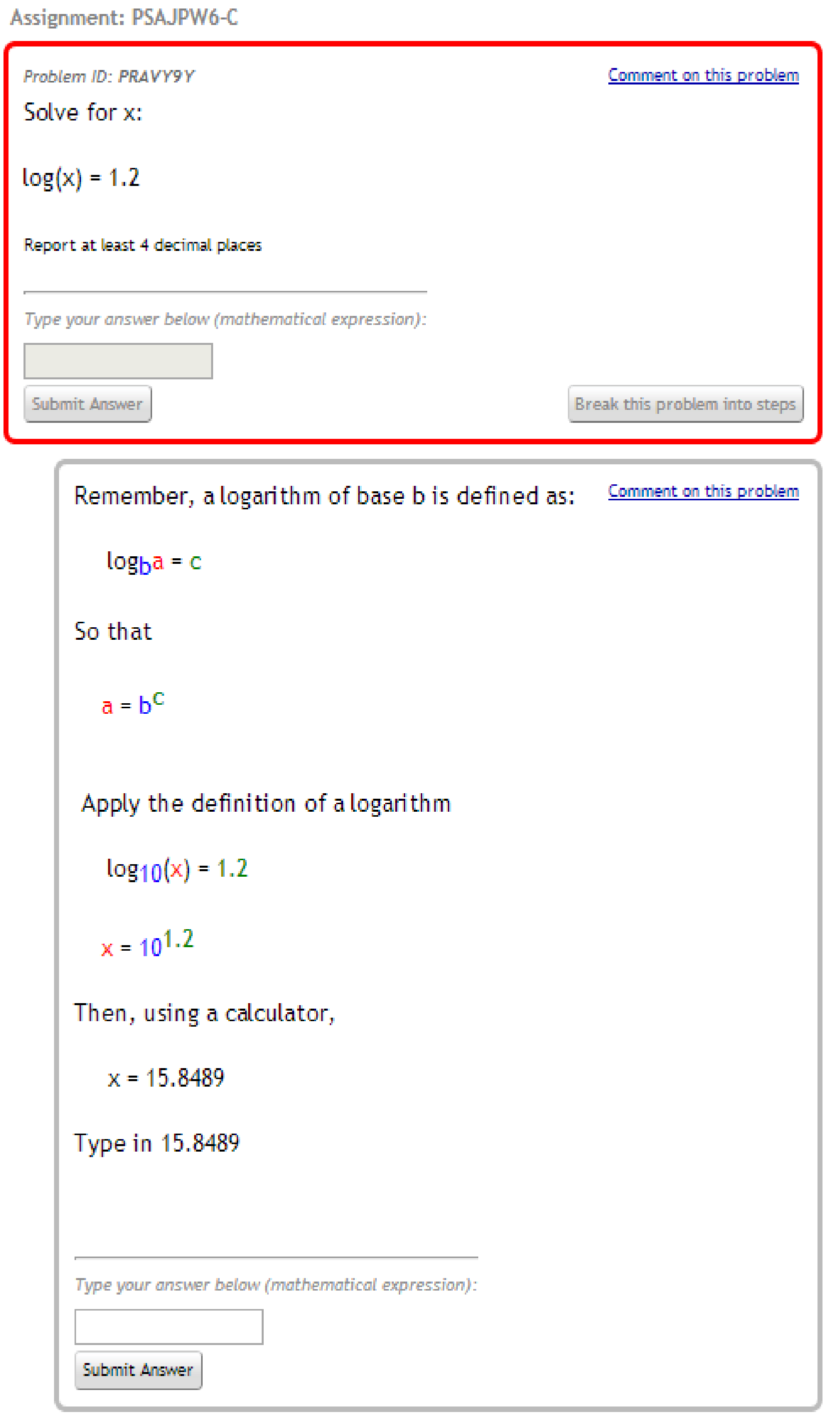

Figure 1. ASSISTments screenshot showing control condition with tutoring

Figure 2. ASSISTments screenshot showing the experimental condition with tutoring. The link to the video is http://youtu.be/ONeX3b8TjjI

Methods

Study Design Methods

In order to determine the effectiveness of video tutoring, we created several problem sets where students would be randomly placed into either the control condition, where the scaffold tutoring given to the students would be text explanations that worked out the solution, or the experimental condition, where the scaffold tutoring given would be screen capture videos that worked out the solution.

The first step to creating these problem sets was determining the topics to use for subject matter. Because these problem sets were designed to be used by high school teachers for their classes and homeworks, we designed each of our problem sets to cover one of the Common Core Standards. The chosen standards were based on whether or not the problems pertaining to the standard could be easily variablized in ASSISTments. The following standards were chosen for our study (the ASSISTments problem set ID for each standard is in parentheses):

- HSF-TF.A.2 - Equivalent Angles (PSAJEQW)
- HSF-TF.A.1 - Converting Between Radians and Degrees (PSAJ43P)
- HSF-BF.A.1c - Composition of Functions (PSAJ4YN)
- HSF-BF.A.2 - Sequences (PSAJ4ZU)
- HSF-LE.A.4a - Solving a*b^(ct) (PSAJVP8)
- HSF-BF.B.5 - Basic Logarithm Manipulation (PSAJPW6)
- HSF-BF.B.5 - Intermediate Logarithm Manipulation (PSAJVPW)

After the standards were chosen, we built a problem set for each standard. To begin each problem set, we built multiple variablized templates that could generate the appropriate problems for each standard. By using these templates, we were able to ensure that the problems within the problem set were consistent. In addition, these templates made it easier for us to generate large sets of unique problems.

Then we generated our problem sets using the templates that we created. For each set, we generated one hundred unique problems. Within each problem set, the number of problems generated by each different template associated with the set were roughly equal. This created base problem sets with one hundred problems each. These were used as a framework for our study's problem sets.

The first issue for us was to determine how we were going to separate the control and the experiment group. According to the wheel-spinner study (Beck and Gong), students were most likely to develop mastery during the first six problems. If students did not master the skill in the first six problems, they were more likely to do a large number of problems before succeeding or give up entirely. Using this information, we decided that we only needed to separate students into the experimental and control condition during the first six problems of the problem set.

The next step was to create the videos that would be used in the problem sets. For each set, we chose six problems that would include screen capture video explanations in the scaffold tutoring. These problems were chosen so there was a roughly equal number of different problem types/template styles containing video explanations.

Screen capture videos were recorded using a touch-screen computer monitor with a built-in stylus for writing on-screen and a microphone to record voice. Videos were recorded using Camtasia Recorder 8 software, and edited and produced by Camtasia Studio 8. Videos were scripted and edited to maintain brevity. The produced videos were then uploaded to Youtube.

After the videos were recorded, edited, and uploaded, we moved on to creating the study problem sets. In order to separate students into either the control or the experiment group, the problem sets were created so that students would be randomly placed into one of two problem sets via ASSISTments' "ChooseCondition". One of these problem sets contains the problems with screen capture videos as explanations, while the other contained problems with normal text-based scaffold hints. The tutoring videos were embedded in the first portion of the scaffold, mirroring the text in the control problems.

In order to maintain consistency between the experiment and the control, a fixed order was determined for the first sixteen problems. The first six problems for each problem set were exactly the same, with the exception that the experimental group got video explanations as hints, while the control group got normal text explanations. After that, the next ten problems for each set were exactly the same, including the explanations. This was done because the students were already past the point where explanations were helpful to them, but they were still capable of obtaining mastery without needing help. After the first sixteen, all remaining problems were placed in a random order, since students who were still working on the problem set were unlikely to get any benefit from further tutoring.

In addition to the normal problems, each problem set began with an intro video that asked the students to input “WPI” as an answer. If they couldn’t view the video for whatever reason, they were instructed to input “Worcester Polytechnic Institute” (Figure 3). This was done so that we would be able to identify students who were unable to watch video while completing the assignment. A similar strategy was implemented with the rest of our problems that contained video.

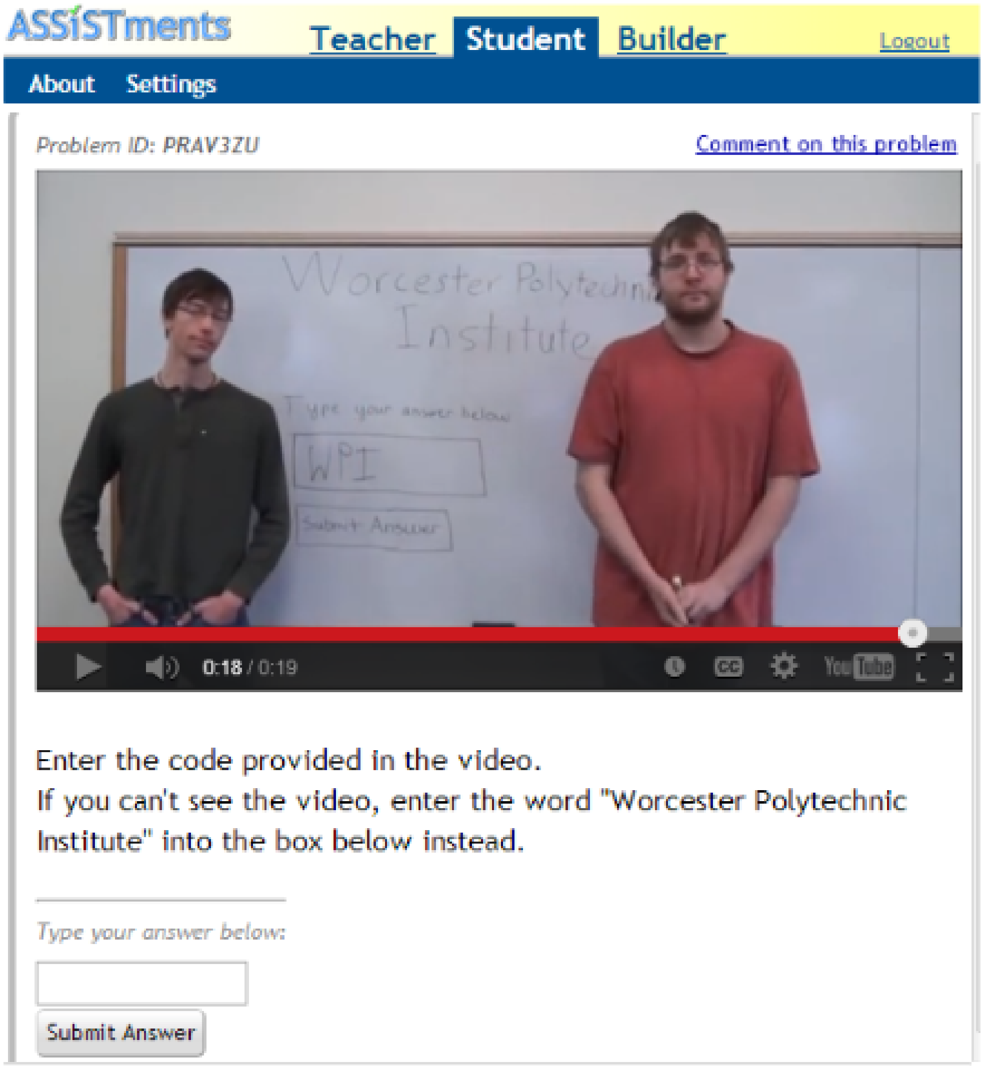

Figure 3. Screen image of the introductory problem

Data Analysis Methods

To gather data for this study, high school teachers that were in the process of teaching one of the above standards were asked to assign the problem sets to their students. This way, the participants in the study would have motivation to complete it, and the problem sets would be the appropriate difficulty for the students who were completing them.

Data was gathered using an SQL query of the ASSISTments' database. This query compiled all of its data into a log file which we were then able to manipulate and store in a tabular format in Microsoft Excel. In this form, the Excel data includes assignment ID numbers, individual student names and ID numbers, prior percent correct for each specific student, problem ID and name, correct answer acknowledgement, actual answer entered, number and type of each hint used, and the start and end times for each problem.

For our analysis, we processed the data further by reporting the condition the student was placed into, whether a student completed the assignment, if they tested out of the assignment (first 3 problems correct), and what their prior knowledge level was.

To figure out what condition the student was placed into, we compared the student's problem ID to the problem ID's for each condition in that specific problem set. The video problem set had one specific ID while the text problem set had a different one.

To determine whether a student completed an assignment and if they saw the intro video, we looked at their answer history. If they got 3 problems correct in a row by the end of their session, they completed the assignment. If the students did not get 3 problems correct in a row by the end of their session, they did not technically complete the problem set.

To calculate the students' prior knowledge level, we took the median of all the students' prior percent correct values. We compared each student's personal prior percent correct value to this median, if it was smaller than the median, they were considered to be of low knowledge, and if it was higher than the median, they were considered to be of high knowledge.

Results

Student Details

Table 1. shows a summary of the number of students included in each study and in each condition. We also show here the effects of disregarding some students, namely, those students who tested out of the assignment and who could not see videos. Throughout most of the analysis we will only consider students who received tutoring (not tested out and indicated that they did see videos)

Problem Set	Condition	Total number of instances	Number of students not tested out	Students not tested out who saw videos (received tutoring)
Basic Logarithm Manipulation PSAJPW6	Experiment	96	63	48
	Control	102	58	41
Intermediate Log. Manipulation PSAJPW6	Experiment	45	39	33
	Control	51	43	35
Solving ab^ct = d PSAJVP8	Experiment	66	51	41
	Control	60	45	37
Understanding Sequences PSAJ4ZU	Experiment	45	45	43
	Control	42	40	31
Composition of Functions PSAJ4YN	Experiment	108	56	47
	Control	123	66	59
Extending Trig Domain PSAJEQW	Experiment	10	9	7
	Control	9	9	6
Understanding Radians PSAJ43V	Experiment	51	50	46
	Control	62	62	55

Table 1. Number of students in each problem set and condition

Problem Set Difficulty

In Table 2. we show three measures of relative problem set difficulty in order to determine if each problem set is equal in its intellectual challenge to students. By reporting the average completion of all students, the median student prior knowledge and the percentage of students who tested out for each problem set, we will be able to interpret the student performance on each problem set accordingly.

Problem Set	Avg. Completion, Includes all students	Median Student Prior Knowledge	Percentage of students who tested out	Relative problem set difficulty
Basic Logarithm Manipulation PSAJPW6	0.892	0.752	0.389	Easy
Intermediate Logarithm Manipulation PSAJPW6	0.767	0.719	0.146	Medium
Solving ab^ct = d PSAJVP8	0.840	0.793	0.238	Easy
Understanding Sequences PSAJ4ZU	0.143	0.648	0.018	Very difficult
Composition of Functions PSAJ4YN	0.836	0.691	0.472	Easy
Extending Trig Domain PSAJEQW	0.810	0.749	0.053*[1]	Medium
Understanding Radians PSAJ43V	0.891	0.703	0.009*[2]	Easy

Table 2. Measures of relative problem set difficulty

*[1] The Extending Trig Domain problem set PSAJEQW data had a very small number of students assigned, and one anonymous student commented saying "This is not what we are covering in class right now…" Both of which are possible reasons why students did not test out as often as others.

*[2] Due to a mistake in the Understanding Radians PSAJ43V problem sets, one problem caused the correct rounded number to be marked incorrect. As this problem was in the first three problems it became very difficult to test out (get the first three problems correct without using any tutoring). This explains the very low percentage of students who tested out of the assignment even though most of them went on to complete the assignment.

Main study bulk analysis

Main study completion rates

The analysis of completion rates for the students in each problem set are presented in Table 3. We expected that the experimental condition would have a higher average of students who completed the assignment. The analysis only includes students who received tutoring (did not test out and did see videos).

Problem Set	Experimental Average Completion	Control Average Completion	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	0.938	0.762	89	0.008	0.409
Intermediate Logarithm Manipulation PSAJPW6	0.848	0.771	68	0.213	0.184
Solving ab^ct = d PSAJVP8	0.762	0.744	78	0.397	0.041
Understanding Sequences PSAJ4ZU	0.163	0.097	74	0.210	0.223
Composition of Functions PSAJ4YN	0.617	0.712	106	0.153	-0.209
Extending Trig Domain PSAJEQW	1	0.75	13	0.091	(No applicable distribution from Experiment Value)
Understanding Radians PSAJ43V	0.938	0.947	101	0.412	-0.043
All assignments combined (Individuals can appear multiple times)	0.714	0.717	374	0.446	-0.008
Problem set avgs. combined	0.752	0.683	7	0.327	0.276

Table 3. Average completion rate analysis

Main study attempt count

Analysis of the attempt count shows the number of answers a student enters for a given problem set. We expect the experimental condition to use fewer attempts to complete the assignment than the control condition. Because we are trying to capture student learning, and not student motivation, in this analysis we have only considered students who have completed the assignment. We also exclude students who tested out of the assignment and did not see videos.

Problem Set	Experimental average attempt count per student. Includes those who did not test out, did see video and completed the assignment.	Control average attempt count per student. Includes those who did not test out, did see video, and completed the assignment.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	9.44	10.8	76	0.156	0.219
Intermediate Logarithm Manipulation PSAJPW6	10.4	13.5	55	0.081	0.338
Solving ab^ct = d PSAJVP8	8.03	13.1	57	0.002	0.638
Understanding Sequences PSAJ4ZU	8.86	9	10	0.486	0.038
Composition of Functions PSAJ4YN	6.59	7.90	71	0.067	0.304
Extending Trig Domain PSAJEQW	12	9.5	11	0.121	-2.236
Understanding Radians PSAJ43V	14.2	11.75	95	0.100	-0.371
All students combined	10.04787	11.0534759	375	0.087143	0.14595
Problem set avgs. combined	9.93	10.8	7	0.252	0.440

Table 4. Average attempt count per student analysis

Main study time until first action per problem

A student's first response time measures the time from when they open the problem to the time when they enter an answer. We expect students in the experimental condition to have longer first response times because as most of the videos are longer than 30 seconds, it is usually faster to skim the text hint than to view the entire video. Because some students started a problem and did not finish it in the same session, there are very large times for some problems. To protect the average from these outliers we assumed that any values larger than 5 minutes were probably due to students not completing the problem in the same session. Therefore, for any values of first response time larger than 5 minutes, we considered them in our averages as equal to 5 minutes. This analysis only considers students who received tutoring.

Problem Set	Experimental average time to first response per problem. (seconds)	Control average time to first response per problem. (seconds).	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	59.4	50.7	89	0.081	0.294
Intermediate Log. Manipulation PSAJPW6	82.6	73.5	68	0.173	0.246
Solving ab^ct = d PSAJVP8	85.3	81.9	77	0.381	0.075
Understanding Sequences PSAJ4ZU	80.1	78.9	74	0.443	0.034
Composition of Functions PSAJ4YN	97.3	96.2	106	0.460	0.020
Extending Trig Domain PSAJEQW	50.7	36.3	13	0.088	1.125
Understanding Radians PSAJ43V	60.4	54.3	101	0.108	0.293
All problems combined	76.3	72.0	528	0.118	0.103
Problem set avgs. combined	73.7	67.4	7	0.274	0.324

Table 5. Time until first response per problem analysis

High vs. Low Prior Knowledge Analysis

Main study completion rate: low prior knowledge

The following analysis considers low prior knowledge students who received tutoring. We expected these students to have a high average completion rate when placed in the experimental condition.

Problem Set	Experimental average. completion. Includes those who did not test out and did see video.	Control average. completion. Includes those who did not test out and did see video.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	0.917	0.619	45	0.008	0.613
Intermediate Logarithm Manipulation PSAJPW6	0.941	0.625	33	0.013	0.653
Solving ab^ct = d PSAJVP8	0.682	0.652	42	0.377	0.061
Understanding Sequences PSAJ4ZU	0.091	0.133	37	0.347	-0.125
Composition of Functions PSAJ4YN	0.571	0.564	74	0.475	0.015
Extending Trig Domain PSAJEQW	0.6	1	7	0.102	(No applicable distribution from Experiment Value)
Understanding Radians PSAJ43V	0.917	0.889	49	0.410	0.088
All assignments combined	0.671	0.618	287	0.193	0.109
Problem set avgs. combined	0.757	0.715	7	0.496	0.160

Table 6. Average completion rate analysis for low prior knowledge students

Main study completion rate: high prior knowledge

The following analysis considers high prior knowledge students who received tutoring. We expected these students to have a high average completion rate when placed in the experimental condition.

Problem Set	Experimental Avg. time. Includes those who did not test out and did see video.	Control Avg. time. Includes those who did not test out and did see video.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	0.957	0.895	41	0.211	0.197
Intermediate Logarithm Manipulation PSAJPW6	0.714	0.895	33	0.098	-0.588
Solving ab^ct = d PSAJVP8	0.85	0.846	33	0.488	0.0107
Understanding Sequences PSAJ4ZU	0.238	0.063	37	0.080	0.725
Composition of Functions PSAJ4YN	0.75	1	32	0.009	(No applicable distribution from Control Value)
Extending Trig Domain PSAJEQW	1	1	6	(No applicable distribution)	(No applicable distribution)
Understanding Radians PSAJ43V	0.958	1	51	0.147	(No applicable distribution from Control Value)
All students combined	0.761	0.824	233	0.010	-0.163
Problem set avgs. combined	0.840	0.870	7	0.478	-0.105

Table 7. Average completion rate analysis for high prior knowledge students

Main study attempt count to completion: low prior knowledge

The following analysis considers low prior knowledge students who received tutoring. We expected these students to have a lower attempt count until completion when placed in the experimental condition.

Problem Set	Experimental Attempt count. Includes those who did not test out and did see video.	Control Attempt count. Includes those who did not test out and did see video.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	10.8	14.5	35	0.076	0.488
Intermediate Logarithm Manipulation PSAJPW6	12.8	15.3	26	0.253	0.224
Solving ab^ct = d PSAJVP8	7.93	17.3	27	0.001	1.08
Understanding Sequences PSAJ4ZU	5	6.5	4	0.246	1
Composition of Functions PSAJ4YN	6.7	8.27	42	0.086	0.344
Extending Trig Domain PSAJEQW	14	9.33	5	0.193	-3.74
Understanding Radians PSAJ43V	18.1	12.5	44	0.046	-0.964
All students combined	11.3	12.5	183	0.172	0.154
Problem set avgs. combined	10.8	12.0	7	0.279	0.345

Table 8. Average attempt count per student analysis for low prior knowledge students

Main study attempt count to completion: high prior knowledge

The following analysis considers high prior knowledge students who received tutoring. We expected these students to have a lower attempt count until completion when placed in the experimental condition.

Problem Set	Experimental Attempt count. Includes those who did not test out and did see video.	Control Attempt count. Includes those who did not test out and did see video.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	8.32	8.44	38	0.446	0.044
Intermediate Logarithm Manipulation PSAJPW6	7.4	12.4	27	0.029	0.441
Solving ab^ct = d PSAJVP8	8.12	9.7	27	0.213	0.182
Understanding Sequences PSAJ4ZU	10.4	14	6	No distribution in control	No distribution in control
Composition of Functions PSAJ4YN	6.33	7.5	29	0.213	0.289
Extending Trig Domain PSAJEQW	10.7	9.67	6	0.208	-1.06
Understanding Radians PSAJ43V	10.8	11.3	50	0.391	0.094
All students combined	8.81	10.0	183	0.163	0.208
Problem set avgs. combined	8.86	10.4	7	0.064	0.797

Table 9. Average attempt count per student analysis for high prior knowledge students

Main study time until first action: low prior knowledge

The following analysis considers low prior knowledge students who received tutoring. We expected these students to have a higher time until first action when placed in the experimental condition.

Problem Set	Experimental Avg. time. Includes those who did not test out and did see video.	Control Avg. time. Includes those who did not test out and did see video.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	58.6	48.4	45	0.102	0.387
Intermediate Logarithm Manipulation PSAJPW6	87.8	71.0	33	0.136	0.408
Solving ab^ct = d PSAJVP8	80.3	74.8	42	0.340	0.131
Understanding Sequences PSAJ4ZU	80.7	97.2	37	0.062	-0.486
Composition of Functions PSAJ4YN	102	112	73	0.208	-0.188
Extending Trig Domain PSAJEQW	43.5	36.5	7	0.337	1.00
Understanding Radians PSAJ43V	56.1	52.0	49	0.244	0.216
All students combined	77.1	76.8	287	0.471	0.008
Problem set avgs. combined	73.3	71.1	7	0.425	0.089

Table 10. Time until first response per problem analysis for low prior knowledge students

Main study time until first action: high prior knowledge

The following analysis considers high prior knowledge students who received tutoring. We expected these students to have a higher time until first action when placed in the experimental condition.

Problem Set	Experimental Avg. time. Includes those who did not test out and did see video.	Control Avg. time. Includes those who did not test out and did see video.	n	P value	Effect Size
Basic Logarithm Manipulation PSAJPW6	59.0	51.7	41	0.244	0.213
Intermediate Logarithm Manipulation PSAJPW6	78.4	75.6	33	0.417	0.085
Solving ab^ct = d PSAJVP8	90.5	84.1	32	0.377	0.136
Understanding Sequences PSAJ4ZU	87.0	67.2	37	0.059	0.614
Composition of Functions PSAJ4YN	83.1	69.0	32	0.216	0.342
Extending Trig Domain PSAJEQW	60.2	36.0	6	0.064	1.45
Understanding Radians PSAJ43V	64.3	57.2	51	0.181	0.325
All students combined	65.1	76.6	232	0.026	0.322
Problem set avgs. combined	74.6	63.0	7	0.082	0.784

Table 11. Time until first response per problem analysis for high prior knowledge students

Using multiple student instances as a post-test

Throughout the study, there were many students who completed both the Basic Logarithm Manipulation problem set and the Intermediate Logarithm Manipulation problem set. Since the titles and the content is sequential, we are assuming that the teachers assigned Basic Logarithm Manipulation before Intermediate Logarithm Manipulation. The difference between the two problem sets is that in the Intermediate Logarithm problem set, the students must simply multiply or divide by a constant before finding the correct answer. With the similarity between the two problem sets, we can use the Intermediate Logarithm Manipulation problem set as a post-test. To perform this analysis, we selected all of the students present in both problem sets. Then, the analysis compares the average percent correct on the first problem in the Intermediate Logarithm Manipulation problem set for students in each condition of the Basic Logarithm Manipulation. The following table compares the two conditions' performance on the post-test.

Average percent correct on first problem in post-test, experimental condition	Average percent correct on first problem in post-test, control condition	n	P value	Effect Size
0.35	0.243	82	0.156	0.249

Table 12. Post-test analysis comparing Basic and Intermediate Logarithm Manipulation problem sets

Students placed in both conditions

Over the course of the study, twelve students were placed into both a control condition and an experimental condition. In our attempts to find that tutoring videos help students learn, we analysed these twelve students separately to determine if there was significant difference between the control and experimental conditions. Six of these students had a higher completion rate in the control condition and six students had a higher completion rate in the experimental condition.

Experiment average. completion of students in both conditions	Control average completion of students in both conditions	n	P value	Effect Size
0.604	0.583	12	0.445	0.059

Table 13. Analysis of students placed in both conditions throughout the study

Discussion and Conclusions

It appears that most of the data does not clearly support the original hypotheses. Some were supported, but only by some problem sets, while others were neutrally supported, and others still, showed an inverse effect on students.

For example, as shown in Table 3, the two “logarithmic manipulation” problem set students had a higher completion rate when they saw the video solutions as compared to text solutions. However, in the “understanding radians” problem sets, students had a higher completion rate when they saw just the text-based solutions.

In the students’ problem attempt count analysis (Table 4), students who were placed in the experimental condition attempted fewer problems before they reached “mastery” status. While again, the “understanding radians” and the “extending trigonometric domains” problem sets showed students reaching “mastery” with fewer attempts if they were placed in the control condition.

With reference to the students’ “time until first action”, or the time a student took to work out the problem before submitting an answer, students took less time when they had been exposed to a video solution compared to a text solution. This is also reversed in the trigonometric problem sets, where students took longer to compute an answer when they had previously seen a video solution (Table 5).

Possible conclusions that can be drawn suggest that videos may be better for some students than other students. Another possible conclusion could be that certain types of problems, or problems of different difficulty levels, are better described with videos while others work better with simple text.

Another portion of this study compared students whose ASSISTments history showed that they had a high or low knowledge of the subject matter. These would be students who have excelled or struggled in ASSISTments mathematics assignments before being exposed to these subjects and types of problems.

Students with “high prior knowledge,” or students who normally do well in ASSISTments math assignments had higher completion rates when exposed to the control text solutions. While students with “low prior knowledge,” or students who sometimes struggle with mathematical concepts, had higher completion rates when exposed to the experimental video solutions.

A clear conclusion that can be inferred from the high vs low knowledge analysis is that students who aren’t familiar with the material receive a higher benefit when they hear/see a problem being worked out in a video, while students with prior knowledge of the subject matter do not see as much of a benefit from videos and can understand text solutions much more clearly.

Using the similarity between the Basic and Intermediate Logarithm Manipulation problem sets we were able to analyse performance on the Intermediate Logarithm Manipulation problem set as it it were a post test. Using only students in both problem sets, we compared the performance on the first problem (following the introductory video) between the two conditions of the Basic Logarithm Manipulation problem set. We showed that there exists an effect students in the experiment performed better in the post-test than students in the control (Table 12).

As for students who were acknowledged in multiple problem set instances, exposed to both control and experimental conditions, analysis is difficult because of the varying problem set difficulty (Table 13). Conversely, if the students were reassigned the same problem set, they would have already been exposed to the material and the tutoring would have less of an effect.

During this study, it had become apparent that the construction of one of the problem sets had a mistake in the instructions portion of the problem. The problem set (PSAJ43P) asked students to “please use 4 decimal places” when the coded problem was looking for whole integer answers. After the initial data was gathered, the experimental problem sets were edited to ask “please round to the nearest degree” so the problem set (PSANG65) could be used in the future. The ASSISTments variablized problem template was also corrected so the normal, non-experimental version could be assigned. This problem design error may have skewed the study data with an erroneously high number of students getting wrong answers and not “testing out” of the problem set (see note under average completion table on page 10). This is specifically apparent in the “attempt count” analyses, where students had the highest average number of attempts out of all of the designed problem sets.

With the consideration of possible future studies, it is possible that students in this study may have seen the videos, but were not able to hear the audio from said videos. The problem setup had students indicate whether they could see the video, but did not have any feedback on whether they could hear the video. Since the screen capture videos relied heavily on the students being able to hear the problem being explained along with the problem worked out on the screen, students in the experimental condition would have received limited educational benefit from watching videos without sound. However, there is no way of knowing which students could or could not hear the videos.

Further study of our data can also be performed. Given the short span of time available to analyze the data were were able to only superficially analyze this data. Further analysis could include specific student analysis, where a student’s performance in multiple problem sets is considered. A class analysis could be performed, where students are analyzed with respect to their class, giving a much better representation of “high knowledge” and “low knowledge.” Analysis classified by student grade level could also be performed. The Assignment ID number output by the SQL query could be used to trace the specific teacher and grade level. Further consideration of the post-test could also be useful, gathering other information like time, attempt counts, etc.

Our study could also be extended to utilize pre-testing and post-testing as a subsequent IQP. Analyzing the student performance over time could give powerful insight as to when each method of tutoring is most beneficial. Another IQP could request that teachers give two instances of the assignment, with a certain amount of time in between. Further considerations as to the effectiveness of tutoring videos could control factors such as the length of the video.

As for the final results of this study, evidence suggests that some students learn better from videos, while others learn better from text. Students with high prior knowledge of the subject matter prefer text solutions, and students with low prior knowledge prefer video solutions. Also, certain mathematical concepts are easier to explain with a quick video, but text works better for tougher subjects. Text should be better for tough subjects so students can go back and reread without having to skip around to different points in a video trying to find what they were confused about.

Appendix

Appendix A: Reference Documents

Beck, J., and Gong, Y. "Wheel-Spinning: Students Who Fail to Master a Skill." *Springer*. http://link.springer.com/chapter/10.1007%2F978-3-642-39112-5_44.

Htet, A., and Ko, S. "Motivational Video Study." April 4, 2013. http://www.wpi.edu/Pubs/E-project/Available/E-project-042313-230311/unrestricted/Motivational_Video_Study.pdf.

Appendix B: Project Website

The following link leads to a website containing all of the study materials for this project, including problem sets, data spreadsheets, and links to tutoring videos:

https://sites.google.com/site/assistmentsdata/iqp-2013-2014/assessing-the-effect-of-video

Appendix C: Study Advertisement Presentation

The following presentation was presented to high-school teachers. This provides teachers with instructions on how to administer our problem sets to students.

Link:https://docs.google.com/presentation/d/1661hTqlfYQjHVDssb-yVL6AmpAh9W1iwI3vJX0vYadw/edit#slide=id.

Appendix D: Study Description Presentation

The following presentation succinctly describes succinctly the design and motives of our study.

Link:
https://docs.google.com/presentation/d/1MkdskENnwn1TaZl6BANTR1UDGkFAhIK-1sQ7lIJwYSw/edit#slide=id.g1daf5b90b_10