# Can We Use Educational Content from the Web?

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**Abstract.** Developers of educational technology often spend hundreds of hours developing content for their systems for a single topic. The World Wide Web has thousands of pages of educational content, some of them quite good. Can we utilize this wealth of instructional content on the web, saving time and resources while helping students to learn? This paper describes two studies that examine the use of web pages containing educational content during a tutoring session. We found that web pages containing educational content could positively affect learning. We did not find a significant difference in learning between web pages containing educational content and tutored problem solving that was specific to a problem. We believe our results show that the intelligent tutoring community should take advantage of educational content on the web.

**Keywords:** interactive learning environment, tutoring content, educational web pages, online educational resources

## 1 Introduction

Relatively few intelligent tutoring systems (ITS) have become commercially successful even though they have been shown to be capable of producing significant learning gains. This may be due to the high cost of building intelligent tutors and a large part of that cost comes from content creation. After surveying many authoring tools for tutoring content, Murray [1] roughly estimated that 300 hours of development time was required for one hour of online instruction time. Anderson, Corbett, Koedinger, & Pelletier [2] suggested that to build the Cognitive Tutor took a ratio of development time to instruction time of at least 200:1 hours. Although the ASSISTment Builder, an authoring tool for example-tracing tutors, produced a smaller ratio of development time to online instruction time of about 40:1 hours [3], a substantial amount of time is still spent creating content for the ASSISTment System as students (in middle school and high school) often use the system throughout the school year.

The World Wide Web has thousands of pages of educational content, some of them very well written. These web pages often include definitions, worked examples,

images and animations. Can we use this wealth of instructional content on the web, saving time and resources spent on content creation? Can students learn from well-designed educational web pages?

The purpose of this study was to determine if students could learn from existing public web pages to help them solve problems in a tutoring system. What percentage of students would show any benefit from having visited a web page? Can we rank the effectiveness of educational web pages? How do these web pages compare to tutored problem solving that is specific to a problem? This paper describes two studies that examine the use of educational web pages to help students solve math problems in an interactive learning environment. We found that students could learn from educational web pages and we did not find a significant difference between tutored problem solving and web pages.

## 2 The Tutoring System: The ASSISTment System

The ASSISTment System [4] aims to assist students in learning the different skills needed for the Massachusetts Comprehensive Assessment System (MCAS) test or (other state tests) while at the same time assessing student knowledge to provide teachers with fine-grained assessment of their students; it assists while it assesses. The system assists students in learning different skills through the use of scaffolding questions, hints, and messages for incorrect answers (also known as buggy messages). Assessment of student performance is provided to teachers through real-time reports based on statistical analysis. Using the web-based ASSISTment System is free and only requires registration on the website; no software need be installed. The system is primarily used by middle- and high-school teachers throughout Massachusetts who are preparing students for the MCAS tests. Currently, there are over 3000 students using the system as part of their regular math classes.

## 3 Choosing Educational Web Pages

We decided to run our study with eighth graders and chose two topics that are typically covered in middle school to use in our experiment: Pythagorean Theorem and Venn Diagrams. We used Google.com's search engine to find web pages about the two topics on November 24, 2008 and December 15, 2008 and chose two "good" pages for each topic. Fig. 1 shows the first page of Google's results for "Pythagorean Theorem."

We evaluated 13 pages about Pythagorean Theorem, using our own judgment before finding two that we wanted to use. For instance, we decided not to use the first result, found on Wikipedia.com (http://en.wikipedia.org/wiki/Pythagorean_theorem), because it appeared to be too advanced for eighth graders. We also excluded the state of New York's Regents Exam Prep web page (http://regentsprep.org/regents/Math/fpyth/Pythag.htm) because it had the answer to one of the questions in the problem set used in this study. We looked for colorful engaging web pages that contained background information about the skill as well as

examples. We chose PBS's page on the Pythagorean Theorem, (www.pbs.org/wgbh/nova/proof/puzzle/theorem.html), because it was age appropriate and highly ranked by Google. Math Forum's page on the Pythagorean Theorem (mathforum.org/dr.math/faq/faq.pythagorean.html) was excluded because it contained a link to the PBS page.

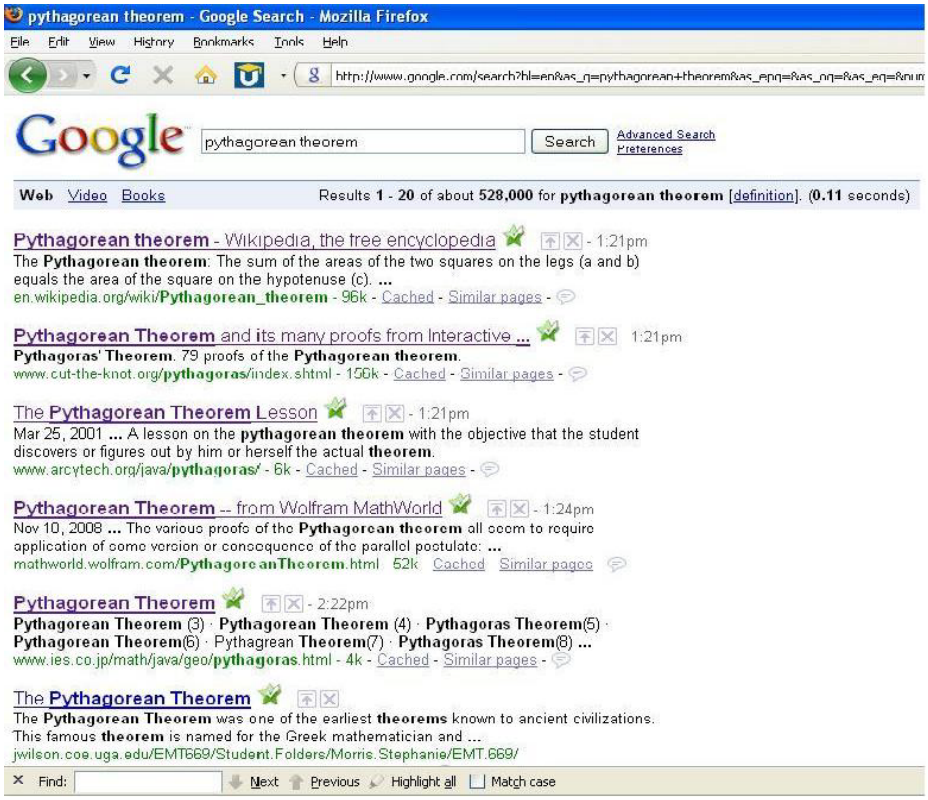


**Fig. 1.** The first page of Google's results for a search on Pythagorean Theorem accessed on November 24, 2008

Originally, we chose a "YouTube" video (http://www.youtube.com/watch?v=0HYHG3fuzvk) because it was the most viewed YouTube video on Pythagorean Theorem and clearly explained the concept. However, the middle school where our study took place blocked YouTube videos on student computers, so we did not use videos in this study. We replaced the video with a web page found at http://www.mathsisfun.com/pythagoras.html, which is shown in Fig. 2.

Similarly, we chose two web pages on the topic of Venn Diagrams. Found at http://regentsprep.org/Regents/math/venn/LVenn.htm and

http://www.itl.nist.gov/div897/sqg/dads/HTML/venndiagram.html. In this way, we chose two web pages for each topic in the experiment.

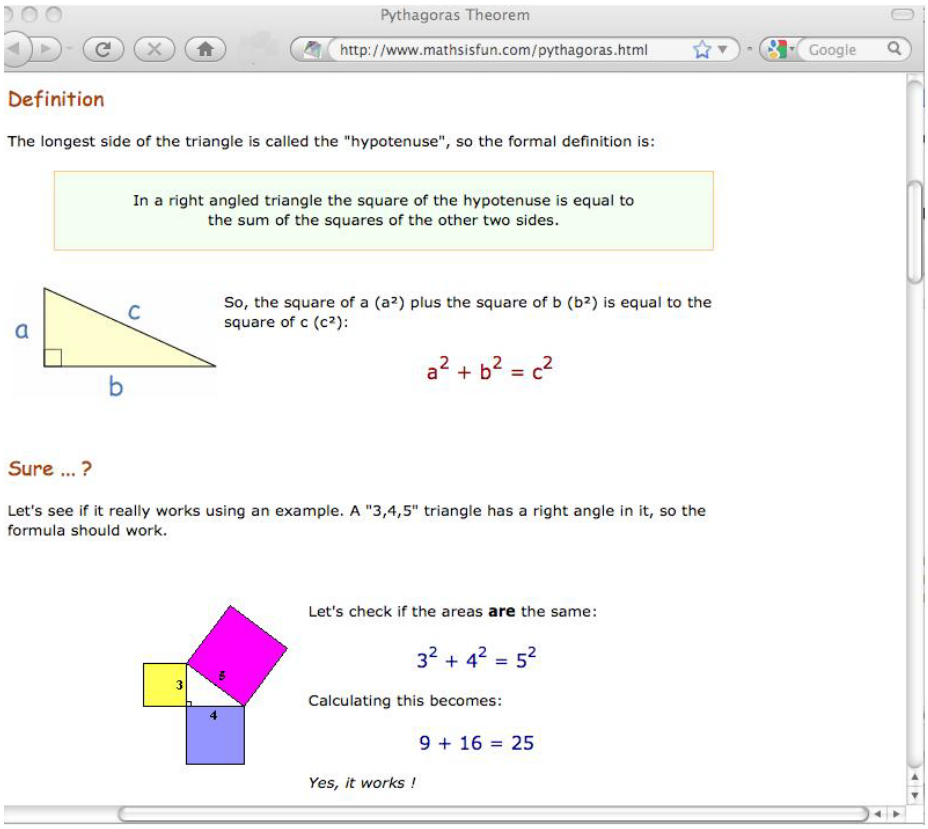


**Fig. 2.** A web page about the Pythagorean Theorem at mathisfun.com

## 4 Can Students Learn from Viewing Educational Web Pages?

This randomized controlled study had two purposes. One was to determine if students working on solving math problems could learn from viewing a web page that addresses the skill involved. The measure of learning was whether a student who got a problem wrong could get the problem correct right after they visited a web page. The second purpose of this study was to determine if it was possible to rank the two web pages for each topic in terms of how effective they were in helping students to solve the problems.

### 4.1 Experiment Design

This study focused on two topics, Pythagorean Theorem and Venn Diagrams, and two web pages were chosen for each topic as described in the previous section. Two of the problems in each topic presented a link to display a web page if students had answered the question incorrectly or asked for help instead of tutoring them through each step or offering hints as the other problems in the assignment did. A counterbalanced design was used to balance for the order of the topics, the order of problems in each topic, the order of the web pages, and the order of the problems that were associated with each web page, resulting in 16 groups. Students were randomly assigned to one of the 16 groups by the system (see Table 1 for the design for one topic).

**Table 1.** The experiment design for one topic.

| **Web page A first** | **Web page A first** | **Web page A first** | **Web page A first** | **Web page B first** | **Web page B first** | **Web page B first** | **Web page B first** |
|---|---|---|---|---|---|---|---|
| Problem A | Problem F | Problem A | Problem F | Problem A | Problem F | Problem A | Problem F |
| Problem B, web page A | Problem B, web page A | Problem E, web page A | Problem E, web page A | Problem B, web page B | Problem B, web page B | Problem E, web page B | Problem E, web page B |
| Problem C | Problem D | Problem C | Problem D | Problem C | Problem D | Problem C | Problem D |
| Problem D | Problem C | Problem D | Problem C | Problem D | Problem C | Problem D | Problem C |
| Problem E, web page B | Problem E, web page B | Problem B, web page B | Problem B, web page B | Problem E, web page A | Problem E, web page A | Problem B, web page A | Problem B, web page A |
| Problem F | Problem A | Problem F | Problem A | Problem F | Problem A | Problem F | Problem A |

### 4.2 Procedure

Students worked through 12 problems, six for each topic during one period of a math enrichment class. Students had already been using the ASSISTment System during this class to help them prepare for the MCAS test, therefore they were familiar with the system. The second and fifth problems in each topic's problem set offered students a link to display a web page if they had answered the question incorrectly or if they had asked for help. After studying the webpage, students were asked their opinion of the web page. Students were then asked to go back to the problem and try answering again. Fig. 2 shows one of the problems and one of the web pages in the study.

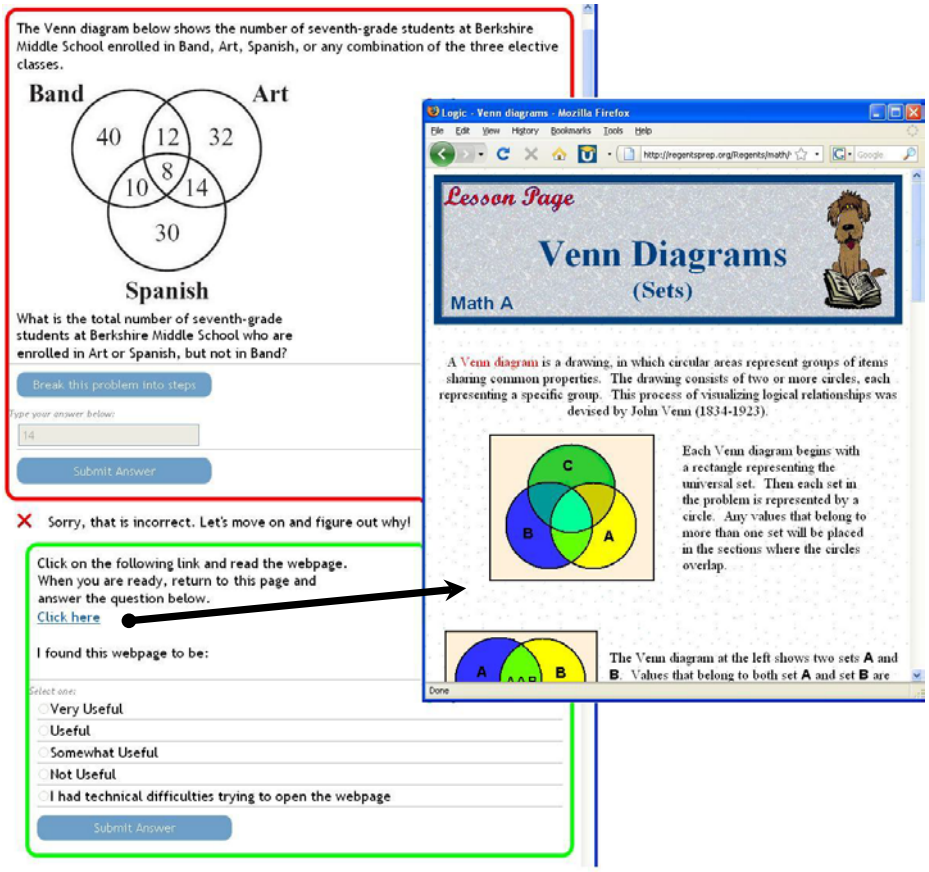


**Fig. 3.** Students were asked to click on a link to display a web page if they needed help.

### 4.3 Results

There were 130 students who participated in the study. We found that 60% of the 70 students who got a problem wrong the first time, could then do the problem after visiting web page A on Venn Diagrams, Of the students who visited the web page A on Pythagorean Theorem, 37% of the 27 students who got the problem wrong the first time could then correctly solve the problem. A one-sample t-test showed that these gains were significantly different from zero (see Table 2). Overall, the results were encouraging in that so many students showed some benefit. However, we cannot be certain that some of the students would have solved the problem correctly on their second attempt without viewing the web page. Nevertheless, overall, it confirmed that a student's success could be impacted by exposure to an educational web page for a few minutes.

Web page A was compared to web page B in each topic to determine if they could be ranked in terms of effectiveness. However, both web pages appeared to be helpful

and gain scores were not significantly different when one web page was compared to another.

**Table 2.** Results for learning gains after viewing the Venn Diagram and Pythagorean Theorem web pages

| | Test Value = 0 | | | | | | |
|---|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean | Std. Dev | 95% Confidence Interval of the Difference | |
| | | | | | | Lower | Upper |
| Gain after Venn web page A | 10.17 | 69 | .000 | .600 | .49 | .48 | .72 |
| Gain after Venn web page B | 9.40 | 68 | .000 | .565 | .5 | .45 | .69 |
| Gain after Pythagorean web page A | 3.91 | 26 | .001 | .370 | .49 | .18 | .57 |
| Gain after Pythagorean web page B | 3.03 | 25 | .006 | .269 | .45 | .09 | .45 |

## 5 How Does Viewing Educational Web Pages Compare to Tutored Problem Solving?

The purpose of this randomized controlled experiment was to compare tutored problem solving to viewing an educational web page. The study described in the previous section showed that students could learn from viewing a web page about the skill needed to solve a problem. The ASSISTment System normally uses tutored problem solving to help students solve problems, which requires students to work through problems step-by-step while the system provides hints and feedback on each step. Tutored problem solving has been shown to significantly increase learning especially for students with low math ability [5]. How does this compare to viewing a web page that is more general and does not specifically address how to solve the problem? Will there be a difference between the two conditions based on math ability? If viewing a web page could help students to learn as much or more than tutored problem solving, time and resources spent on content development could be significantly reduced.

### 5.1 Experiment Design

This study focused on two topics, Venn Diagrams and Pythagorean Theorem. Students participated in both conditions, web pages and tutored problem solving, in a

repeated measures design. The experiment controlled for the order of topics and the order of conditions, which were randomly assigned by student (see Table 3). A pretest and post-test was given before and after each topic, and learning was measured by gain score from pretest to post-test.

**Table 3**. Students were randomly assigned to one of four groups.

| | **Group 1** | **Group 2** | **Group 3** | **Group 4** |
|---|---|---|---|---|
| **First** | Venn Diagrams with TPS | Pythagorean Theorem with Web Page | Venn Diagrams with Web Page | Pythagorean Theorem with TPS |
| **Second** | Pythagorean Theorem with Web Page | Venn Diagrams with TPS | Pythagorean Theorem with TPS | Venn Diagrams with Web Page |

This study took place during one period of a math enrichment class. Students had already been using the ASSISTment System during this class to help them prepare for the MCAS exam, therefore they were familiar with the system.

### 5.2 Results

Seventy-one middle school students (aged 13-14) participated in the study and 66 students completed both problems in both conditions. The Pythagorean Theorem topic was more difficult (mean pretest score = 45%) compared to the Venn Diagram topic (mean pretest score = 58%). The results showed that there was significant learning overall with a mean gain score of 33% [$t(68) = 7.48$, $p < 0.001$] for the Pythagorean Theorem topic and a 19% gain score [$t(67) = 4.18$, $p < 0.001$] for the Venn Diagram topic.

The repeated measures analysis showed that the difference between tutored problem solving and web pages was not statistically reliable. Students had taken a practice MCAS test and a median split on the test scores was used to divide students into "low math ability" and "high math ability." No aptitude treatment interaction was found.

**Table 4.** Pythagorean Theorem, students learned slightly more with tutored problem solving than viewing the web pages

| Math Ability | Condition | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| High | Web | 0.348 | 0.076 | 0.195 | 0.500 |
| | TPS | 0.444 | 0.122 | 0.200 | 0.688 |
| Low | Web | 0.292 | 0.075 | 0.142 | 0.441 |
| | TPS | 0.500 | 0.138 | 0.223 | 0.777 |

For the more difficult topic, Pythagorean Theorem, students learned slightly more with tutored problem solving than viewing the web pages [F(63, 1) = 7.45, p = 0.22]. (See Table 4 and Fig. 4.)

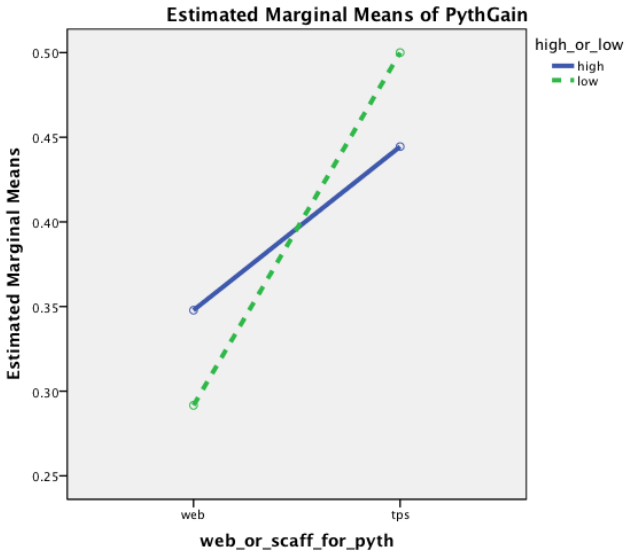


**Fig. 4.** Students learned slightly more from tutored problem solving in the Pythagorean Theorem topic.

## 6 Conclusion

This paper presented two studies to examine the use of educational web pages to help middle school students solve math problems in a tutoring system. If we could show that these web pages were effective, it could encourage tutoring system developers to make more use of the wealth of free educational content available on the web saving time and resources from content development.

The first study was to determine if a) students could learn from viewing a web page and b) web pages could be ranked in terms of effectiveness. The results showed that students could gain significantly from viewing educational web pages. We were not able to distinguish between the web pages in terms of effectiveness. Perhaps the web pages were equally good as we tried to choose web pages that appeared to be well designed and informative. However, there are also educational web pages that are not well designed or may contain incorrect information. If developers of interactive learning environments are to make use of educational web pages, they need an efficient way to sift through the thousands of educational web pages available on every topic and rank them similar to the way a search engine ranks web pages. Where a search engine ranks web pages according to relevance or popularity, we would like to rank according to effectiveness. We see potential for future work here.

The purpose of the second study was to determine which method was more effective: tutored problem solving, which was specific to a problem or viewing a web

page that was more general. This may be compared to studies such as Ringenberg and VanLehn's [6] study of worked examples to hints that were specific to a problem. However, the web pages we used tended to have more background information and multiple examples as well as links to other web pages. No significant difference between the two was found in this study. Tutored problem solving appeared to help students slightly more when the topic was more difficult, though not reliably more. Could this result be because the tutored problem solving condition targeted specific problems and how to solve them while the web pages were more focused on the broader principles involved in the topic? We do not know, but believe that there is potential for future work here.

In conclusion, we believe this work is evidence that developers of ITS should be taking advantage of tutoring content on the web.

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