Web-Design, and NSES Content and Process Standards Analysis of Teacher-Published High School Physics Websites

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(*Submitted* 12-03-2014)

Abstract

This study investigated high school Honors Physics (N = 76) and Advanced Placement Physics (N = 76) websites for Web-Design, National Science Education Standards (NSES) Physics Content and Science Process Standards. The websites used in the study were accumulated using the Google™ search engine. The evaluation of each website was performed using an instrument developed based on three attributes: Web-Design, NSES Physics Content, and NSES Science Process Standards. The results of the study indicated that there was a significant difference between high school Honors Physics websites and those of AP Physics in terms of NSES Physics Content Standards. It was found that Advanced Placement Physics websites contained more NSES physics content than Honors Physics websites. There was no significant difference found between the websites in regards to Web-Design, and NSES Science Process Standards. Implications for Physics Content Standards in web-based physics education are discussed.

1. Introduction

Teachers in high schools have traditionally focused on the in-depth instruction of specific subject matter to prepare students for post-secondary education, or, specifically, to provide sufficient background to succeed in a college curriculum. Particularly challenging to teachers today is the digital divide between teachers and students, especially students who are maturing in a world where computers, the Internet, video games, and cell phones are common, and where expressing themselves through these tools is the norm [1, 2]. Consequently, teachers need to include in their instruction engaging content materials and assessments with more hands-on science and multimedia-based activities than printed textbooks. One approach to help teachers meet this need is through well-designed websites. This enhancement to traditional instruction is usually referred to as Web-Assisted Instruction (WAI). WAI has been defined as using the Internet with email and World-Wide-Web (WWW) browser software to set-up and maintain a webpage in order to supplement conventional classroom instruction [3].

2. Web-Assisted Instruction and the Classroom

Within the realm of education, WAI can be implemented in so many different ways that it is frequently regarded in an over-simplified manner as "teaching with the Internet." Consequently, misinterpretations usually occur because the World-Wide-Web (WWW) can be applied in a myriad of ways to pedagogy. It seems that the most common conclusion that some may draw is that the Internet is being used in the classroom as a teaching tool. But for this research proposal, the term WAI is intended to mean instruction and communication outside the classroom via a teacher-authored class website. The students use it to electronically access content-related learning materials while practicing inquiry, conducting simulations, performing self-assessments, and maintaining communication with each other along with their teacher.

3. Benefit of Web-Assisted Instruction

The benefit of WAI appears to be its ability to offer a way for students to remain connected to their instructional setting beyond the walls of the classroom [4,5,6]. The teacher includes weekly plans and assignments on the website along with lecture notes and links to other sites for enrichment and practice. The teacher can occasionally post quizzes and tests on the Website for students to complete, supported by a file upload link for submission of their work. Additionally, the website should have an email link for communication outside of class, and include streaming video along with audio (MP3) files to support webcasting. The email capability is especially useful for students who may be hesitant to ask questions in class or for those who may have thought of something later.

Having a class website could be useful in a subject like high school physics, for example, because more class time can now be devoted to essential demonstrations, discussions, student lab work, inquiry, and other discovery-related activities. Basically, class websites can give the course content the same "anytime, anywhere" communication appeal to which the technology-literate students of today have become accustomed in their everyday lives. In fact, studies suggest that the internet has become the medium of choice for young people in doing their research and homework, compared to newspapers, magazines, books, or libraries [5].

4. Web-Assisted Instruction and Physics Education

According to Mottmann [7], two of the more important reasons for introducing technology and other instructional innovations into physics education are "(a) to improve students' physics ability, and (b) to improve students' negative reactions toward physics" (p. 75). Rios and Madhavan [8] identified four classifications of technologies that are appropriate for physics instruction and provided brief descriptions of a few examples. The classifications were (a) computer interfacing equipment to collect and process data, (b) experimental or theoretical modeling, (c) computer simulations requiring graphics, and (d) research/reference/presentation programs for gathering, reporting, and/or displaying information. However, there seems to be a lack of published attempts by researchers to gauge the use of Web design standards for WAI in physics at the high school level. It may be difficult to single-out a particular reason why more advantage is not taken of Web-Assisted Instruction. Schell's [9] research may be providing a clue. Teachers may simply feel that it is too time-consuming, and they may not have enough expertise.

5. The Promises of Technology

Many times in the past "modern technology" has led us to believe that it will improve education but this has not always been the case. For example, in the 1950s, television was once promised as a great asset to education. Some may contend that it has yet to prove any educational usefulness [10]. Now, even though the Internet can be used in a variety of settings for a range of purposes, its use can place unexpected demands on even the most experienced teachers, at times reducing them to novices. Equally disappointing is that, with regard to infusing technological innovations in their pedagogy, teachers have usually been left to figure things out on their own.

The current-day technologies have shown great promise to teachers and students. It is the latter who seem to expect more from the former in terms of their educational experiences. Students, particularly those in upper-level math and science courses, are arriving to the classroom with a technological savvy that many teachers may find intimidating. These students expect their educational experiences to include Web technologies, such as multimedia presentations of subject content, interactivity, simulations, streaming video, and access to their instructors through email, on-line forums, and chat-rooms [11].

With all this exposure to technology available to students, the Internet has already become the medium of choice for young people in doing their research and homework, compared to newspapers, magazines, books, or libraries [5]. It now becomes apparent that educators should at least consider including in their pedagogy some well-designed Web-based instructional techniques and strategies. By doing so, teachers can provide their students with a structured, virtual learning environment outside the classroom, whose rudiments have evolved with the growth of the Internet, an entity that their students have already become accustomed to using.

6. Statement of the Problem

The purpose of the study was to investigate whether statistically significant differences existed between high school Honors Physics websites and those of AP Physics in terms of Web-Design, National Academy of Science (NSES) Physics Content Standards, and NSES Science Process Standards [12]. A total of 152 sites were evaluated comprising two groups with sample sizes of 76 each for the types of physics classes in the study.

7. Method

The websites used in the study were accumulated using the Google™ search engine. For example, to find Honors Physics websites, the search query "honors physics high school" was entered into the search engine. This produced approximately 222,000 results. For the query, "advanced placement physics high school," the search engine estimated about 190,000 results. In both cases the results were examined sequentially until the required amounts of websites published by physics teachers were selected and evaluated using the instrument developed by the researcher. The selection process was based on the order in which the search engine ranked the results of the query. All 76 of each type of high school physics websites were found by going no more than 27 pages deep into the search results which listed 10 websites per page that contained the search words.

8. Website Evaluation Protocol

Protocols for analyzing curriculum and instructional websites have been reported [3, 6] and they vary depending on the subject matter and the purpose of the analysis. For this study, once a website is found it was evaluated according to the presence of three major attributes: Web design structure, physics content standards, and science process standards. There were five criteria for each attribute listed in the instrument to aid in determining if the website possessed the given attribute (Table 1).

Evaluation Criteria	
For 4 or more criteria, Score = 1. For less than 4 criteria, Score = 0.	
A. Design Structure **Score**	
1. Homepage title begins with Physics website name. 2. Similar format on every page that links from the homepage.	

3. All multimedia resources work properly. 4. Page footer area -- copyright, last update, contact e-mail address. 5. Short paragraphs and bulleted lists are used.	
B. National Science Education Standards for Physics Content **Score**	
1. History and nature of science. 2. Conservation of energy and increase in disorder. 3. Study of motion and forces. 4. Interactions of energy and matter. 5. Nature of Light and Optics.	
C. National Science Education Standards for Science Process **Score**	
1. Includes opportunity to conduct scientific inquiry. 2. Incorporates critical thinking skills. 3. Provides practice for problem-solving. 4. Emphasizes the Scientific Method. 5. Provides practice for analyzing and synthesizing data.	

Table 1. High School Physics Web-Design, NSES Physics Content and Science Process q Checklist

Websites could only receive a score of "1" or "0" for the attribute. A "1" is scored if the website contains four or more out of the five criteria for each attribute, otherwise a "0" is given. The advantage of using a "1" or a "0" in the evaluation process for each website attribute is that the mean also returns the probability, in a frequentist sense, that similar sites will possess the attribute under consideration.

For example, to evaluate the design structure of the website, look for the presence of the following criteria: page title begins with physics website name, similar format or appearance to every page that links from the homepage, short paragraphs and bulleted lists are used, all multimedia resources work properly, and the page footer area contains either copyright or last update as well as a contact e-mail address.

In order to determine if the website contained NSES Physics Content Standards references to the following information were searched: the history and nature of science, conservation of energy and increase in disorder, the study of motion and forces, interactions of energy and matter, and the nature of light and optics.

When deciding whether or not the website contained the NSES Science Process Standards, the following criteria must be present: opportunities to conduct scientific inquiry, use of critical thinking skills, practice for problem-solving, emphasis on the Scientific Method, and practice for analyzing and synthesizing data. A flowchart illustrating how to find and evaluate for example an Honors Physics website is shown in Figure 1.

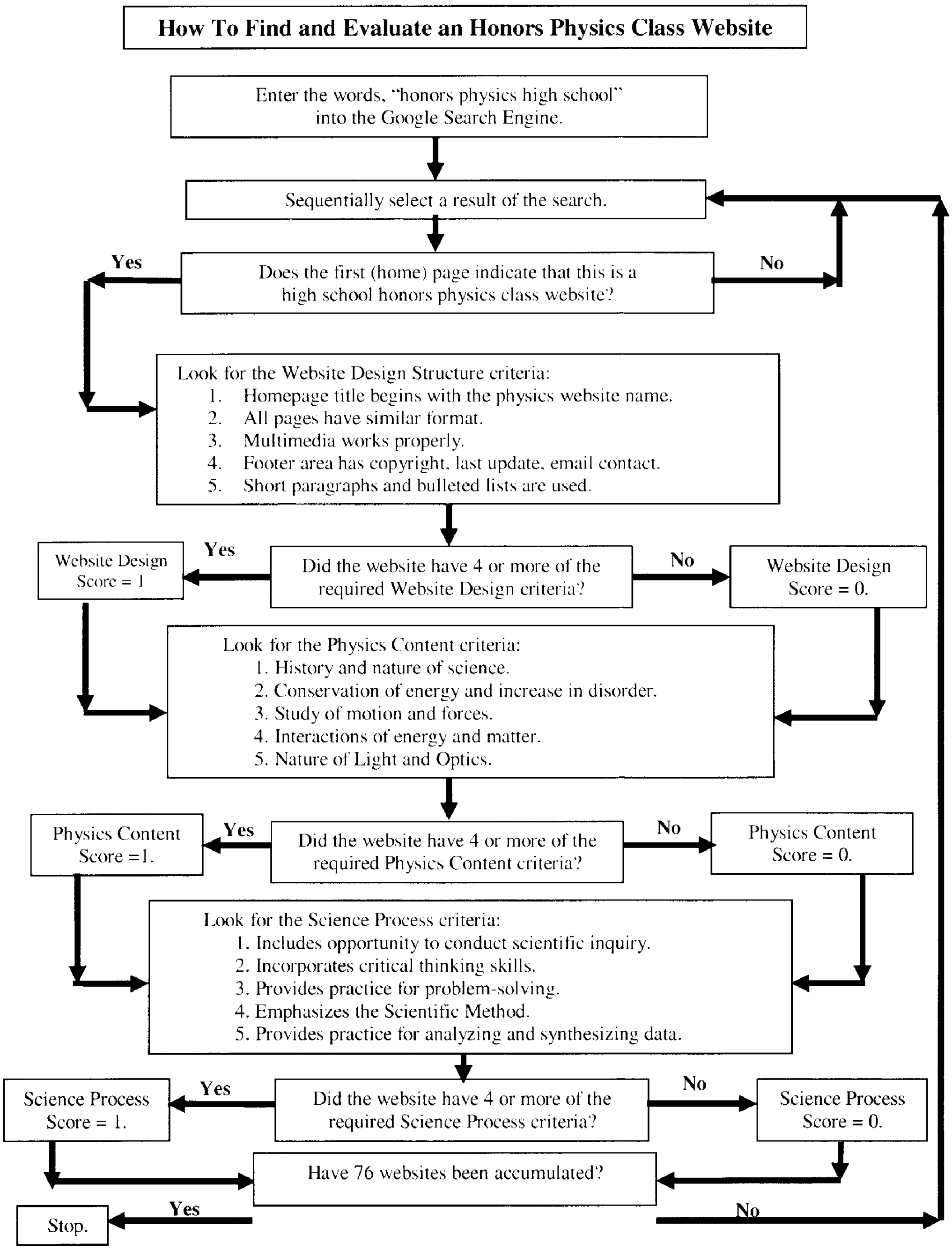

Figure 1. How to Find and Evaluate an Honors Physics Class Website

9. Results

To examine if there is a significant difference on the website elements Web-Design, Physics Content, and Science Process by Website Type (Honors vs. AP), three independent samples *t* tests were conducted.

9.1. Web-Design

H1$_O$: There is no significant difference between Honors Physics and AP Physics websites in Web-Design structure.

The results of the *t* test on Web-Design were not significant, *t* (150) = 0.83, *p* = 0.41, indicating that no significant difference existed in Web-Design by Website Type (Honors vs. AP) (Table 2). Web-Design for the Honors sites (*M* = 0.59, *SD* = 0.50) was not significantly different than Web-Design for the AP sites (*M* = 0.66, *SD* = 0.48). The Levene's test for homogeneity of variances returned a value of .134 with a significance of .143. The post hoc power returned a value of .054 for the probability of rejecting the null hypothesis when it is false.

			Honors		AP	
Website Elements	*df*	*t*	*M*	*SD*	*M*	*SD*
Web-Design	150	0.83	0.59	0.50	0.66	0.48

Table 2. Independent Samples t Test on Web-Design by Website Type (Honors vs. AP)

9.2. Physics Content

H2$_O$: There is no significant difference between Honors Physics and AP Physics websites in terms of NSES Physics Content Standards.

The results of the *t* test on Physics Content were significant, *t* (150) = 2.15, *p* = 0.03, indicating that a difference existed in Physics Content by Website Type (Honors vs. AP) (Table 3). Physics Content for the AP sites (*M* = 0.51, *SD* = 0.50) was slightly higher than Physics Content for the Honors sites (*M* = 0.34, *SD* = 0.48). To determine the effect size of this significant effect, the value of the Cohen's d was .35, with a Confidence Interval from .23 to .45, indicating a small to moderate effect. The Levene's test for homogeneity of variances returned a value of 2.46 with a significance of .906. The post hoc power returned a value of .123 for the probability of rejecting the null hypothesis when it is false.

			Honors		AP	
Website Elements	*df*	*t*	*M*	*SD*	*M*	*SD*
Physics Content	150	2.15*	0.34	0.48	0.51	0.50

Note. ** $p < 0.01$ and * $p < 0.05$.

Table 3. Independent Samples t Test on Physics Content by Website Type (Honors vs. AP)

9.3. Science Process

$H3_O$: There is no significant difference between Honors Physics and AP Physics websites in terms of NSES Science Process Standards.

The results of the *t* test on Science Process were not significant, *t* (150) = 1.25, *p* = 0.21, indicating that no significant difference existed in Science Process by Website Type (Honors vs. AP) (Table 4). Science Process for the Honors sites (*M* = 0.14, *SD* = 0.35) was not significantly different than Science Process for the AP sites (*M* = 0.22, *SD* = 0.42). The Levene's test for homogeneity of variances returned a value of .537 with a significance of .574. The post hoc power returned a value of .064 for the probability of rejecting the null hypothesis when it is false.

			Honors		AP	
Website Elements	*df*	*t*	*M*	*SD*	*M*	*SD*
Science Process	150	1.25	0.14	0.35	0.22	0.42

Table 4. Independent Samples t Test on Science Process by Website Type (Honors vs. AP)

10. Discussion and Summary

The results of the study indicated that there was only one statistically significant difference between high school Honors Physics websites and those of AP Physics. This was in terms of National Science Education Standards (NSES) Physics Content Standards. AP Physics websites had more Physics Content than did those of Honors Physics. There was no significant difference found between the two types of high school physics websites in regards to Web-Design, and NSES Science Process Standards.

Based on the findings of this study, several conclusions may be drawn that can be applied to high school physics teachers who attempt to build their own websites. Even though a rubric exists for Web designers to use when constructing websites, high school physics websites developed by teachers are lacking in such things as a homepage title beginning with the website name, similar design format on every page, working multimedia resources, a page footer area containing a copyright, last update and email contact, and the usage of short paragraphs and bulleted lists.

The physics content of all high school physics websites does not seem to completely reflect that which is recommended by NSES. Teachers are not including all of the following content on the site: history and nature of science, conservation of energy and increase in disorder, study of motion and forces, interactions of energy and matter, and nature of light and optics.

All high school physics websites are not providing students with opportunities for Science Process which is recommended by NSES. Teachers may not be including all of the following on the site: opportunities to conduct scientific inquiry, incorporating critical thinking skills, providing practice for problem-solving, emphasizing the Scientific Method, and providing practice for analyzing and synthesizing data. More comprehensive analyses incorporating both quantitative and qualitative methods [13] are necessary to gain a clearer picture of teacher authored physics websites in high school physics education.

It may be useful to find out if similar results exist across other subject areas with corresponding degrees of variation. For example, a replication of this study may need to be conducted using data from other instructional settings in other content areas e.g. mathematics, language, and other sciences.

Follow-up studies need to be undertaken to compare the performance of high school physics students on comprehensive and/or standardized tests based on whether or not their teacher utilizes Web-Assisted Instruction (WAI). This could help in determining the efficacy of WAI.

Teaching in the 21st century implies that practitioners become skillful at designing instruction that includes opportunities for their students to interact with learning materials published on the Internet. Those who are adept at designing online learning materials should share their knowledge with their colleagues, especially novice teachers. They should also try to establish an online repository of best practices to improve instruction.

Further research may be needed to try to determine why more high school teachers, in general, do not utilize WAI for their students outside the classroom. This could provide in-service trainers, curriculum developers, and policymakers with valuable information. For example, Web designers should be invited to participate in teacher in-service programs in order to provide information and expertise in the development of a knowledge base of best practices to facilitate Web-Assisted Instruction. Curriculum developers need to continue to review the emerging published research concerning Web-Assisted Instruction to determine its importance in the design of curriculum. Policymakers must realize that pushing any web-based technology measures may not be adequate. Emphasis must be placed on NSES-based physics content. This is critical to replenishing the scientific workforce critical to development.

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