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DEVELOPMENT OF A USABLE WEBSITE FOR AN ELECTRIC  
MOTORBOAT DRAG RACING PHYSICS PROJECT

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A Project  
Presented to the  
Faculty of  
California State University,  
San Bernardino

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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Arts  
in  
Education:  
Instructional Technology

---

by  
Reno Don Barry  
December 2006

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## ABSTRACT

This report shares the development of a usable website for a high school physics project called "Electric Motorboat Drag Racing." The website, located at [www.electricboatproject.com](http://www.electricboatproject.com), provides the information to engage students in the educational, hands-on, project. The website was produced following the ADDIE instructional design model and was designed using key usability concepts identified through research: speed, content, appearance, and navigation. These concepts were organized into an acronym, S.C.A.N., so they could be more easily remembered and applied to the website design. The website was developed and tested by asking experts for their feedback and by having participants use the website. The website was implemented in physics classrooms and data from 43 participants was evaluated. The data showed 97 percent of the participants' boats successfully completed the five meter drag race. It also showed that the two targeted California physics standards were selected the most by participants as the standards they most needed to apply, learn, or review to complete the project. Through all of this, the website was made more usable and the project helped physics students learn and apply specific physics concepts while gaining exciting hands-on experience.

## ACKNOWLEDGMENTS

My God, family, friends, fellow teachers, students, and Dr. Newberry all made this project possible. Thank you all for your contributions.

## DEDICATION

To Jean, Simeon, and Anna, my greatest joy this  
side of heaven (James 1:17).

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## CHAPTER ONE

### BACKGROUND

#### Introduction

The contents of Chapter One present an overview of the project. The context of the problem is discussed followed by the purpose, significance, assumptions, limitations, and definitions of terms.

#### Context of the Problem

The context of the problem was to address specific needs in high school physics classes. First, our nation needs more students to enroll in advanced science classes to remain competitive internationally (Johnson, 2006). Second, there is a need for projects that grab students' interest and motivates them to learn and apply the content standards. Third, instructors should not have to waste time trying to re-invent what others already have done.

Would you want to sign up for a class that is not interesting or fun? Most students probably would not unless it is required for their future. For an elective class in high school, such as physics, students are more likely to enroll if their peers say it is fun or

interesting. This word of mouth advertisement requires lessons and projects that engage students in hands-on or real-world experiences. Students long for this. Even struggling students ask, "Are we going to do anything fun today?" To increase enrollment, teachers need to offer more than daily lessons with boring assignments.

Students also crave a meaningful education, evidenced by another of their infamous questions: "When are we ever going to use this?" The pendulum of educational approaches should not swing so far that students are merely entertained or engaged with experiences. Educational experiences should result in targeted and meaningful student learning. It should not become a burden or drawback to have students learn required standards, but an ally. In science, students can learn specific content standards and experience how those concepts are applied. Students can find more satisfaction by learning to hit a target than simply shooting an arrow. It is more meaningful and enjoyable for students to experience, not just hear, how the concepts are applied.

Would you like to think up every fun activity you might do or would you rather have fun ideas available to

you? Having many ideas available is one thing that makes vacations so much fun. Having great learning experiences available could make lessons and lesson planning more fun and time-efficient. Teachers should not have to re-invent the wheel each new class. Great learning experiences shouldn't be kept in isolation, but made available across classroom, district, and state boundaries. These experiences could motivate, engage, and inspire multitudes of science students to wonder about our physical world and how its laws apply to real-life. At the same time, these students will enjoy learning required science standards.

#### Purpose of the Project

The purpose of the project was to develop a website to share a motivating and educational project with physics educators, providing an example to follow. Physics should be an exciting subject to learn since its concepts can be easily observed and experienced in the classroom. To support new physics courses or improve existing ones, this project makes available a motivating and educational summative project through the development of a usable website.

## Significance of the Project

The project has significance because it can provide an example of a motivating and educational physics project delivered through a website. For students, this could result in higher interest and enrollment in advanced sciences and real-world understanding of multiple physics standards. For teachers, this can provide them with an example of an exciting summative project that they do not have to invent. In addition, to encourage beginning web designers, key usability concepts were organized into an easy to remember acronym, S.C.A.N., and simplified usability testing procedures were followed.

## Assumptions

The following assumptions were made regarding the project:

1. The website was designed for teachers to result in a greater implementation of the website. This was assumed since they determine whether or not the project will be used for their classes.



2. Teachers are assumed to want hands-on projects that meet educational objectives. With a greater emphasis on standards-based education, some may feel there is less time for hands-on projects.
3. Students are able to accurately identify and select state standards that they applied or learned from the project.
4. If students' boats functioned successfully, it was counted as evidence for them applying or learning a standard, but that part of the project may have been completed by someone else.
5. Data was recorded based on the success of the boat and the data was attributed to both partners, even though they may not have equally contributed to it.

#### Limitations

During the development of the project, the following limitations were found to apply to the project:

1. Bandwidth and download speed is a technical limitation that forces web designers to use

strategies to maximize it. For example, though instructive, the use of video clips of boat races was limited.

2. Software to quickly produce visually rich website features was not readily available to this teacher. For the website, three dimensional visuals with controlled rotation and zoom features would have been a valuable resource for students.
3. The graphic arts in website development require artistic skills or assistance to make it look professional and appealing. Additional time and focus groups may have been helpful.
4. The project is limited based on estimating what teachers and students can afford or what they have available. This limited the drag-racing to easily purchased rain-gutters and stopwatches. Ideally, starting lights and a laser-based timing system would be used.
5. Certain sources of error in the implementation phase could not be eliminated. For example, some students had prior knowledge of the project since it had been assigned annually

since 1997 in the author's classes. Also, the data was based on limited observations of the participants.

#### Definitions of Terms

The following terms are defined as they apply to the project.

Content: all of the necessary written, visual, and auditory information that is present in a website

Download: opening or saving files from the internet

Email: a message sent or received electronically using a computer network

Heuristic Evaluation: an expert uses a list of usability criteria to examine a website to fix and improve aspects of the web design

Hyperlink or link: selectable text or visual that opens another part of a webpage or another website

Mouse-over: a change in hyperlinked text or a visual on a website when the cursor is on that item

Navigation: the complete set of organized links in a website allowing the user to travel quickly and predictably to desired content

Pixel: the smallest single-colored unit of a computer screen or digital display

Project website: a website that communicates the guidelines for an extensive hands-on assignment and provides students with resources to accomplish the assignment

Scaffolding: resources and activities that help students reach academic objectives that are beyond their current abilities

Thumbnail: small digital photographs presented on a webpage to give a preview of the actual, larger, photograph

Usability or usable: a term that addresses the ease of use and the likeability of a product or system

## CHAPTER TWO

### REVIEW OF THE LITERATURE

#### Introduction

Chapter Two consists of a discussion of the relevant literature. Specifically, making science resources available through the internet, the importance of website usability, designing a usable website, reasons to give a website a usability test-drive, procedure for usability testing, and an instructional design model for website production.

Educators, even those at the secondary level, can use hands-on projects to stimulate greater student interest in learning (Zahorik, 1996). There are a variety of hands-on projects, including problem-based learning scenarios that bring real-world context to the classroom (Roberts & Zydney, 2004) or competitions that can provide extra motivation for gifted students (Ngoi & Vondracek, 2004). Hands-on projects can benefit more students and schools when they are shared. To easily share these resources, websites can be constructed to make hands-on projects available. Designing an effective website allows the project guidelines to be accessed easily,

communicated consistently, implemented successfully in other classes, and improved through feedback. To maximize teachers' web design efforts, research-based strategies for developing a usable website for a motivating project will be discussed.

This literature review focuses on organizing key usability concepts into an easily remembered acronym, S.C.A.N., with practical strategies for teachers to design usability into their project websites. Simple usability testing methods are also discussed to improve a website for its intended audience. The entire process is placed in the context of the ADDIE instructional design model.

#### Making Science Resources for the Internet

The right web resources provide a variety of educational benefits for the classroom. Clinch and Richards (2002) summarized how the internet can be used to enhance a physics classroom, but their general suggestions should be useful for most science classrooms. They suggest that internet resources can enhance teaching by providing more interactivity, variety, sharing of resources with other teachers, independent learning, home

access to class materials, and providing relevant resources. The internet can also enhance the classroom through online assessment, projects and other web-based learning tasks.

Though there are a variety of benefits from using the internet in class, not just any website will enhance learning. According to Brown (2000, p. 4), "Web-based learning tasks should require students to construct meaning rather than repeat information..." and include organizers, links, and scaffolding to support student success. To greatly enhance learning though, websites need to include more than just academic support. They should involve students in relevant, real world, situations. Web-based projects with real world contexts can dramatically affect learning (Hancock & Betts, 2002).

Design projects are ideal tools to enhance science education because they engage students in real world contexts. Design projects related to technology and engineering have been reemphasized since the development of national standards (Haury, 2002). Haury states: "The lack of attention to learning science through design is unfortunate since this neglected counterpoint to inquiry has the potential to profoundly enrich science teaching"

(p. 2). Using design projects helps to connect science with real life learning and problem solving skills. It addresses various learning styles, sparks creativity, and is useful for "[d]eveloping skills in critical thinking, problem solving, and decision-making" (Haury, 2002, p. 3).

Depending on the project, students can also hone skills related to the scientific method such as identifying a problem, gathering information, developing ideas, collaborating and communicating, designing multiple tests or experiments, dealing with sources of error or failure, and communicating conclusions or outcomes. Many design projects will also nurture gifted students because they involve higher-level thinking, real-world complexity, and product testing or experimental design (VanTassel-Baska, 1998). Using design projects in science education not only adds variety to the course, but can enhance each student's learning and skills beyond the classroom.

To gain educational benefits from the right websites and design projects, teachers can develop or implement websites for standards-based design projects. The websites could provide the guidelines, related links, and



scaffolding for web-based learning tasks (Brown, 2000), problem-based projects or design projects. Many such projects are probably in use in classrooms throughout the country, but just need to be made available to others through websites. Eventually a collection of science project websites could be made for each grade level and science subject, as determined by state standards, and made available through one website. The only way teachers would not benefit from individual project websites is if they did not know about them, did not have access to them, or as Niederhauser and Strudler (2002) discuss, did not access them because of various perceptions related to technology, education, or themselves.

The principles of developing usable websites discussed in this review could also be presented to students so that they can make websites. The students could invent project websites or just select a topic and make a website for it (Hall & Basile, 1997). With these possibilities, there is the potential for project websites to be used as both a learning tool and a resource. This review of literature will focus on how to develop an individual teacher's project website by designing for and testing its usability.

## The Importance of Usability

Usability methods are used to make websites function more quickly and easily for their intended users. The U.S. Department of Health and Human Services (USDHHS, 2005e) defines usability as "the measure of the quality of a user's experience when interacting with a product or system – whether a Web site, a software application, mobile technology, or any user-operated device" (What is usability section, ¶ 1). They further describe the factors that are involved in determining usability: "Ease of Learning", "Efficiency of Use", "Memorability", "Error Frequency and Severity", and "Subjective Satisfaction" (USDHHS, 2005e, What is usability section, ¶ 2). These factors address the ease of use of the product or system and the likeability of that product or system. Designing for and testing usability should address and result in a website that is both easy to use and has features that make the website likeable to the user. These are both necessary and significantly impact the success of a website.

Usability engineering has been a part of industry research and development for 50 years (Hallahan, 2001). It is used to improve computer hardware and software

products and is now a critical component of web design. Jacob Nielsen, author of [www.useit.com](http://www.useit.com), has written and co-written papers and essays estimating the monetary impact usability engineering can have. *A Useful Investment* (Nielsen & Coyne, 2001) describes a \$750,000 savings through usability engineering, and *Usability on the Web Isn't A Luxury* (Nielsen & Norman, 2000) describes how business sales can be lost and budgets negatively reduced by poor usability. In his article *Discount Usability for the Web*, Nielsen (1997) states: "By my estimates, bad intranet Web design will cost \$50-100 billion per year in lost employee productivity in 2001 (\$50B is the conservative estimate; \$100B is the median estimate...)" (Amateur designers section, ¶ 2). If a business site has too many usability problems, Forrester Research has found that they could lose half of their potential sales and almost half of the users will not try that site again (USDHHS, 2005e). Even the best websites only enable users to find answers to site-based questions less than half of the time (Spool, 1999). The losses pointed out reflect poor usability and reduced success of the websites.

A website with poor usability wastes time, results in unanswered questions, does not appeal to its users, and causes aborted business. It just does not function well for its user and causes users and companies to lose time, money, or both. Though monetary profits or losses are not likely to be linked to a teacher's project website, making one with a high usability will save the students' time, result in fewer questions, higher appeal, and more completed tasks. Usability is critical to the impact and success of any website, even educational websites.

#### Designing a Usable Website

In this section, it is assumed that teachers will be the website designers, preparing websites to communicate projects and resources to their students and to classes at other schools. This means that a few components that are critical for designing large information database sites or business websites will not be included in this discussion. For example, an online library or catalog business should provide advanced help, search, and feedback functions. These functions, though they improve the usability of some sites, may be unnecessary and too

time consuming for teachers to include in their websites for students.

There are many lists of features and design concepts to include in websites. Many lists describe design features for effective or usable websites (Chen, 2000; Sarapuu, 1998). Many of these lists are also difficult to use in the design or development phase of a website because they are often long, unorganized, and contain a wide variety of guidelines. These lists are not memorable and are difficult to use efficiently. The lists themselves need improvements in usability.

There is also little research documenting the effect of using the lists to design a website or the relative importance of items on each list (Zhang & von Dran, 2000). Many of these lists are a tool for a method of usability testing called heuristic evaluation, using the list of design concepts to check a website for potential improvements once it has been made. To improve web design efficiency, why not have a framework of research based, usability concepts in mind from the beginning? For the average time-starved teacher to benefit from critical usability concepts, the concepts themselves must be

quickly understood, easily remembered, and simple to incorporate into web design.

Designing for usability requires analyzing why a site is being designed, who will be using it, and what they will need to do (USDHHS, 2005e) Assuming a teacher would design a project website to enhance learning related to specific educational standards, the "why" question is answered. The characteristics of the student users, what they will be doing, and the environment that they will use the website in is addressed by the following web design process and discussion.

Since a website must be usable by its users, their characteristics are a key starting point of the design process. A website may be usable by its designers or others with specialized skills, but if typical users will be from the general public, it may not be usable by them. The users from the general public may not have the latest technology, terminology (Brown, 2002), search skills, patience or time (Nielsen, 1994). Steve Krug, in chapter 2 of the online edition of his book *Don't Make Me Think* (2000), emphasized that most users quickly scan a web page and click on a link with words similar to the topic they are searching for. He explains that most users, like

drivers trying to scan a billboard, will not take time to read a lot of words. Morke and Nielsen (1997) also state that writing for the web should be to the point and scan-able. If design should be based on the users' characteristics, and most users scan websites, then websites should be designed to maximize their approach and success.

Since users scan websites, web designers need to scan their websites too. More than having the designer put himself in the users' shoes, S.C.A.N. is a memorable acronym encompassing key usability concepts in web design that have been identified in this literature review. Speed, Content, Appearance, and Navigation (S.C.A.N.) encompasses crucial usability concepts. Nielsen and Loranger's (2005) outline for their full day tutorials in 2005 directly identified speeds of use, content, navigation, and a few more topics to address as the most important usability items out of the more than 1200 documented usability guidelines. They also identified items related to appearance such as simplicity, multimedia, and interface. In addition, they identified items that are not likely to be implemented by a teacher designing a website, such as: designing database forms,

error messages and handling, and international users. Speed, content, appearance, and navigation are critical topics in web design that greatly affect whether a site is easy to use and likeable.

#### Usability Concept: Speed

Speed is a primary consideration for web design according to several usability researchers. Jakob Nielsen, usability expert and author of [www.useit.com](http://www.useit.com), has stressed on several occasions the necessity of speed. In his article *Sun's New Web Design*, he stated: "Fast downloads are the single most important usability consideration in Web design" (Nielsen, 1998, Speed section, ¶ 1). He also reported that survey data from 1,854 users showed that "...speed was more than three times as important as looks" (Nielsen, 1998, Speed section, ¶ 1). Though appearance is important and will be discussed later, speed should be a top priority. Also in his "Alertbox for March 1, 1997: The Need For Speed", he summarized his research stating: "Every Web usability study I have conducted since 1994 has shown the same thing: users beg us to speed up page downloads" (Nielsen, 1997, ¶ 1). Keith Instone (1997) calls access speed



"...currently one of the major constraints on design" (Bandwidth section, ¶ 1). Finally, Kirk Hallahan (2001), after reviewing literature from Nielsen, Spool, Kent, and Middleberg stated: "A review of the usability literature suggests that two criteria are paramount in websites: content and design simplicity" (Elements of effective websites section, ¶ 7). At first glance, it seems speed is not included, but one of the four design simplicity criteria emphasizes speed of use and speed of user decision-making.

Since both speeds of download and use are important, strategies for increasing both need to be addressed. Chris Lewis (2003), Ph.D. and designer of the course website "Web Design for the Arts and Humanities" at the University of Colorado, recommends designing web pages that can be downloaded within ten seconds and even trying the download on a 28K or 56K connection. To increase speed of download through design, Nielsen (1997) gives a solution: "To keep page sizes small, graphics should be kept to a minimum and multimedia effects should only be used when they truly add to the user's understanding of the information" (¶ 7). The design of each page should have even the slowest systems in mind and only use

necessary graphics or multimedia effects. Graphics should be saved at a minimum necessary size and resolution to reduce the file size and resulting download time. If several pictures are used, they could be grouped on one page. It is helpful to present thumbnail pictures first and then let the user click on the desired picture for enlargement (Abdullah, 1998). This insures that only those interested in downloading large photograph files are the ones doing the waiting and only when they choose to. Sound files and animated graphics files are usually not necessary and increase the download time.

To reduce the speed of use and decision-making, it is important to have your information accessed through short menus with concise text (Hallahan, 2001). Since users scan pages quickly, short lists will optimize their approach. To further aid their approach, links should be traditional blue hyperlinks, concise, and use the user's language. This maximizes user familiarity and minimizes time wasted from interpreting link color, terminology, or sifting through words.

## Usability Concept: Content

The second crucial concept in web design is content. Content is the reason the users want to access the website; it is all of the necessary visual, auditory, and written information that is present on the website. As stated earlier, Hallahan (2001) summarized web design as content and design simplicity. He quoted Nielsen: "Ultimately, content is king from a user's perspective" (Hallahan, 2001, Content section, ¶ 3). Since content is critical, website design should focus on the users early in order to learn who the users will be and what content they will want or need (USDHHS, 2005c). For teachers making project websites, the target users will be students and other teachers. The information they have come looking for will most likely include: 1) the requirements or guidelines for the project, 2) examples of final products, 3) student resources such as a tutorial and hyperlinks, and 4) teacher resources. Xiaoshi (2000) found that tutorials are one of the most helpful components in web-based learning sites. When tutorials include words and pictures, they can provide qualities of an embedded teacher (Lohr, 1998) and help students understand the content.

The content should be logically organized and effectively chunked to help the user quickly find and understand it. The content should be organized into categories the users are looking for with the most important information at the top of each menu. It should also be presented in a consistent way throughout each page and from page to page. For example, page titles should be consistently located and designed so that the user doesn't have to visually reinterpret the page to find the desired information.

The content should be presented concisely with the appropriate language. The language presented should be at a reasonable reading level and include the user's language to maximize the user's comprehension. For any reading level, the text should also fit on the screen without scrolling. The amount of text should be about half as much as for print (Hallahan, 2001). Even a decade ago, after redesigning Sun's website, Nielsen (1995) emphasized that users dislike missing content, scrolling, and that designers should use half the words. When necessary, new or potentially unknown words should be hyperlinked to a glossary or include short mouse-over definitions.

Throughout the website, content needs to be credible. To aid its credibility and possibly its accuracy, the site owner or designer should be identified (Zhang & von Dran, 2000). The Environmental Education and Training Partnership developed guidelines for educators to evaluate the content of websites. They recommended actually providing the owner or designer's email for feedback as well as a "date last updated" (North American Association for Environmental Education, 1999). The site owner, designer, and "date last updated" are easy to include and should be provided. An email address should only be provided if it is practical for the owner or designer to manage a potentially large number of emails.

#### Usability Concept: Appearance

The "A" in S.C.A.N. could stand for accessibility if the site being designed is a federal or federally funded site because of Section 508 of the Rehabilitation Act (USDHHS, 2005a). The focus of accessibility is providing the great variety of disabled users with equal access to internet resources. There is a prioritized checklist of strategies to make a website more usable to the disabled. This requires text equivalents for every picture and

audio files to explain video files. Pop-up windows and flashing screens or text should not be used. These and other format limitations are all discussed to maximize a website's usability for the disabled (W3C, 1999). Though the requirements of text equivalents can benefit all users, many other strategies require HTML programming skills and may hinder or prevent teachers from making project websites.

The third concept in the S.C.A.N. approach to design for usability is appearance. Nielsen (1996), a usability expert, states that websites need to be more than just efficient, they need to be seductive and that "high-quality graphics are the basis for the seductive experience, but are not enough in themselves" (Further explorations section, ¶ 2). In addition to speed and content, appearance is a major contributor to the likeability of a website and, like accessibility, addresses the site's visual layout and multimedia elements.

Although appearance is subjective, it is an important element of web design to visually attract and keep the users' interest without compromising the speed of use or content. After Nielsen discussed the priority

of speed in *Sun's New Web Design*, he stated "Of course, we still wanted the design to look good. Not only is .08 a positive weight (meaning that good graphic design adds quality in its own right), but we also found that a great visual appearance made users think more highly of the site" (1998, Speed section, ¶ 2). Improving appearance must not supersede the importance of making the site accessible though. The website needs to be accessible to most schools and classrooms, so the latest advances in multi-media effects should not be used. Though eye-catching, visuals or effects should not inhibit the ease of access and use (Hallahan, 2001).

One study shows that visual appearance increases user satisfaction for educational websites. Zhang and von Dran (2000) researched satisfiers and dissatisfiers in web design. They developed a two-factor model for web design addressing the need for websites to have both hygiene factors and motivator factors (Zhang & von Dran, 2000). The hygiene factors relate to the functionality of a website and when those factors are absent it causes dissatisfaction in the user, such as technical aspects, navigation, privacy, and security. Motivator factors relate to adding value to the website and when those

factors are present it causes satisfaction in the user, such as enjoyment, cognitive outcome, and credibility. Motivator factors relate to the likeability of a website. Eighty-six percent of the respondents believed some categories could be hygiene or motivator factors depending on the users' expectations for that type of website: "...as an example, visual appearance is hygiene for entertainment websites but motivator for educational websites" (Zhang & von Dran, 2000, p. 1263). This means that a good visual appearance led to higher user satisfaction with the website; the website was more likeable. This also means a lack of attractive appearance should not cause dissatisfaction in the user.

The results of a separate study also placed visual appearance as a motivating web design feature. On the Website Motivational Analysis Checklist, an "Eye-catching title and/or visual on home page" is listed to address the attention component of the ARCS Model of motivating website design (Small, 1997, Motivation Assessment Instruments section, ¶ 3). Eye-catching visuals in a website hold the attention of users, motivates them, and leads to a more satisfying, likeable, website.



Zhang and von Dran (2000) found the visual appearance category, though subjective, could be described by six features. They listed the following six features, quoted here, for visual appearance: "attractive/unattractive overall color use", "sharp/fuzzy displays", "visually attractive/unattractive screen layout", "attractive/unattractive screen background and pattern", "adequate/inadequate brightness of the screen/pages", and "presence/absence of eye-catching images or title on the homepage" (Zhang & von Dran, 2000, p. 1259). The six features can be used to make a survey, but that would only provide data on users' self-reported opinions (USDHHS, 2005b). Those opinions may depend on age, gender, culture (Hallahan, 2001), course subject, or trends that change with time. Since appearance is subjective, it would be best to survey a broad range of potential users and when possible, have them rate actual alternate designs.

*The Non-Designer's Web Book* (Williams & Tollett, 2000) explains how to actually produce a professional appearance. The home page and the critical information on the rest of the pages should fit within a 640 pixel wide by 460 pixel high screen space (pp. 150, 154), leaving

space for the browser in the commonly used 640 X 480 screen size. Though many monitors are larger with better resolution, no user would have to scroll sideways. This maximizes the design for most users, including lap top users (p. 128). Within that space, they give four design principles to make the appearance more professional: alignment, proximity, repetition, and contrast. "These principles are the underlying factors in every printed piece you see anywhere, on screen or elsewhere...your web or printed pages will look clean, neat, and professional" (p. 105).

Alignment means keeping one consistent vertical and horizontal alignment throughout the design, but not necessarily having all the text along the same edge of the entire screen. Proximity refers to visually grouping related elements and putting space between unrelated elements (p. 110), the "...spaces create a hierarchy of information" (p. 111). Repetitive, consistent, design and navigation for all pages in a website increases the user's familiarity with the site (p. 114). Finally, strong contrast between different elements is created by changing font, color, size or graphics. This can help the message or logo of the website stand out more clearly

(pp. 118-119). The text should have a strong contrast with the background to maximize readability. The color scheme should use a reasonable range of colors in the design, perhaps only four to seven (Abdullah, 1998).

#### Usability Concept: Navigation

Usability experts and lists agree that navigation with accurate links is a critical component of usability. Navigation is expected to function properly or users will be dissatisfied with the website (Zhang & von Dran, 2000). If there are errors in the navigation, such as broken, missing, or misdirected links, then just those navigation errors could make the site useless or turn users away.

The navigation should have a consistent design and be available on screen. Typically, links are blue text and underlined, but they can be color coordinated with the rest of the page if they are still obvious and consistent, not disguised as a picture (Williams & Tollett, 2000, p. 154). Consistency in navigation also provides the user with a sense of familiarity and allows more rapid decision-making and travel within the website.

Besides travel within a website, Keith Instone lists four topics that every navigation design should address on every web page. The navigation design should make it clear to the user: 1) what page they are on within the website, 2) how to get to the other pages, 3) what the other pages and website are about, and 4) the site "brand" (Instone, 1997, Structure section, ¶ 1). Beyond accurately taking the user from place to place within the website, the navigation should be consistent and provide a sense of meaning and location within the website.

#### Reasons to Give a Website a Usability Test-Drive

A website must be given a proper test drive to ensure that it performs well for its users (USDHHS, 2005d). Few people would buy a car that has never been test-driven. It must perform for the user and it does not matter what the designer intended or claims. Without user testing of a website, some problems will go unnoticed and some necessary improvements will not be made. Since websites should be tested a few times, a clear procedure for user testing of a website will be discussed.

The procedure must be user-friendly for beginning designers. If the procedure is too difficult for them,

the sites will not be tested and that can leave errors that turn away many users (Nielsen, Coyne, & Tahir, 2001). The result is students and teachers will be less likely to try the project. Even for the business world, the loss of business caused by the average individual designer is "...not nearly enough to justify the costs of hiring professional designers or paying for advanced usability work. Discount usability engineering is our only hope" (Nielsen, 1997, Amateur designers section, ¶ 3). He emphasizes that discount usability engineering must be cheap, simple, and fast enough so that individual departments or designers will actually do it. Discount usability engineering can be summed up as "simplified user testing with one or two users per design and heuristic evaluation" (Nielsen, 1997, Amateur designers section, ¶ 3).

Even though simple usability testing is designed to be relatively fast and easy to do, it still provides excellent results. Jared Spool (1999), a usability expert, describes their web design course in which students "...conduct simple usability tests with their classmates. The results are astounding -- within a few minutes, these designers have a list of changes that they

are ready to make to the site, based on just those simple tests" (Gathering user data section, ¶ 2). Even remote evaluation and feedback by students using lists of usability heuristics was reported to have a positive impact on the usability of sites in Melbourne and Canberra university classes (Collings & Pearce, 2002).

### Procedure for Usability Testing

The U.S. Department of Health and Human Services provides an outline for usability testing. It includes the following steps that will be applied to the situation of a teacher testing a website designed for students. The following steps for usability testing are quoted here:

"1) Plan scope, issues, participants, location, budget", "2) Develop scenarios", "3) Recruit test participants", "4) Conduct usability testing", and "5) Make good use of the test results" (USDHHS, 2005d, What are the steps in usability testing and in using the results section, ¶ 1).

For the sake of making this list more memorable and possibly a little easier for a teacher to implement, this author summarizes these usability testing steps as 1) Plan and Purpose, 2) Prepare, 3) Participants,

4) Perform, 5) Problem Solve. In addition, 6) Repeat has been added to ensure this important step.

#### Plan and Purpose

The first step in testing a website is to plan. The goal and logistics for two to three tests must be considered. For a business, the logistics may involve choices about test location and equipment, budget, and other issues such as security. For this study, the location is assumed to be in a school room with a computer and web browser available for multiple tests, no money for a test budget, and no security issues. The primary planning issue for this study is to determine the purpose, the goal of testing.

"The goal of usability testing is to find out what is and is not working well on the site" (USDHHS, 2005d, Overview section, ¶ 2). This is important because there are a variety of reasons and methods to gather data from users. These methods include a variety of surveys, interviews, focus groups, and usability testing methods (USDHHS, 2005b). Surveys, interviews, or focus groups provide self-reported data on the user's preferences and experiences, but usability testing provides data on where the site actually causes the user trouble (USDHHS,

2005b). A "usability test allows you to observe the user's actual behavior, its real forte is in telling you where the interface causes frustration" (Spool, 2005, Mistake #1 section, ¶ 4).

Sometimes users might like a site but were not able to use it or they could use it but did not like it (Spool, 2005). Since both are important, the first goal of user testing is to identify the problems so they can be fixed. The second goal is to make the site more likeable. To do this, usability testing will be used to improve functionality while a survey and interview questions will be used to help determine the likeability of the website's features.

#### Prepare

The second step is to prepare the materials that will be used to test the website. The instructions should even state that the website is being tested, not the user, and that any difficulties or problems simply show where the website needs to be improved.

Tasks. The test consists of specific and necessary tasks that potential users will need to perform using the actual website. Jared Spool explains that tasks should be designed with the following question in mind "What events



or conditions in the world would motivate someone to use this design?" (Spool, 2005, Mistake #4 section, ¶ 5). He explains that if the task is worded as simple directions, such as "find a bookcase", it will not expose usability problems (¶ 1). Instead, he explains, ask behavioral questions that relate to accomplishing specific and necessary tasks, such as "You have 200+ books.... Find a way to organize them" (¶ 2). It is important to design the tasks as simple scenarios with a real world "context of use" so the test may expose real usability problems, not participants' ability to follow specific steps (¶ 5).

For each major use or important page of the website, one task should be written to test it (King, 2003). Nielsen, Coyne, and Tahir (2001) emphasize that each task should be written in plain language without using specific website terms and presented on individual test pages. The tasks themselves should even be tried out and refined if they are misunderstood or take too long to perform within the testing period. Prepare the number of tasks so that the test will be less than an hour to reduce testing fatigue (Hallahan, 2001). For example, one usability study used 8 short tasks (Brown, 2002) and

another used 9 short tasks (Makar, 2003); these tests took users approximately 30 minutes.

Observation Sheets. To maximize the effectiveness of observations during the usability test, it is critical to plan what will be observed and how the information can best be recorded. This helps focus the observations and can make them more efficient, especially if one can "prepare check sheets to speed recordings of observations" (Hallahan, 2001, Appendix section, Figure 1). If a check sheet is too time consuming to develop, especially with the limited experience teachers will have, a blank table can be created with space to write short notes and abbreviations for observations.

The goal is to observe and record where the site needs improvement and what causes the user problems or frustration, so there must be space for it on the observation sheet. The following are example headings that might be included on an observation data table:

- 1) webpage name,
- 2) download time,
- 3) time on webpage,
- and 4) user action(s), frustrations or problems.

There should be space to record data for each page the user accesses and the data should be short, abbreviated, or even coded. For example, web-pages can be referred to as

numbers and check marks can be used to indicate download times less than a few seconds. The "user action(s), frustrations or problems" are the focus of the test and user's words and actions should be summarized. Notes should be recorded that concentrate on "...observations of behavior rather than inferences" (USDHHS, 2005d, Steps in usability testing section, ¶ 4). For example, notes may summarize a user's behavior as scanned and clicked link, moved cursor between two links, or long pause and quit (Nielsen, Coyne, & Tahir, 2001). The observation sheets are included in Appendix J.

Survey and Interview Questions. Since the second goal of a teacher would likely be to determine the website's likeability, the most appropriate approach would be a follow-up survey and interview questions to determine user preferences. A few strategies will be given here to expedite the process.

To improve likeability, a survey can be used to determine basic user preferences regarding the website's appearance. After a few user background questions, such as web usage and knowledge related to the website, survey questions addressing the appearance need to be included. As discussed, Zhang and von Dran (2000) found that the

appearance of a website could be described by six features. Since each feature can be rated between the two opposite descriptions, it makes a simple survey item to confirm users' like or dislike of the feature. The survey is included in the Appendix K with the interview questions.

Interview questions should be brief and provide the designer with specific feedback related to the site (USDHHS, 2005d). There are questionnaires available, but they should only be used if they will provide specific data to meet the testing goal. One example is the MUMMS, Measuring the Usability of Multi-Media Systems, from the Human Factors Research Group (Human Factors Research Group, n.d.; Phelps & Reynolds, 1999). Another questionnaire for teachers and students is the WebMAC, Website Motivational Analysis Checklist (Small & Arnone, 2005), "...an instrument used for designing and assessing the motivational quality of World Wide Web sites" (Small, 1997, Motivation assessment instruments section, ¶ 3).

Some questions should solicit participants' reactions to core aspects of the web design, such as speed, content, appearance and navigation. There may also be a need to include questions related to preferences

based on culture or other attributes of the user (Hallahan, 2001). This may be especially important for websites that need to represent diverse or opposing opinions and experiences accurately without making one side look or feel bad.

Other questions addressing likeability include open-ended questions. Open-ended questions give the user an opportunity to provide various or unexpected feedback (Brown, 2002). As stated before, this should include questions about their experiences and preferences (USDHHS, 2005b). For example, questions should ask what parts of the site they liked and why, what parts of the site they did not like and why, and what could be added, subtracted, or changed to improve the site. The interview questions are included in Appendix K with the survey.

Once the tasks, survey, and interview questions are prepared, an application to use human subjects for research should be completed and filed with the appropriate review boards as necessary.

### Participants

Most experts agree that a few users per design and two to three tests is best, so recruiting should meet these needs. For discount usability engineering, Nielsen

recommended "...user testing with one or two users per design and heuristic evaluation" (Nielsen, 1997, Amateur designers section, ¶ 3). Jared Spool reports his team feels they reach "...the point of least astonishment..." after six to ten users, even though four is enough in some cases (Spool, 1999, Gathering user data section, ¶ 5). The USDHHS recommends five to twelve total users (USDHHS, 2005b). A problem that would be common to most users seems to surface within a couple users. Once changes have been made, new participants can be used to retest the redesigned site to verify the changes were helpful. Since there will likely be two or three tests and at least one to five users are needed for each test (Hallahan, 2001), it seems one must recruit at least three and up to fifteen users.

Possibly more important than the actual number of users is the type of user recruited. It is critical to recruit users that match and "...accurately represent your current or potential users" (USDHHS, 2005d, What are the steps in usability testing section, ¶ 3). Without participants that match your potential users, it is possible to miss problems and completely waste all of the efforts devoted to usability testing. As Jared Spool

(2005) explains, if the recruited participants are far more skilled than your potential users, they will not expose the same problems with the webpage that your real-world users will have. Likewise, if the recruited participants are far less skilled than your potential users, they may have problems that your potential users will not have. For this reason, professional usability tests may need to use a company that specializes in recruiting participants. The test is dependent on the recruited participants matching your potential users.

Even if a database or company that specializes in finding usability testing participants is used, Jared Spool explains it is best to start by asking "What attributes will cause one user to behave differently than another?" (Spool, 2005, Mistake #3 section, ¶ 4). It is possible to match many attributes of the participants with the potential users, such as age and gender, but what is critical to their use of the webpage? Jared Spool states that "One common mistake is to focus on demographics (such as age and income) and not look at those distinctions that make the users behave differently, such as their fluency in the design's content area" (Spool, 2005, Mistake #3 section, ¶ 3). For

an educational website, efforts should be made to recruit students with a range of knowledge in the content area. Similarly, since testing involves using a website, teachers should recruit participants with a broad range of internet usage. Since both factors may significantly affect the users' actions during usability testing. Recruit participants to best represent the key diversity in potential users.

### Perform

Since the website has been designed and preparations made, the next step is to facilitate the usability test. Tests can be performed in usability labs with monitoring equipment (Hallahan, 2001), but for teachers, testing should take place in homes or in classrooms with a variety of computers their students are likely to use. Keith Instone (1997) states that, when possible, usability testing should be done using a variety of computers that potential users would view the website with, including ones that have slow processing speeds and older versions of browsers. Observing users on a variety of computers and browsers will help expose new usability problems so that they can be fixed or the website improved.



According to Nielsen, Coyne, and Tahir (2001), the test should take 20 minutes to 2 hours, have up to three observers that do not talk or aid the user, instructions that emphasize testing the website and not the user, and the user should think out loud. Kirk Hallahan (2001) limits the test time to less than an hour then has users complete a questionnaire and debriefing. The USDHHS (2005d) agrees that users should think out loud and that the facilitators should not lead them in any way; sometimes using trained facilitators and observers is best.

Teachers would not need to arrange the videotaping of a web testing session for analysis. This may seem like a loss, but even usability expert Jared Spool states that his team treats "...video like backup tapes -- 99% of the time you never look at them; 1% of the time you'll be very glad you made them" (Spool, 1999, Gathering user data section, ¶ 2). It may only be useful if there was a design team and some were not able to observe the test.

#### Problem Solve

Even before the usability testing is over, the designer likely has a mental list of problems and potential solutions. In more formal settings, there may

be reports produced, review sessions, email discussions, and workshops to share the results and develop solutions (Spool, 2005). Regardless of the setting, it is important to analyze the results and determine both where and what the problems are. To quantitatively analyze the data, the number of clicks, path frequency, or time to complete the task can be compared to the optimal path (Makar, 2003). For teachers, rather than counting and comparing results for each user on each task, and not really knowing what numerical differences are significant, the data can be qualitatively analyzed. To qualitatively analyze data, the notes of user behavior and responses to questions should be studied and conclusions made case by case.

The designer should start by making a list from the data, marking the biggest or most frequent problems (USDHHS, 2005d). This list should state what each problem was and where it occurred. It should be determined from the data if the problem is from wording or a design problem (King, 2003). Potential solutions need to be brainstormed and may come from reconsidering the basic usability themes already discussed. The potential solutions then need to be designed into the website and tested. Some experts use paper mockups to redesign

websites and have them ready for testing within a matter of minutes (Spool, 1999).

### Repeat

The usability testing process has been summed up as "Test, edit, repeat: Steps to improve your website" (Brown, 2002, p. 1). Usability experts agree that the re-designed website must be re-tested (Instone, 1997; Nielsen, Coyne, & Tahir, 2001; Spool, 2005; USDHHS, 2005d). The usability test may result in a complete failure if the potential solutions are not also tested. Without testing the redesigned website, it is not known if the solution fixed the problem, relocated it, or made the website worse (Spool, 2005). Simple usability testing, including repeat testing, has been shown to improve the usability of a variety of sites: a web-based course in meteorology (Phelps & Reynolds, 1999), the Kansas City Public Library website (King, 2003), another library website at Hampshire college in Massachusetts (Brown, 2002), and the National Institute of Standards and Technology Virtual Library (NVL) website in Maryland (Makar, 2003). Repeating the testing process two to three times is crucial to testing and improving a website.

## An Instructional Design Model for Website Production

Since a project website will be part of an instructional program, an instructional design model will be followed to develop it. The Dick and Carey model, Kemp model, and ADDIE model are three distinct approaches (McGriff, 2001) out of "...more than 100 different ISD models, but almost all are based on the generic "ADDIE" model" (Kruse, 2002, The ADDIE model section, ¶ 1). McGriff (2001) describes the ADDIE model as "...a general purpose model, most useful for creating instructional products, but also applicable for program design" (¶ 3). According to McGriff (2001), the Dick and Carey model is best used to produce curriculum and programs while the Kemp model is best used to produce large programs with a variety of resources. Since a project website will be used as an instructional tool, the ADDIE instructional design model will be followed.

ADDIE has even been used to define instructional design as "...the *systematic* approach to the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) of learning materials and activities" (McGriff, 2000, ¶ 1). These five phases for making instructional

programs or products can be summarized in other ways. For example, Willis (1992) summed up the instructional design process as a four-phase process of design, development, evaluation, and revision. Plotnick (1997) summarized it as analysis, design, development, and evaluation. Rather than including a critical phase as part of another phase, it would be beneficial to explicitly describe the five common phases of the instructional design model known as ADDIE.

The first phase of ADDIE is analysis because the needs should be determined and the problem defined before design of a product begins. The gap between what the students need to be able to do and what they currently can do should be determined (Willis, 1992; Kruse, 2002). Often, this is in the form of "...defining the problem or need, understanding the audience, and identifying instructional goals and objectives" (Willis, 1992, p. 2). In addition to defining the problem, its source and solutions should also be considered (McGriff, 2000) with the help of external data and past experiences (Willis, 1992). In the analysis phase, both the problem and the potential solutions should be considered so that the best solution or instructional product can be designed. For a

project website, analysis would focus on the student needs and teacher goals for creating the website. Any similar existing resources, websites, and usability concepts can be used to help determine the best web design solution.

The second phase of ADDIE is design because the potential solution must be planned in more detail before it can be fully developed. To meet the student needs and instructional goals from the analysis phase, some of the details that need to be addressed include documentation of "...specific learning objectives, assessment instruments, exercises, and content" (Kruse, 2002, The ADDIE model section, ¶ 2). In addition, McGriff (2000) states the design phase includes choosing a delivery method and order. In the design phase for a website, the usability concepts from S.C.A.N. should also be considered. The content would need to be determined and organized based on the instructional goals and student needs, giving some structure to the navigation and possible appearance of the website.

Before reaching the development phase, it may be more efficient to produce a prototype of the instructional product to verify its usefulness before

developing a full version (Kruse, 2002). According to Kruse (2002), the advantages of making a rapid prototype are twofold. First, the users' reactions and the product's usefulness or effectiveness can be observed and tested. Once this preliminary information has been examined, the prototype can be revised. It is usually easier to modify a prototype or even create a new prototype than it would be for a full version of the instructional product. The second advantage of making a rapid prototype is that the development phase of the instructional design process will proceed more quickly and with more confidence since it is based on a working model (Kruse, 2002).

The third phase of ADDIE is development because a full version of the instructional product and materials will be completed (McGriff, 2000; Kruse, 2002). The development of the instructional materials always needs to reflect the needs, goals, audience, and planned content (Willis, 1992). Before developing a new product from scratch though, it is always helpful to search for existing ones and consider their effectiveness (Willis, 1992; Tester, 2005). If new development begins, the delivery method and technologies need to be finalized so

that the products and materials can be available and accessible to the users (Willis, 1992). All instructional materials, administrative materials, and usability testing materials need to be completed at this development phase so that they can be tested and revised.

Successful website development can be accomplished by preparing the website for an alpha test and beta test. The alpha test involves expert feedback regarding the design and content of the product. The beta test involves the usability testing procedures previously discussed, observing users on the website, re-designing, re-testing, and obtaining feedback from them regarding their preferences. This may expose a lot of usability problems that can be fixed to make the site ready for implementation.

The fourth phase is implementation. In this phase, the materials are distributed and presented to the students (Kruse, 2002; Tester, 2005; McGriff, 2000). The implementation should involve consistent, quality instruction and take place in an environment matching its expected use: classroom, lab, or computer room (McGriff, 2000). During the implementation phase, it is important to keep careful records so that the data obtained while



using the product can be analyzed. The data from the presentation and the actual project will be examined in the next phase so that the products can be improved.

Evaluation, the fifth phase of ADDIE focuses on "the effectiveness of the training materials" (Kruse, 2002, The ADDIE model section, ¶ 2). Evaluation may be done qualitatively, such as case studies and observations of small groups, and quantitatively, for mathematical analysis to determine relationships of variables. According to Willis (1992), "Qualitative approaches may be of special value to the distance educator because the diversity of students may defy statistically relevant stratification and analysis" (p. 4). Since a teacher's project website would be accessed remotely by a wide-variety of students, it is similar to a distance education website. It is also not likely that a teacher will have the time, desire or ability to gather large quantities of quantitative data and analyze it to improve a project website. For these reasons, simple qualitative methods of evaluation will be discussed.

There are two types of evaluation in this phase: formative and summative (Willis, 1992; Plotnick, 1997; McGriff, 2000). Both can be done using qualitative and

quantitative methods, but only simple qualitative methods will be discussed below. Formative evaluation really takes place throughout the ADDIE process to improve the results of each phase (Tester, 2005; McGriff, 2000). For example, formative evaluation of the design and development phases would examine how closely the product reflects the needs and goals determined in the analysis phase. Formative evaluation of the development phase would focus on improving the usability testing materials to get better feedback from the users. Formative evaluation of the implementation phase would focus on improving the instruction during that phase as well as result in final revisions of the instructional materials. "There is room for improvement in even the most carefully developed distance-delivered course, and the need for revision should be anticipated" (Willis, 1992, p. 4). Every formative evaluation does not need to be formalized and time-consuming. Sometimes the best source of ideas for revision comes from the teacher's own reflections (Willis, 1992). The results from each phase of the ADDIE process should be evaluated to improve them and the final product.

Usually after a final version of the instructional product or materials is complete, summative evaluation occurs (McGriff, 2000). Summative evaluation focuses on whether or not the needs and goals were met and the problem solved. For example, was the training time-efficient and how well do the users actually complete the task that the training addressed? (Tester, 2005). For this report and project, the summative evaluation involved using the data from the implementation phase to determine if the project was motivational and educational, meeting the targeted objectives. For most teacher designed websites, a summative evaluation would involve analyzing how many students actually complete their final projects with success and excellence.

#### Summary

The literature important to the project was presented in Chapter Two. Specifically, making science resources available through the internet, the importance of website usability, designing a usable website, reasons to give a website a usability test-drive, procedure for

usability testing, and an instructional design model for website production.

Research shows that hands-on projects can be motivating and enriching for many students, especially when the projects involve them in real-world contexts. Research also shows that the right web resources can enhance education by providing more interaction, opportunities for various learning styles, creativity, independent learning, and developing real-world problem solving skills. To benefit from both hands-on projects and the right web resources, websites should be developed for design projects that target appropriate learning objectives.

The developed website must be usable. It should be easy to use and liked by its intended audience. Four usability themes emerged from the literature review to help teacher's accomplish this in a website design. The S.C.A.N. acronym was used to easily remember and apply the four usability concepts of speed, content, appearance, and navigation. The site should download quickly and allow the user to quickly make decisions. The content should be concise, accurate, and organized into menus for easy access. The appearance should be appealing

and accessible to all users, including ones with disabilities or ones using older technology. The navigation should be consistent, available, and provide a sense of location within the website.

The ADDIE instructional design model was selected for the process of developing the website. For the analysis phase, the instructional needs should be analyzed. For the design phase, the website content and layout should be planned. For the development phase, the website should be examined by experts and tested by potential users for its usability. This requires planning logistics, preparing usability test materials, recruiting participants, performing the test, solving problems identified with the website, and repeating the testing process for major website redesigns. For the implementation phase, the website should be used and outcomes observed in an appropriate educational setting. Finally, for the evaluation phase, data from the implementation phase should be used to analyze the success of the website.

## CHAPTER THREE

### METHODOLOGY

#### Introduction

Chapter Three documents the steps used in developing the website. Following the ADDIE instructional design model, the steps included are the analysis of the population served, the website design and development, and its implementation and evaluation.

#### Population Served

The population served included high school physics students and their teachers. The following analysis describes those students, what instructional needs they had, and how attainment of those needs was measured.

Typical high school physics students at Martin Luther King High School, Riverside, CA, were juniors or seniors that have met the algebra prerequisite for regular physics or the pre-calculus prerequisite for AP Physics. The author's physics classes consisted of 88 students, about one-third AP students and two-thirds regular physics students. Collectively, they were a heterogeneous group, seemingly representative of the school's population regarding ethnicity and

socio-economic backgrounds, but about two-thirds were males and one-third were females. Nearly all of the students had access to the internet at home and all of the students had access to the internet in their science classroom and at their school.

The physics curriculum focused on required state standards and was guided by a district-wide pacing guide. Projects were assigned to add interactivity, creativity, and real-world problem-solving skills to the course. By the time the Electric Motorboat Drag Racing project was assigned, students had completed most of the state standards required. This project helped them apply and synthesize standards from the beginning and end of the academic year, but not to learn them for the first time.

Since this project was designed by the author in 1997 as a summative project, prior instruction on most or all of the standards was assumed. The project website did not need to teach the physics concepts themselves, but it did need to provide information for students and teachers to complete the project successfully. To complete their project, students needed a website that provided the following: 1) rules and parameters for the project, and 2) supporting resources including pictures of example

boats, a tutorial, and helpful links. In addition, the website provided teachers with resources and details on how to prepare for, grade, and officiate the electric motorboat drag racing tournament.

The electric motorboat project provided a hands-on activity for students to apply at least two content standards from the California State Standards in Physics and one Investigation and Experimentation standard for all sciences. The standards selected from the state standards (California State Board of Education, 2003) were:

- 1b. Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law). (p. 40)
- 5a. Students know how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors. (p. 43)
- I. and E. 1c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. (p. 61)



Measurable evidence that students attained the selected standards, at least in part, consisted of the following. For standard 1b, students demonstrated they knew the standard, at least in part, by designing a boat to accelerate itself as a result of an unbalanced force. If their boat did not propel itself at first, because the forces were balanced, and they fixed it by causing an unbalanced force, they also demonstrated they knew the standard. They further demonstrated they knew the standard by trying to improve or maximize the amount of unbalanced force that propelled the boat. This was done by increasing the force from the motor or decreasing the resistance forces that opposed the boat's motion. They also demonstrated an understanding of the affect of the net force by reducing the boat's mass to increase its acceleration.

For standard 5a, students demonstrated they knew the standard, at least in part, by powering their boat with a properly wired DC circuit, using the batteries to provide the motor with a definite voltage and current. If their motor did not turn on at first, because it was not receiving enough current, and they fixed it by properly rewiring the circuit or replacing the batteries, they

also demonstrated they knew the standard. They further demonstrated they knew this standard by trying to maximize the amount of voltage or current that powered the motor by properly selecting or adding batteries.

For investigation and experimentation standard 1c, students demonstrated they knew the standard anytime they noticed inconsistent performance from their boat, identified the problem, and fixed it.

The following data were used to measure attainment of the standards. For a general understanding of applying the three standards, the total number and percent of boats that were completed and those that successfully completed the five-meter race were determined. For standard 1b, the total number and percent of boats that were fixed or adjusted related to forces was determined. For standard 5a, the total number and percent of boats that were fixed or adjusted related to the circuit was determined. For standard 1c, the total number and percentage of boats fixed or improved in any way was determined. These measurements showed, at least in part, that the students were able to apply and synthesize the three selected physics standards.

## Website Design, Development, Implementation, and Evaluation

### Website Design

The original Electric Motorboat Drag Racing website was previously constructed as part of a graduate course and was not made available online. The author's goal was to take his Electric Motorboat Drag Racing project and make a new website, <http://www.electricboatproject.com>, so that other schools could use it.

The original site design was based on its anticipated use in the author's classroom. Microsoft® FrontPage® 2002 was chosen to create the site because of its availability and the author's familiarity with it. The appearance was kept simple and efforts were made to apply alignment, proximity, repetition, and contrast concepts from *The Non-Designer's Web Book* (Williams & Tollett, 2000). All of the content was organized and accessed through the menu on the homepage. The homepage was titled with a water-textured font and had an image showing a motorboat, held by its designer, with the drag-strips in the background (Figure 1).

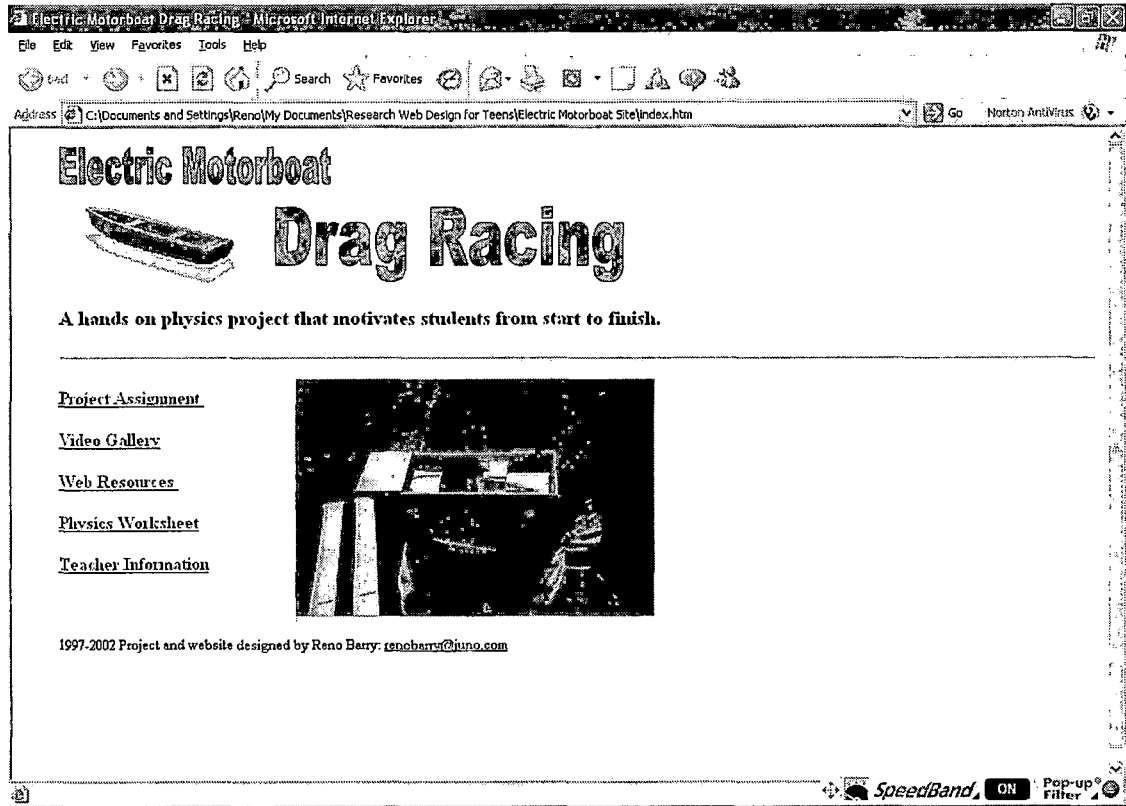


Figure 1. Original Electric Motorboat Drag Racing Homepage

Each menu link had its purpose at the time. The Project Assignment link accessed the assignment guidelines: objective, due date, grading, teams, boat designs, motors, and materials. The Video Gallery link accessed three video clips. Two of the video clips showed a few boats racing from start to finish while one explained Newton's third law. The Web Resources link provided links to five other resources, mostly related to model boat design because there were not any specific

resources related to electric motorboat drag-racing in rain gutters. The Physics Worksheet link accessed a downloadable worksheet that was too difficult and required the application of many physics concepts not included in the state standards. The final link, Teacher Information, accessed an anchored page to help teachers manage the project and address the following: grade appropriateness, goals of the designer, project timeline, setup of the rain gutters, and administrating the tournament.

As a result of the literature review and having the S.C.A.N. usability concepts in mind, the following design changes were made prior to any testing of the website. In relation to the speed of use and download speed, the video gallery was switched to a photo gallery and enlarged pictures were made accessible through thumbnails in a table. This provided students with faster access to a better variety of boat examples and close-ups. The best video clip remained accessible through the photo gallery to give clear ideas of the rain gutter setup and the dynamics of electric motorboat drag racing.

Other content changes were also made. The worksheet was simplified and redesigned to focus on content from

the published, statewide, standards. Content of the project assignment, such as due date and grading, was also altered to allow for other teachers to fit the project into their course timelines and grading systems. The rest of the site content was edited so that no prior knowledge of the project was needed. Lastly, a simple tutorial replaced the outdated web resources. It was not a "How to" manual because that would reduce the project to how well the directions were written and followed. The tutorial broke the project into four manageable steps and gave students additional websites as resources (Figure 2). The tutorial was designed as scaffolding to help students complete the project successfully.

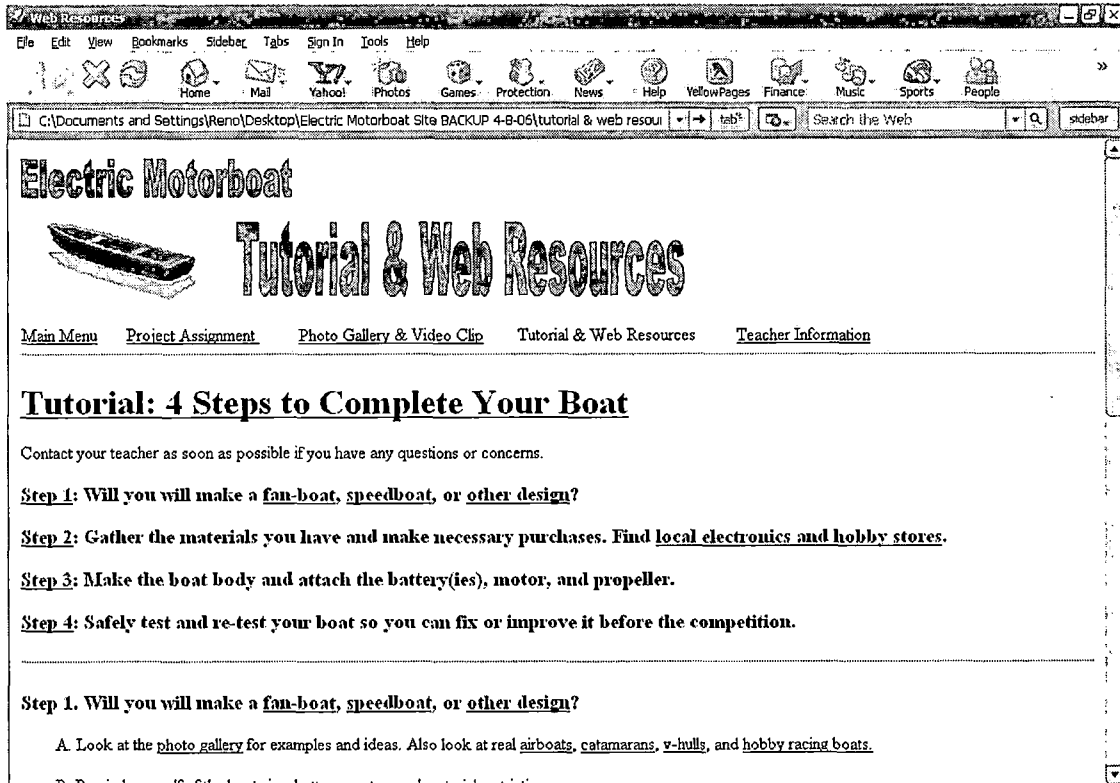


Figure 2. Tutorial and Web Resources Before Alpha Testing

In relation to appearance, few changes were made to the original website, but the navigation needed critical changes. The appearance was kept simple to ensure its accessibility and to appeal to teachers since they make the decision to make the project an assignment. The original navigation needed dramatic changes because it was not available within the site nor did it provide a sense of location within the site. The first deficiency was corrected by replacing a "Back to Main Menu" link on each page with a complete menu on each page. The second

deficiency was corrected by titling each page to match its link on the menu.

### Website Development

Discount usability engineering involves expert reviews and simplified user testing, discussed here as alpha and beta testing. For the alpha test, two content teachers and two website design teachers were recruited to get their expert feedback. The focus group of content teachers addressed how well the site met the educational goals selected from the California Content Standards for Physics. The focus group of website design teachers addressed how well the site design met web design goals, common web design expectations, and the users' needs. The site was then changed to incorporate much of their feedback. For the beta test, usability testing was performed with five users, one at a time, to expose site problems and make changes before the next test. The final usability tests confirmed the usefulness of the changes but additional feedback and solutions were still sought out. The completed website was then implemented at the school site.

Alpha Test. The following paragraphs describe each focus group meeting in terms of the information gained



from it, the changes made to the website as a result, and reasons that some changes were not made.

The first focus group consisted of two physics teachers from a local school district. They were asked to read and sign the "Informed Consent for Adult Participants" (Appendix A); this form was required for all adult participants thereafter. The teachers addressed how well the site would help students attain the selected physics standards by discussing questions from the "Focus Group Questions for Content Teachers" (Appendix B). After the focus group, the teachers were given the "Debriefing Statement" (Appendix C); this statement was also given to all recruits upon completion of their participation. Each teacher gave about 30 minutes of their time to provide thoughtful feedback on the site.

In question 1 from the questions for content teachers (Appendix B), the two physics teachers rated the project and site on a six point scale, six being best, according to how well it would help students learn each selected standard. The average rating for Investigation and Experimentation standard 1c was 5.5, for motion and forces standard 1b was 5.5, and for electricity and magnetism standard 5a was 4.5. In question 2, both

recommended adding more standards that the project partially addresses, but not removing any of the three selected standards. In question 3, addressing student evidence of learning selected standards, both teachers felt students making specific changes or improvements to their boats would demonstrate their knowledge of the standards. For attainment of standard 5a, teachers specifically recommended students complete the physics worksheet and not just have their circuit function on the boat.

Finally, for question 5, neither teacher felt anything should be subtracted from the project or site, but they had suggestions for adding to it. One teacher experienced the need for a "New here?" link and felt a review sheet or more tips for teachers could be added to the site. The other teacher suggested a project summary that emphasized many standards, minimal class time requirements and had access to all printouts, including a sheet for grading and a tournament tree diagram.

In response to this feedback, links were added for those new to the site, additional tips were added and clarified throughout the site, and a project summary was added as the first section in the information for

teachers. The project summary encapsulated the project in a table and gave teachers a tool to quickly decide whether or not they wanted to do the project. It also emphasized the additional related standards, minimal class time requirements, and provided access to printable handouts for the project rules (Appendix D), grade sheet (Appendix E), tournament tree (Appendix F), and physics worksheet (Appendix G). The project summary made the site more usable for teachers and connected multiple physics standards with the real world, hands-on, project (Figure 3).

Electric Motorboat Teacher Information, Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites

Address http://www.electricboatproject.com/teacher%20information.htm#Start%20Here%20Project%20Summary

Search Web Mail Yahoo! Photos Games News Yellow Pages

### 1. Start Here: Project Summary

Electric Motorboat Drag Racing is a culminating activity for high school physics.

Students design, build & race model-sized electric motorboats. For printouts:

Activity	CA Physics Standards	Materials	Timeline	Printouts (need Adobe Reader)
Electric Motorboat Drag Racing	<ul style="list-style-type: none"> <li>• Motion &amp; Forces 1b</li> <li>• E &amp; M 5a</li> <li>• Inv. &amp; Exp. 1c</li> </ul>	<ul style="list-style-type: none"> <li>• this website</li> <li>• rain gutters (\$40)</li> <li>• 3 stopwatches</li> </ul>	<ul style="list-style-type: none"> <li>• 1 class: assign</li> <li>• 6 weeks: HW</li> <li>• 2 classes: grade &amp; race</li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Project Rules</a></li> <li>• <a href="#">Grade Sheet</a></li> <li>• <a href="#">Tournament Tree</a></li> </ul>
Electric Motorboat Physics Worksheet	<ul style="list-style-type: none"> <li>• 1a, 1b, 1c, 1d</li> <li>• 2a, 2c, 3a, 4a</li> <li>• 5a, 5b, 5c</li> <li>• Inv. &amp; Exp. 1a, 1b, 1c, 1d, 1i</li> </ul>	<ul style="list-style-type: none"> <li>• boat &amp; race times</li> <li>• electronic balance</li> <li>• multi-meter</li> </ul>	<ul style="list-style-type: none"> <li>• 1 class</li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Physics Worksheet</a></li> </ul>

[Back to Top](#)

### 2. Selected California Content Standards for Physics

The project gives students hands-on experience with these [CA Content Standards for Physics](#):

Figure 3. Project Summary in Information for Teachers

Both content teachers stated that in addition to making a boat that functioned properly, students could demonstrate their knowledge of the standards by fixing or improving their boat. Though true, it was not made a part of the grading sheet for the following reasons: 1) it is difficult to verify which group fixed or improved their boat because groups are spread out and many adjustments are made during the competition, 2) it is too much to manage in addition to the teacher's officiating responsibilities, 3) it makes good follow-up questions

and was included in at least two questions on the physics worksheet.

The second focus group consisted of two web design teachers from a local school district. The teachers addressed how well the site met the web design goals and the users' needs by discussing questions from the "Focus Group Questions for Web Design Teachers" (Appendix H). Each teacher gave about 30 minutes of their time to provide thoughtful feedback on the site.

In question 1 from the questions for web design teachers (Appendix H), the two teachers rated the project and site on a six point scale, six being best, according to how well it met the five design objectives described on the questionnaire. For objective 1, related to the audience and purpose, the average rating was a 6. For objective 2, related to speed of download and use, the average rating was a 5. For objective 3, related to content, the average rating was a 6. For objective 4, related to appearance, the average rating was a 4.5. For objective 5, related to navigation, the average rating was a 5.5.

There were a variety of recommendations given in response to questions 2 and 3 to help the site better

meet its design objectives as well as common web design expectations. For speed of use, both mentioned the video needed to download faster. A variety of recommendations were discussed relating to appearance, the lowest rated aspect of the site. Both made recommendations to correct the alignment of the layout; one recommended the use of fixed table sizes. The headers of each page were recommended to be made into picture files so that font substitution or other appearance changes would not take place. Making the pictures into a slide show format for easier navigation, making headings a few points larger, and adding light color to table backgrounds were also suggested. For navigation, one suggested a horizontal menu bar and the other recommended placing navigation text-links as page footers for accessibility compliance. In addition, it was recommended for links to appear highlighted on mouse-over. For question 4, no new suggestions were given for adding to or subtracting from the project or website.

In response to this feedback, the alignment was changed with the use of fixed tables. The tables were fixed at 600 pixels wide and centered to fit the lowest screen size yet look pleasing on larger screen sizes. A

menu bar was added and text navigation was placed in the footer of each page (Figure 4).

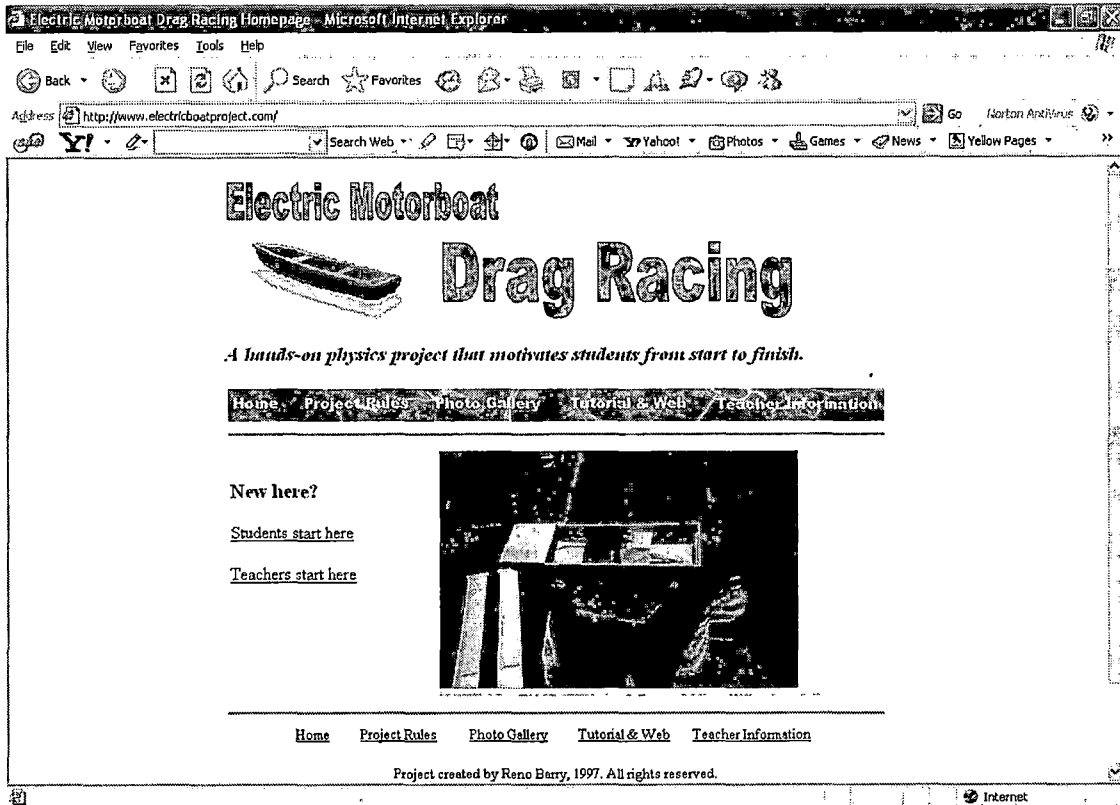


Figure 4. Homepage Before Implementation

To further address the feedback, headings were consistently made two points larger than the text and bolded. Also, links were made to change color to a light brown during a mouse-over to highlight them. Lastly, to improve the photo gallery, the pictures in table format (Figure 5) were also made available as a slide show. The

slide show webpage also included the menu bar and navigation to aid picture selection (Figure 6).

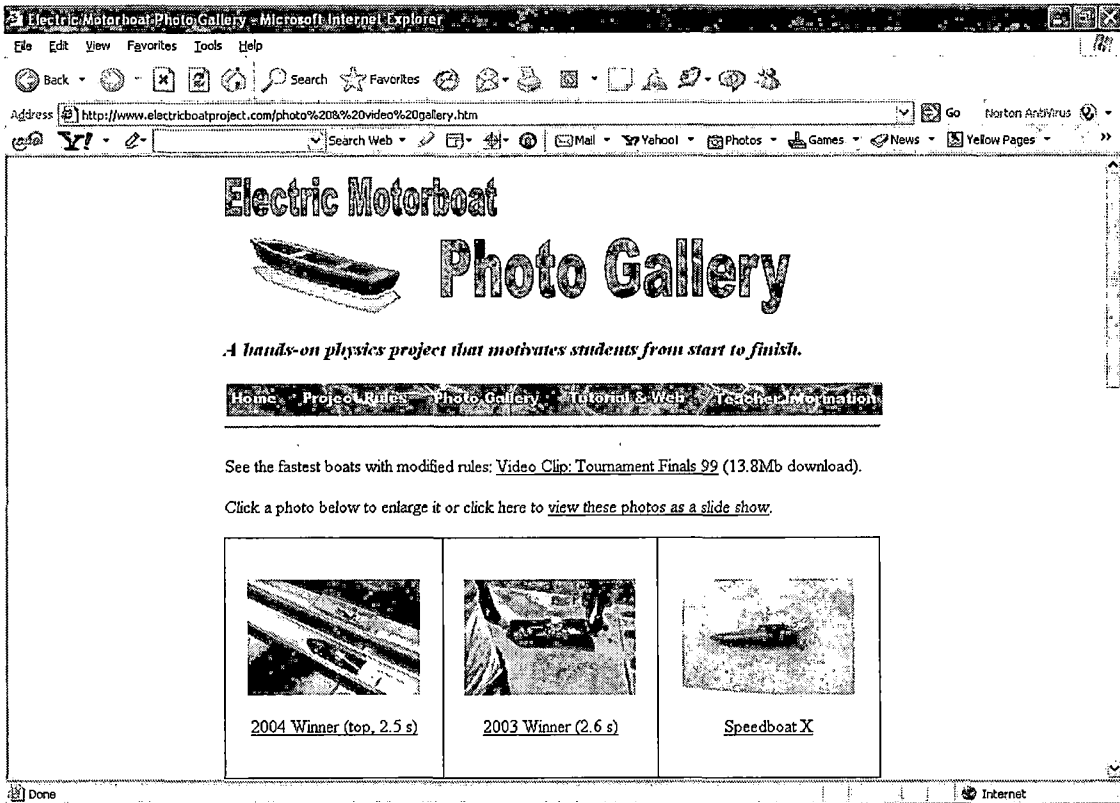


Figure 5. Photo Gallery Table Before Implementation



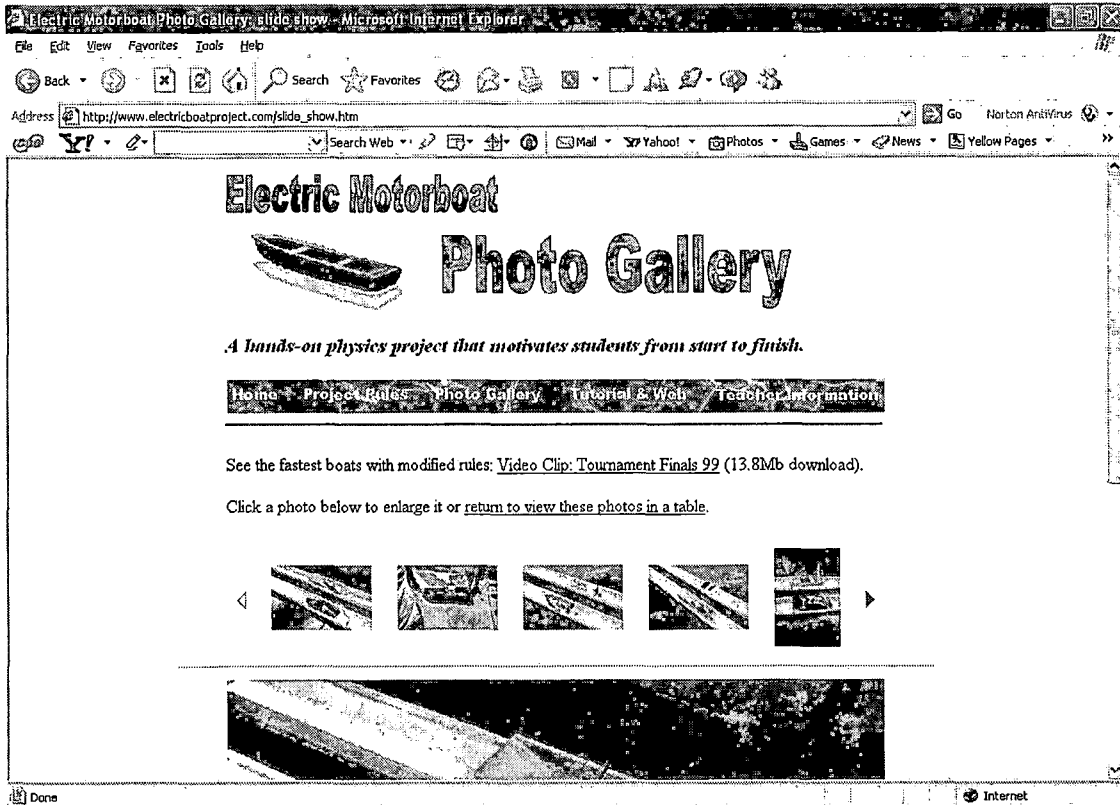


Figure 6. Photo Gallery Slide-Show Before Implementation

Some appearance changes, such as the header and background color, were not made for the implementation phase. These were not done so that more time could be given to consider potential color schemes and a better logo. A faster flash video format was also attempted but not completed before the implementation phase because of technical difficulties.

After these improvements, additional and open-ended feedback from three other web design professionals was sought out. They were asked to provide recommendations to

improve the website. They provided many ideas of how the website could be improved and even suggested the development of a list of future improvements for the next version of the site.

One theme of this feedback was browser independence, not just screen size independence. The site had been developed for the Internet Explorer browser because it seems a large number of schools use it, but some home computers or schools may not use it. This was suggested because text in the headers and the slide show layout were found to have faults when viewed on Mozilla Firefox, a different internet browser. A second theme of the feedback was accessibility and Bobby-compliance. Bobby, named after British police officers, is a Web authoring tool that checks a website's accessibility for the disabled according to Section 508 of the Rehabilitation Act (United Way of New York City, 2001). Feedback from the design professionals included using alternate text tags on all links as well as captions on all pictures to aid accessibility for those using website readers. Headers were not changed at this time but alternate text tags were implemented.

Many refinements were also recommended, including the use of a contact form, matching the URL to the homepage title, matching page titles in the browser to page titles displayed on the website, changing downloadable documents to Portable Document Format (PDF), improving the tutorial, and improving the file structure to make site maintenance easier. The browser page titles were matched to the website screen titles and downloadable files were changed to Portable Document Format (PDF). Other recommendations were placed on the list of future improvements for consideration.

Beta Test. The five participants in the website usability test were all adult acquaintances from the community. The participants included science and non-science educational backgrounds as well as a range of self-reported internet use from four to twenty-five hours per week.

The usability test was broken into two parts: the usability test and follow-up questions. The usability test lasted approximately fifteen to thirty minutes and took place at the participants' homes on laptop or desktop computers with wireless cable or DSL connections. Older and slower computers or connection speeds were not

available. They tested the website by performing tasks defined on the "Tasks for the Usability Test-Drive" (Appendix I) while being observed by the author. The author used the "Observation Sheet for the Usability Test-Drive" (Appendix J) to record delays or problem locations with the website. Since most speed of download and use times were very fast, a check mark was used to indicate results within a few seconds and longer delays were noted for potential problems. After the usability test, the participants were given the "Survey and Interview Questions after the Usability Test-Drive" (Appendix K), taking an additional fifteen to thirty minutes.

Observing the participants led to several clear problems with the site and improvements made. For each of the five usability test participants, problems or delays experienced with the website, answers to follow-up questions, and changes made to the website will be summarized.

The first usability test participant quickly found answers to all of the questions but experienced relative delays answering question 1c, if any motor could be used, and 2c, ideas from real boat builders. On the follow-up

questions, this participant rated each feature of the appearance positively and answered that the download speed, speed of use, content, visuals, and navigation were sufficient. The photo gallery was listed as a part of the site that was liked, and "descriptions are wordy" was listed as a part of the site that was not liked. Adding and improving visuals, background color, and fewer words in the teacher information section were suggested.

It was not clear if the delays were caused by the website or unclear questions, so more data was desired before changes were made to the website. To improve the pictures, the slide show enlargements were reduced to better fit on the screen with the picture choices. The teacher information section was also edited to make it more concise. A background color was not added yet since more time was needed to consider a color scheme.

The next two participants took the usability test one right after the other so their feedback will be summarized together and then the resulting changes discussed. These participants quickly located answers to all of the questions and also experienced relative delays answering question 1c, if any motor could be used. Both also experienced delays answering question 2c and

wondered if it referred to builders of real boats or project boats.

On the follow-up questions both rated each feature of the appearance positively. They also answered that the download speed, speed of use, content, visuals, and navigation were sufficient and provided additional positive comments. The video was listed as one exception to a sufficient download speed and a solution was in progress. The photo gallery and detailed, organized, concise information were listed as parts of the site that were liked. A message board was suggested as a feature for students to share ideas.

As a result of this data, and the fact that all three participants so far experienced delays considering whether any electric motor could be used, the electric motor rules were reworded to include the word "any". The phrase "click to enlarge" was also added to the photo gallery to clarify how to use the pictures provided in the table. Moving the links of professional boat pictures to the photo gallery was not done since it might confuse students looking for example projects to follow. Instead, the usability test question 2c should have been edited and this was communicated to the participants thereafter.

The previous editing to make the site more concise was helpful since one of the participants listed that as a feature that was liked. The message board was included on the list of future improvements, but not included in the website for technical reasons and because content posted could not be monitored.

The fourth participant quickly found answers to all of the questions and delays over the use of "any" motor were apparently solved by the changes. The participant agreed that question 2c was unclear and needed editing.

On the follow-up questions, this participant rated each feature of the appearance positively and answered that the download speed, speed of use, content, visuals, and navigation were sufficient. Additional comments were provided, such as: "There are enough visuals for a beginner" and "Every question I would have was answered." The photo gallery was again listed as a part of the site that was liked. Finally, "Nothing..." was answered for parts that were not liked and for suggested changes.

As a result, previous changes were supported and no significant changes were made to the site. A few edits and adjustments to appearance were made.

The fifth participant also quickly found answers to all of the questions, including question 2c, agreeing that the question should have been edited since it also implies actually communicating with the boat builders.

On the follow-up questions, this participant rated each feature of the appearance positively and answered that the download speed, speed of use, content, visuals, and navigation were sufficient. The detail of the content and ease of locating it were listed as parts of the site that were liked. Deleting the "New here?" and "...start here" messages on the homepage were also suggested.

This completed the development phase, but not improvements to the site. After the implementation phase, further reflection on the feedback from the focus groups, the participants, and other users of the site resulted in improvements to the appearance. A more colorful design for the homepage, with coordinated header, menu bar, and document header, were made and implemented throughout the site. This resulted in a simpler homepage design (Figure 7) that incorporated the picture, did not require scrolling, and no longer included the "New here?" links since additional feedback indicated they were not needed.



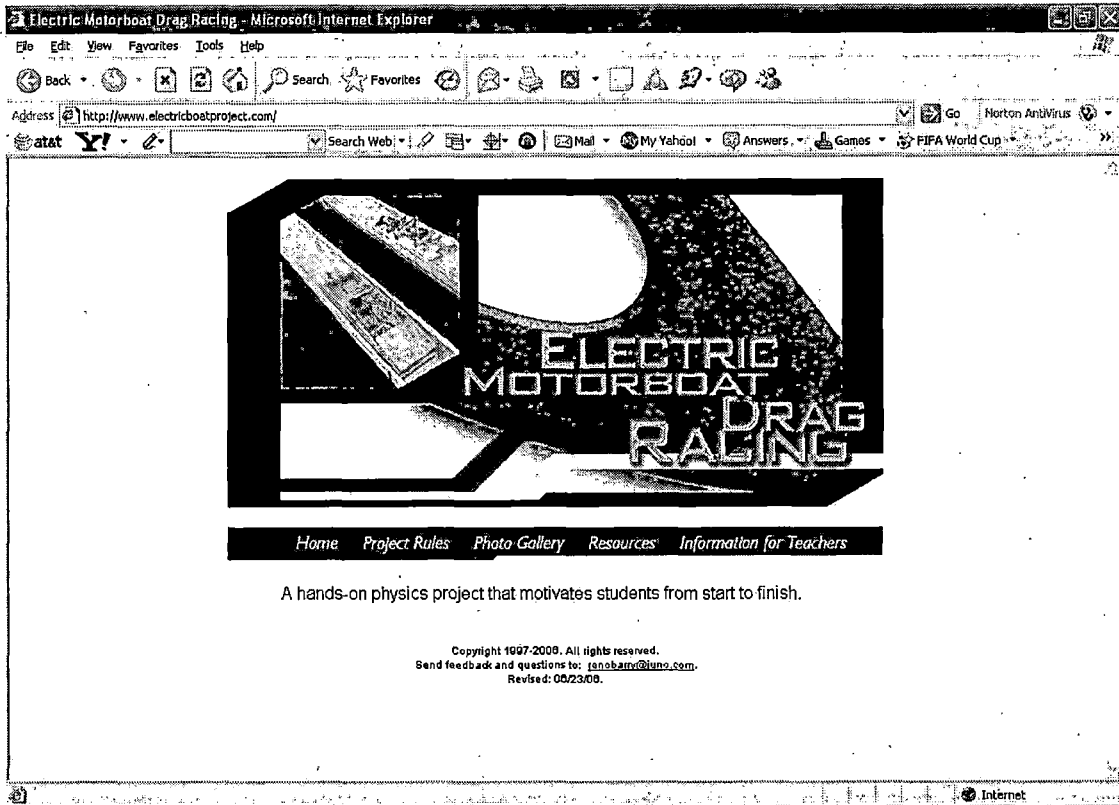


Figure 7. Final Appearance of Homepage

The new header improved the appearance throughout the website and eliminated the possibility of undesired font substitution or effects in other browsers, a need identified in the focus groups. The improved appearance better met users' expectations for a professional appearance and will help future users like the site. In addition to the header, the problematic flash video clip in the photo gallery was also replaced (Figure 8). The new video clip in Windows Media Video format finally addressed the demands for a rapid download time.

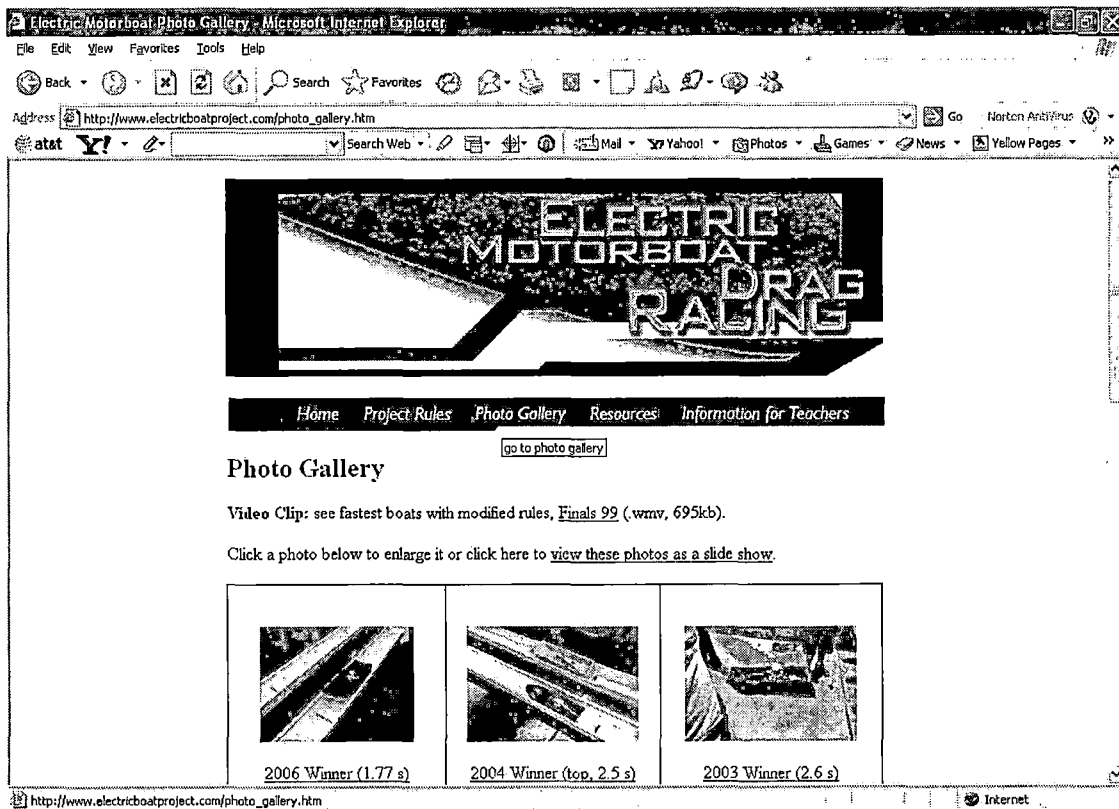


Figure 8. Final Appearance of Photo Gallery Table

### Website Implementation

On April 10, 2006, the Electric Motorboat Drag Racing project was assigned to this author's 88 physics students at Martin Luther King High School, Riverside, California. As discussed at the beginning of this chapter, about one-third of the students were from AP Physics, two-thirds were from regular physics, two-thirds were male, and one-third were female. Under the guidance of this author, the physics curriculum at this school included this summative project the past five years. At

King High School, this project has been somewhat popular. At the beginning of the school year, some students have asked if they get to do the project and some students in other classes also asked if they can do the project. The project was implemented at King High School where some students had an awareness and positive impression of the project.

With the development of the website, the presentation of the project was unique. An effort was made to present the project using the website and printouts, not example boats. This was done to simulate what classes new to the project might experience. The date of presentation was at the beginning of the fourth quarter to allow students at least six weeks of homework time. That also allowed time after the class tournaments to complete the physics worksheet and have a final tournament with the best boats from each class. To prepare for the presentation, a copy of the project rules printout was made for each student in case one did not have access to the internet at home. Also, for this report, a copy of the "Informed Consent for Parents and Students" (Appendix L) was made for each student.

To assign the project, less than one class period was used. First, the informed consent paperwork was distributed and discussed with the students. The project rules were then read and explained with an attitude of fun and humor. The due date for the project was given as May 30 or 31, 2006, depending on the class schedule. After discussing the rules, the website was used to display the photo gallery. The video clip of boats racing and the pictures of different boats were emphasized to give students ideas. The students reacted most to the video clip, surprised by how fast the best boats could go. One example boat from a previous year was used to demonstrate the sound and speed of the boat's motor. First time users of the project would have to wait for their second year or until a new video clip with sound can be added to the site. Finally, an overview of the other resources was given and a few links shown. Students were instructed, as stated in the information for teachers webpage, to begin looking for propellers. Many students appeared excited about the project and talked about what they were going to do to have the fastest boat.

During the following six weeks, occasional announcements and reminders were made to help students plan and make a better boat. Some students would ask questions about the best designs and others would ask how to do something on a basic design. Either way, the website was referred to, but this author's experience with the project was also shared. This inevitably gave these students an advantage over classes new to the project.

#### Website Evaluation

Of the 88 students assigned the project, 43 (49%) chose to be participants in the study and completed the "Informed Consent" form (Appendix L). This accounted for 37 (67%) of the 55 total boats in the competition. Of the 43 participants, 17 (40%) were from AP Physics, 26 (60%) were from regular physics, 23 (53%) were male, and 20 (47%) were female.

Once the project and races were completed on May 31, 2006, the participant data was mined for the following information: a) the percent of groups that completed boats, b) the percent of boats that were fixed or adjusted related to forces, c) the percent of boats that were fixed or adjusted related to the circuit, and d) the

percent of boats that completed the five meter race. The participants were also asked to take an additional ten to twenty minutes to answer a few questions (Appendix M) about their experience with the project and circle a few California State Standards for Physics that they feel they applied, learned more about, or reviewed as a result of the project.

From the participants' boat data, it was found that 36 (97%) of the 37 boats were completed on time and according to the rules. The one boat was missing as a result of an absence on the project due date. Of the participants' 36 completed boats, 28 (78%) were observed to be fixed or adjusted related to one or both of the selected standards. Of the participants' boats, 25 (69%) were observed to be fixed or adjusted to improve the net force to accelerate the boat more, providing evidence for an understanding of California Content Standard for Physics 1b. Also, 20 (56%) were observed to be fixed or adjusted to improve the voltage received by the motor, providing evidence for an understanding of California Content Standard for Physics 5a. These observations were primarily made when boats failed to operate or operated poorly. If the boat worked well, adjustments were rarely

seen. Additional adjustments were likely made at home or simply not observed during the competition because of the demands of officiating the competition. Finally, of the participants' 36 boats, 35 (97%) completed the 5-meter distance and qualified for the drag races.

Though this data reflects a successful class project, it may be biased since participants chose to participate and had to complete and return a form on time. Some students may not choose to be participants if they feel they may not contribute positively to the data, so the results may be better than a typical classroom experience.

After the completion of the Electric Motorboat Drag Racing tournament, 41 (95%) of the 43 participants completed the follow-up questions "Website Experience Questions for Participants" (Appendix M). Their responses are summarized in the following table:

Table 1. Response Summary for Website Experience Questions

Question Number and Topic	1 <sup>st</sup> Highest Response	2 <sup>nd</sup> Highest Response	3 <sup>rd</sup> Highest Response
1. Internet access at home?	Yes 41 (100%)	No 0 (0%)	
2. If you didn't use website...why?	No need or thought 11 (27%)	Used other resources 4 (10%)	Not aware/not found 2 (5%)
Accessed the website at...?	Home 26 (63%)	Neither 14 (34%)	School 3 (7%)
The following percents are based on the responses of the 27 (66%) participants that accessed the site.			
If you used Project Rules feature...why?	Check rules easily 8 (30%)	Replace lost sheet 4 (15%)	
If you used Photo Gallery feature...why?	Design ideas 16 (59%)	Video clip 1 (4%)	
If you used Tutorial and Resources...why?	Find motor or store 4 (15%)	To design or improve 2 (7%)	
3. In Photo Gallery ...layout preference?	Table 9 (33%)	Both 6 (22%)	Slide-show 3 (11%)
4. Which browser did you use?	Internet Explorer 19 (73%)	Mozilla Firefox 3 (11%)	Netscape 2 (7%)
In that browser, rate website's function (1 = un-useable to 6 = perfect)	Rated 5 12 (44%)	Rated 6 5 (19%)	Rated 3or4 2 (7%)
In that browser, rate website's appearance (1 = un-useable to 6 = perfect)	Rated 5 9 (33%)	Rated 6 8 (30%)	Rated 3or4 2 (7%)
5. Add to website?	Fine or N/A 4 (15%)	Pictures and videos 2 (7%)	Multi-view of boat 2 (7%)
Subtract from website?	N/A 2 (7%)	Hard to understand 1 (4%)	Pop-ups 1 (4%)
6. Additional comments?	Good/great, cool/fun 7 (26%)	Helped or educational 3 (11%)	Add to tutorial 1 (4%)



The above summary includes almost all of the data gained from the follow-up questions. When the numbers do not add up to the number of respondents, it is because many chose not to answer all of the questions. For some questions, this makes the significance of the results uncertain and more feedback necessary.

Data for question 1 established that all 41 participants that completed the questionnaire had internet access at home. Data for question 2 showed that two-thirds of the participants chose to access the site and one-third did not, primarily because they did not need to. Out of those that accessed the site, almost half accessed the project rules to check them and more than half accessed the photo gallery for design ideas. For the photo gallery, the table layout was preferred but the data showed the slide-show format should not be eliminated. The project rules and photo gallery clearly stood out as valuable to the students while the tutorial was only used by about one-fifth of the participants.

The original responses for question 4 showed that almost all of the participants accessed the site with the Internet Explorer browser and three participants used Mozilla Firefox, Netscape or both. Overall, the users'

average rating was 5.1 for the website's function, six being best, and 5.3 for the website's appearance. This was surprising since the author's impression was that the appearance at the time would not rate as high as the function. Though insignificant, the three participants that used browsers besides Internet Explorer rated the website's function a 5 and its appearance a 5. Finally, many students chose to write positive feedback about their enjoyment of the project and website. The most common change recommended was the addition of a few pictures, possibly of different angles of one boat.

Lastly, the 41 participants that completed the questionnaire were given the list of California Content Standards for Physics and the Investigation and Experimentation standards for science (California State Board of Education, 2003) and asked to circle a few standards they felt the project helped them apply, learn, or review. The following table shows the total number of times each standard was selected.

Table 2. Totals for Selected California Physics Standards

Standard Group and Topic	Specific Standards and Number of Times Selected by Students									
1 Motion and Forces	1a)	13	1b*)	21	1c)	19	1d)	12	1e)	4
	1f)	6	1g)	4	1h)	3	1i)	0	1j)	1
	1k)	2	1l)	0	1m)	1				
2 Conservation of Energy and Momentum	2a)	6	2b)	2	2c)	1	2d)	12	2e)	4
	2f)	12	2g)	3	2h)	1				
3 Heat and Thermodynamics	3a)	5	3b)	1	3c)	2	3d)	0	3e)	4
	3f)	0	3g)	1						
4 Waves	4a)	3	4b)	1	4c)	0	4d)	1	4e)	0
	4f)	1								
5 Electric and Magnetic Phenomena	5a*)	29	5b)	7	5c)	17	5d)	10	5e)	3
	5f)	14	5g)	5	5h)	8	5i)	2	5j)	4
	5k)	1	5l)	1	5m)	0	5n)	0	5o)	1
1 Investigation and Experimentation	1a)	16	1b)	9	1c*)	14	1d)	15	1e)	3
	1f)	5	1g)	7	1h)	1	1i)	4	1j)	1
	1k)	2	1l)	7	1m)	1	1n)	1		
*One of three targeted standards identified by the author.										

Since a wide variety of standards were selected, including ones that do not apply, only general conclusions were made. The most selected standards accurately reflected standards the students had to apply, learn, or review as a result of the project. The top ten most selected standards were: 1) 5a at 29 times, 2) 1b at 21, 3) 1c at 19, 4) 5c at 17, 5) I and E 1a at 16, 6) I

and E 1d at 15, 7) I and E 1c at 14, 7) 5f at 14, 9) 1a at 13, 10) 1d at 12, and 10) 2f at 12. These top ten most selected standards do reflect the project, at least in part, and demonstrated the general validity of the students' choices from the 68 possible standards. The participants' top ten standards also evenly reflect the three categories the targeted standards were chosen from: motion and forces, electricity and magnetism, and investigation and experimentation. Since a variety of valid standards were chosen from multiple areas of the curriculum, it supported the project's value as a hands-on summative project.

Amazingly, the students' top two selections were the two-targeted content standards for physics. This confirmed the educational value of the project because students identified those standards the most as ones they had to apply, learn, or review to complete the project. The third targeted standard was the seventh most selected standard. Some of the student-selected standards could be added to the targeted standards if further data supported it or if the targeted standards were more liberally chosen.

## Summary

The original website was designed to showcase the project for a graduate class and was never made available online. After the literature review, specific changes were made to improve the design's speed of use, content, appearance, and navigation. The most notable changes included the elimination of a video gallery, the addition of a tutorial that used other websites as resources, a photo gallery, and the main menu placed at the top of each page.

For the development phase of the ADDIE instructional design model, the alpha test was completed in two parts. First, the site was examined by two content teachers. This validated the targeted standards and content. Listing more standards was recommended and a project summary was added to the information for teachers. The project summary also centralized access to the list of materials, timeline, and the printouts: Project Rules, Grade Sheet, Tournament Tree, and a refined Electric Motorboat Physics Worksheet.

Secondly, to complete the alpha test, the site was examined by Web design teachers and many improvements were recommended. To improve appearance, the site was

redesigned using centered and fixed tables to control its display, the main menu was made into a menu bar for each page, and the photo gallery was also made available in a slide show format. Additional feedback resulted in a list of future improvements. The recommendations included using a faster video file format, making the entire site compliant to accessibility codes, and making the site browser independent. As a first step toward an improved appearance and browser independence, improved page headers were recommended. This appearance change for the site was completed after the implementation phase and included attractive page headers and a new color scheme.

For beta testing, the site was user-tested five times with minor changes each time. As a result of the participants' feedback, the site was made clearer and more concise. The participants also confirmed the need for a faster video format, which was completed during the implementation phase. Though minor adjustments were made after the development phase, the site was ready for the implementation phase.

For the implementation phase, the website was used to assign the project to 88 physics students at Martin Luther King High School, Riverside, California. They were

given six weeks to design and build an electric motorboat at home. During class, the project was referred to and reminders were given about the due date, but no class time was devoted to working on it.

For the evaluation phase, data from the 43 participants' boats, a follow-up questionnaire, and standards they selected from the state standards were qualitatively analyzed. Data from the 37 boats suggested the project was motivating because of its 97% completion rate among participants. It also showed the project was educational because 78% of the boats were adjusted or fixed in certain ways that showed at least a partial understanding of the targeted state standards.

The follow-up questionnaires were often not fully completed making some results inconclusive. Out of the 41 participants that completed the questionnaire, all had internet access at home and two-thirds accessed the site, mostly at home. Of the 41 participants, almost half accessed the project rules and more than half accessed the photo gallery. Both helped students complete the project. The average rating for the function of the site was 5.1, six being best. The average rating for the appearance of the site was 5.3, six being best.

Finally, when participants were instructed to select a few state physics standards from the entire list that the project helped them apply, learn, or review, their top two picks were the two targeted content standards. The top two most selected standards were the motion and forces standard 1a and the electricity and magnetism standard 5a. Even the third targeted standard was the seventh most selected by students out of the 68 standards to choose from. Their selections provided further evidence for the project's educational benefit. Overall, the data support the use of the Electric Motorboat Drag Racing project as a motivating and educational summative project.



## CHAPTER FOUR

### CONCLUSIONS AND RECOMMENDATIONS

#### Introduction

Included in Chapter Four is a presentation of the conclusions drawn as a result of completing the project. Further, the recommendations extracted from the project are presented. Lastly, the Chapter concludes with a summary.

#### Conclusions

The conclusions extracted from the project follows.

1. S.C.A.N. was helpful but had limits. The acronym for usability concepts provided a memorable approach to design and improve a website, but had limits. The primary limit experienced was that S.C.A.N. did not account for some common web design expectations such as browser independence, file formats and an artistically professional appearance. Specifically, it did not account for failures of web design software to produce a browser independent appearance. It did not account for expected PDF and Flash file formats for

documents and videos, nor for the artistic touch to produce a professional and attractive appearance.

2. Appearance may be more important than the research revealed for educational websites. Far from being a bonus to educational websites as the research implied, a professional appearance seemed more of an expectation since much of the negative feedback received was in regards to the appearance of the website.
3. Discount usability engineering, with professional feedback and simplified user tests is a critical step of the development phase of the ADDIE instructional design model. Nearly all the website improvements resulted from these steps in this phase.
4. The project rules, photo gallery, and information for teachers were indispensable features that should be included on all project websites. The resources feature was used less but could become a valuable feature. Though not experimentally tested, these features should allow the project to be repeated successfully

at other school sites since the website could be referred to instead of model boat examples.

5. The Electric Motorboat Drag Racing project is a motivating physics project (97% completion rate, positive comments on feedback) that educates students (78% of the boats were fixed or adjusted related to the targeted standards and the top two standards selected by students were the two targeted content standards). The website, especially the project rules and photo gallery, was an integral part of the success of the project (about two-thirds of the participants accessed the site and were helped by those features).

#### Recommendations

The recommendations resulting from the project follows.

1. For busy teachers to design their own project website, they should consider finding recent software with adequate templates to produce a professional appearance and browser independence. A graphics art focus group should

- also be considered to provide constructive feedback to improve the website's appearance.
2. Research is needed to study the efficiency of web design when beginners use a summary page for S.C.A.N. versus lists of usability heuristics. This could be done with and without web-design templates.
  3. More research is needed regarding the relative importance of usability concepts so that design decisions can be improved. For example, a change can have a positive affect in one area, like content or appearance, while simultaneously having a negative affect on another, like speed.
  4. To further motivate students individually, the motorboat project could require boats to finish the 5-meter race within a time limit, such as thirty seconds, or include time as part of the grade.
  5. A journal documenting the development of each group's motorboat could be required to document that adjustments were made related to the targeted standards. This would provide more

evidence that each group is attaining the standards, but would likely detract from the enjoyment and motivating power of the project.

6. Though electric motorboat drag racing is a summative project completed to apply and review selected standards, more research is needed to test the educational effectiveness of the project. For example, before and after tests could be used to determine the educational impact of the project and worksheet.
7. More research is needed to determine if this project and others like it can improve enrollment in advanced science classes, helping to keep our nation internationally competitive. Students do enjoy the project, some ask about it at the beginning of the class, and it is used to promote class enrollment. Whether or not the project actually affected students' decisions to enroll has not been determined.

#### Summary

Chapter Four reviewed the conclusions extracted from the project and the recommendations derived from the

project. It concludes with this brief summary of those conclusions and recommendations as they related to the design, development, and evaluation phases of the ADDIE instructional design model.

An Electric Motorboat Drag Racing website was developed to share this author's project with future physics classes and other schools. After research, usability concepts for website design were organized into four themes: speed, content, appearance, and navigation. These concepts, organized into the S.C.A.N. acronym, provided a memorable and helpful approach to designing and improving a usable website. The result was several unsolicited compliments regarding the quick and easy to access content.

The process of developing the website should have been more efficient and produce a more professional appearance. Templates could have been investigated to more easily produce a professional layout that is browser independent. A graphics art focus group could also have been consulted since professional appearance seems expected and easily becomes the focus of negative feedback and dissatisfaction with the website.

The focus groups and simplified user testing were very successful since the majority of website improvements did result from them. This discount usability engineering, divided into the alpha and beta tests for the development phase of the ADDIE instructional design model, should be used by all teachers hoping to design a project website.

Upon evaluation, the most important website features were the project rules and photo gallery. The information for teachers would also be critical to other schools doing the project, but that was not the focus of this report. The project may successfully be used at other schools in physics classes or as an example for other standards based projects to follow. The project was motivating and clearly reinforced educational standards. The many positive comments provide an indication that the project may even encourage increased enrollment in advanced science classes, but more data should be collected.

APPENDIX A  
INFORMED CONSENT FOR ADULT PARTICIPANTS



### **INFORMED CONSENT for Adult Participants**

The study in which you are being asked to participate in is designed to test the usefulness of a website for a physics project called Electric Motorboat Drag-Racing. This study is being conducted by Reno Barry under the supervision of Dr. Newberry, professor of education. This study has been approved by the Institutional Review Board, California State University, San Bernardino.

In this study you will be asked to view the website for the physics project, complete tasks, and respond to survey and interview questions. The “Tasks for the Usability Test-Drive” should take about 15 to 30 minutes. The “Survey and Interview Questions after the Usability Test-Drive” should also take about 15 to 30 minutes. If you are a teacher selected to perform an expert review, the “Focus Group Questions for Content Teachers” or the “Focus Group Questions for Web design Teachers” are all that is asked of you and should take about 15 to 30 minutes. No matter which way you participate, all of your responses will be held in the strictest of confidence by the researchers. Your name will not be reported with your responses. All data will be reported in group form only. You may receive the group results of this study upon completion by September 15, 2006 at Martin Luther King High School, Riverside, California.

Your participation in this study is totally voluntary. You are free not to answer any questions and withdraw at any time during this study without penalty. When you have completed the tasks and questions, you will receive a debriefing statement describing the study in more detail. In order to ensure the validity of the study, we ask that you not discuss this study with other students or participants. The benefits of this research include the satisfaction of helping to make a useful physics project website that helps to educate and inspire many future students, locally and far away. There are no reasonably foreseeable risks or discomforts caused by your participation in this study.

If you have any questions or concerns about this study, please feel free to contact me: Mr. Barry at (951) 789-5690 X 3042 or at rbarry@king.rusd.k12.ca.us. You may also contact Dr. Newberry at (909) 537-5000 X 77630 or at bnewberr@csusb.edu. If you have questions about rights of participants, please contact Michael Gillespie, IRB secretary, at (909) 537-5027 or at mgillesp@csusb.edu.

By placing a check mark in the box below, I acknowledge that I have been informed of, and that I understand, the nature and purpose of this study, and I freely consent to participate. I also acknowledge that I am at least 18 years of age.

**Place a check mark here**     

Signature: \_\_\_\_\_  
Participant (if at least 18 years of age)

Date: \_\_\_\_\_

APPENDIX B

FOCUS GROUP QUESTIONS FOR CONTENT TEACHERS

**Focus Group Questions for Content Teachers**  
By Reno Barry, updated 3-5-2006

**Instructions:** Answer the following questions to help improve the project and website.

**Educational Objectives for the Electric Motorboat Drag-Racing Project from the California Content Standards for Physics:**

**I and E 1c.** Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

**1b.** Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law). "A push or a pull (force) needs to be applied to make an object accelerate."

**5a.** Students know how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.

**Questions:**

1. Rate how well the project helps students to learn each standard by circling one of the numbers on the scale below (1 = not at all, 6 = completely):

I and E 1c:	1	2	3	4	5	6
1b:	1	2	3	4	5	6
5a:	1	2	3	4	5	6

2. Are there other California Content Standards for Physics that the project also or better helps the students to learn? Please list or explain.
3. What measure-able or quantifiable evidence would make you feel the students are learning each one of those standard(s) as a result of completing the project?

I and E 1c:

1b:

5a:

Other:

4. What element(s) could be added to or subtracted from the project or website to better meet the educational objectives?

added to project:

added to website:

subtracted from project:

subtracted from website:

APPENDIX C  
DEBRIEFING STATEMENT

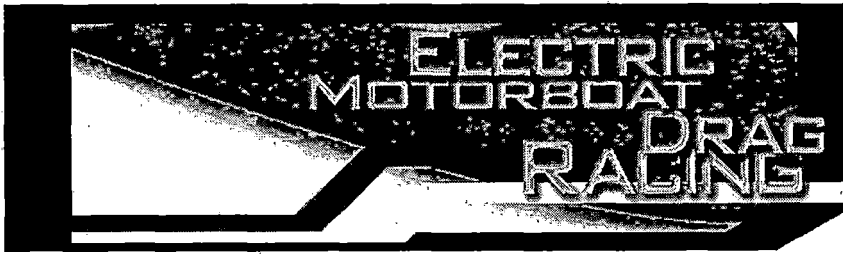
## Debriefing Statement

This study you have just completed was designed to develop a usable physics project website called "Electric Motorboat Drag-Racing." The goal of this study is to motivate and educate physics students by involving them in a hands-on project, available to them and other schools through a website. The website may also encourage other teachers to make their best hands-on projects available to other classes through websites. The website was designed with speed, content, appearance, and navigation usability concepts identified in research. These concepts were organized in the acronym S.C.A.N. so they can be more easily remembered and therefore developed into the website. The website was tested by asking experts for their feedback and then tested for its usability by volunteers. The usability test required volunteers to complete tasks and answer follow-up survey and open-ended questions. Each time suggestions were made, problems found, or deficiencies identified, the website was analyzed and adjusted to function better for the users and meet their needs. The website was then implemented in physics classrooms to evaluate its success by measuring and quantifying student success on the project. Student success was identified as completion of a boat that can propel itself across the racing distance. Students then identified physics concepts from the California State Standards for Physics they feel the project helped them learn. Through all of this, the website was made more usable and the project can be shown to educate physics students.

Thank you for your participation and for not discussing the contents of the study with other students. If you have any questions or concerns about this study, please feel free to contact me: Mr. Barry at (951) 789-5690 X 3042 or [rbarry@king.rusd.k12.ca.us](mailto:rbarry@king.rusd.k12.ca.us); or Dr. Newberry at (909) 537-5000 X 77630 or [bnewberr@csusb.edu](mailto:bnewberr@csusb.edu). If you have questions about rights of participants, please contact Michael Gillespie, IRB secretary, at (909) 537-5027 or at [mgillesp@csusb.edu](mailto:mgillesp@csusb.edu). If you would like to obtain a copy of the group results of this study, please contact Professor Newberry at UH 401.06 at the end of Fall Quarter of 2006.

APPENDIX D

ELECTRIC MOTORBOAT DRAG RACING PROJECT RULES



### **Project Rules**

**Objective:** Make an electric motorboat, by the rules, for 5 meter rain gutter drag races.

**Groups:** 1 or 2 students per boat. Write your names on or attach them to the boat.

**Due Date:** \_\_\_\_\_ The boats can be tested \_\_\_\_\_.

**Grading (50 points possible):** A boat built according to all of the restrictions earns 35 points. As a boat propels itself down the 5 meter track at one time, it earns +3 points per meter completed. The boat must meet all of the rules and propel itself 5 meters at one time to qualify for competition. The top 3 boats in the tournament will earn extra credit.

**Boat and Propeller Designs:** The boat design may be based upon a fan-boat, speedboat, submarine, paddle wheel, or jet-ski. Air and water propellers may be taken from an available toy or purchased for a few dollars at a hobby store (notify the teacher if neither option is possible). The boat must fit within and operate according to all of the following size, battery, motor, and material restrictions.

**Size Restrictions (+5 points):** The size of the rain-gutter limits the boat's size. The length of the entire boat must be less than 35 centimeters from tip to tip. The width of the boat must be less than 9 centimeters at all points at the water's surface-level. The rain-gutter has a "U" shaped cross-section and narrows at its base. It will be filled and have a depth of about 6 centimeters. Design the boat to fit and operate within these dimensions.

**Battery Restrictions (+10 points):** The boat may **not** use any high-ampereage batteries or battery packs such as ones designed for remote-control vehicles, recreational vehicles, camping, or automobiles. The boat may **only** use the following unmodified common household batteries: **1) one 9V battery or 2) up to six D, C, AA, or AAA batteries.** Contact the teacher for any questions; use batteries only according to their instructions.

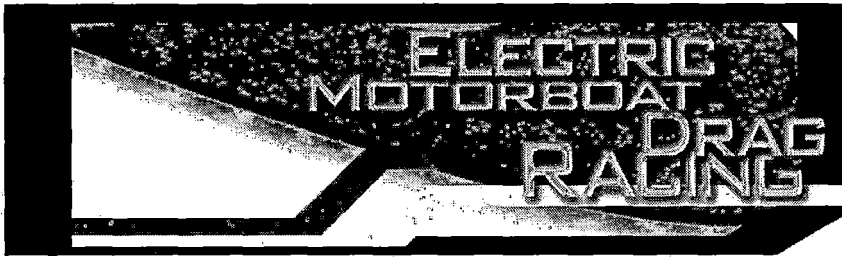
**Motor Restrictions (+10 points):** The boat must propel itself with **only 1 or more** electric motors. An electric motor can be of any type that meets all other restrictions. An electric motor can be taken from an available toy or purchased for about \$3 at a hobby store (notify the teacher if neither option is possible). These motors are often rated 1.5V to 3V, but they work fine with the higher voltages allowed by the battery restrictions.

**Material Restrictions (+10 points):** You may purchase propellers, motors, and batteries, but the boat may **not** use any manufactured toy boat body. You may use household, hardware, and hobby store materials **only** according to their instructions. Common materials include: plastic bottles, Styrofoam, balsa wood, wires, switches, battery holders, tape and glue. Contact the teacher for any questions.

APPENDIX E

ELECTRIC MOTORBOAT DRAG RACING GRADE SHEET





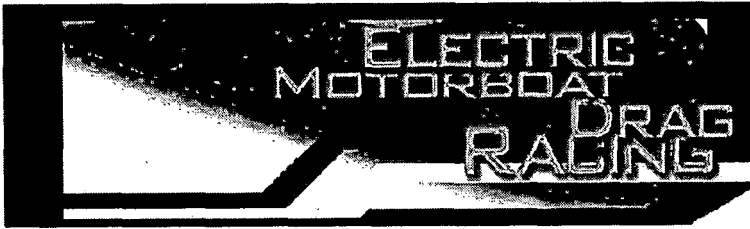
**Grade Sheet**

**Instructions:** Write student names, scores, and the fastest times for each boat.

	<b>Name(s):</b> written on boat 2 students maximum	<b>Materials:</b> no toy body or dangers (+10 pts)	<b>Boat Size:</b> l < 35cm and w < 9cm (+5 pts)	<b>Batteries:</b> one 9V or six regular (+10 pts)	<b>Electric Motor:</b> 1+ (+10 pts)	<b>Distance:</b> +3pts/m for 5m (+15 pts)	<b>Total Score:</b> 50 pts	<b>Time(s):</b>
1								
2								
3								
4								
5								
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APPENDIX F

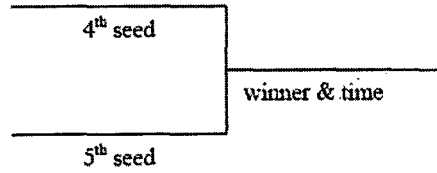
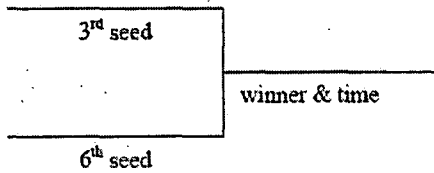
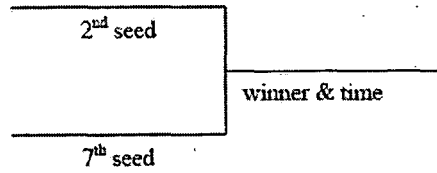
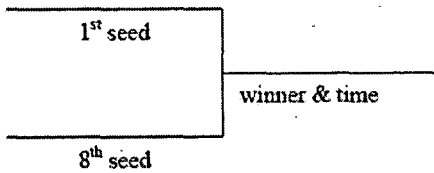
ELECTRIC MOTORBOAT DRAG RACING TOURNAMENT TREE



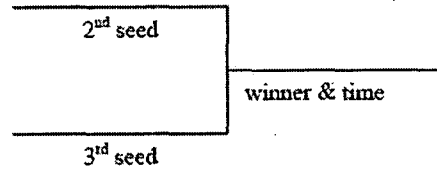
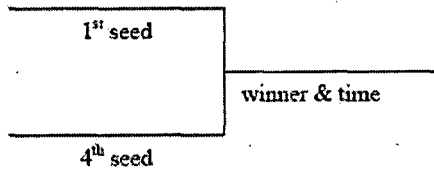
**Tournament Tree**

**Instructions:** Write student names and times to record their progress in the tournament.

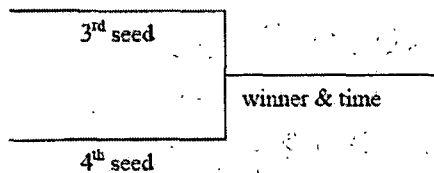
**The Fastest Eight**



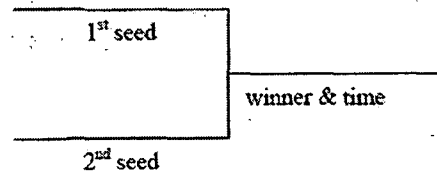
**The Final Four**



**The Drag Race for Third & Fourth**



**The Drag Race for First & Second**



APPENDIX G  
ELECTRIC MOTORBOAT DRAG RACING PHYSICS  
WORKSHEET



11. Draw and label a circuit diagram (schematic) that shows your battery(ies), motor, and switch.

12. Did you wire your circuit in series or parallel? How do you know?

13. What was the maximum voltage your motor received?  $V = \underline{\hspace{2cm}} V$

14. Using a multi-meter, measure the resistance of your motor.  $R = \underline{\hspace{2cm}} \Omega$

15. Using Ohm's Law, calculate the current through the motor.  $I = \underline{\hspace{2cm}} A$

16. Calculate the electrical power delivered to the motor.  $P = \underline{\hspace{2cm}} W$

17. Calculate the total energy delivered to the motor during a 5 m drag race.  $E = \underline{\hspace{2cm}} J$

18. Compare this electrical energy (#17) to the kinetic energy of the boat (#10). Which is greater? Why?

19. This electrical energy (#17) came from the battery. List three forms of energy it became.

1)

2)

3)

20. Give two more ways your motorboat could be made faster (besides the answers given for #8).

1)

2)

APPENDIX H

FOCUS GROUP QUESTIONS FOR WEB DESIGN TEACHERS





APPENDIX I  
TASKS FOR THE USABILITY TEST-DRIVE

**Tasks for the Usability Test-Drive**  
By Reno Barry, updated 1-17-2006

**Instructions:** These tasks are designed to test the website, not you. Please think out loud as you are working through each scenario. This will help improve the website.

1. Your teacher assigned the electric motorboat drag-racing project and you have a few questions. Using the website, find answers to the following:

- a) How many people can be in a group?
- b) How big can the boat be?
- c) What can't the boat be made from?
- d) Can any toy electric motor be used?
- e) What batteries can be used?

2. After reading some of the directions and hearing about the electric motorboats, you are having trouble imagining what one will look like so that you can build one.

- a) Find a place in the website to get ideas to help build an electric motorboat.
- b) Is there a way to see some up-close details of an electric motorboat?
- c) Find a place in the website to get some ideas from real boat builders.

3. You are a teacher and you want to know how you can do the project for your class.

- a) Find a place in the website that tells you what materials you will need.
- b) Find a place in the website that tells you how to set up the project and races.

APPENDIX J

OBSERVATION SHEET FOR THE USABILITY TEST-DRIVE

### Observation Sheet for the Usability Test-Drive

**Instructions:** One copy of this sheet will be needed for each user for each task. During observations, you may remind the user to think out loud but do not aid or lead the user. Simply note onscreen behaviors and indicators of website problems or user frustration.

Usability Test #: \_\_\_\_\_ User #: \_\_\_\_\_ Task #: \_\_\_\_\_

Webpage (title, code, or #)	Download Time	Time on Webpage	User actions, indicators of frustration, and website problems

APPENDIX K  
SURVEY AND INTERVIEW QUESTIONS AFTER THE  
USABILITY TEST-DRIVE

**Survey and Interview Questions after the Usability Test-Drive**  
By Reno Barry, updated 1-17-2006

**Instructions:** Use the website to help you answer the following questions.  
This is not to test you, but to help improve the website.

**1. User Data** ( User #: \_\_\_\_\_ )

Estimate the number of hours you use the internet each week: \_\_\_\_\_

List classes you have completed that relate to the website (science, engineering...):

**2. Survey**

According to the research of Zhang and von Dran (2000), visual appearance of a website can be described by the following six features. For each feature, please circle the choice you most agree with.

- |  |            |              |
|--|------------|--------------|
| a) The overall color use is...                         | attractive | unattractive |
| b) The displays are...                                 | sharp      | fuzzy        |
| c) The screen layout is visually...                    | attractive | unattractive |
| d) The screen background and pattern is...             | attractive | unattractive |
| e) The brightness of the screen/pages are...           | adequate   | inadequate   |
| f) Eye-catching images or title on the homepage are... | present    | absent       |

**3. Interview Questions**

- a) Is the download speed sufficient? If not, describe where downloads are slow.
  
- b) Is the speed of use sufficient? If not, describe where the site is slow or hard to use.
  
- c) Does the content meet your needs? If not, what are you hoping for?
  
- d) Would the visuals help you complete the project with success? If not, why not?

- e) Does the navigation give you a sense of location and content within the website?  
If not, where did you feel lost or unable to know what a link would take you to?
- f) Is the navigation clear and did it enable you to travel quickly within the website? If not, where is it unclear or take too much time to read and understand?
- g) Using the website, state a part or two that you like and why you like it.
- h) Using the website, state each part you did not like and why you did not like it.
- i) What could be added, subtracted, or changed for you to like the website more?
- Added:
- Subtracted:
- Changed:

APPENDIX L  
INFORMED CONSENT FOR PARENTS AND STUDENTS



## INFORMED CONSENT for Parents and Students

The study in which your son or daughter is being asked to participate is designed to test the usefulness of a website for a physics project called Electric Motorboat Drag-Racing. This study is being conducted by Mr. Barry under the supervision of Dr. Newberry, professor of education. This study has been approved by the Institutional Review Board, California State University, San Bernardino.

The study in which your son or daughter is being asked to participate involves normal class activities related to the Electric Motorboat Drag-Racing project. This includes class-time to view the website that explains the project, making his or her own electric motorboat at home during the 6 weeks allowed, racing it on the due date, and identifying a few physics concepts from the California physics standards that he or she learned more about as a result of completing the project. Identifying a few physics concepts from the California physics standards list should take about 10 to 20 minutes. The success of his or her boat and all of his or her responses will be held in the strictest of confidence by the researchers. Names will not be reported with the success or failure of a boat nor with any of his or her responses. All data will be reported in group form only. You may receive the group results of this study upon completion, September 15, 2006 at Martin Luther King High School, Riverside, California.

Your son or daughter's participation in this study is totally voluntary. He or she is free not to answer any questions and/or to withdraw from this study at any time without penalty. Upon completion of participation in this study, your son or daughter will receive a debriefing statement describing the study in more detail. In order to ensure the validity of the study, we ask that participation in this study is not discussed with other students or participants. The benefits of this research include the satisfaction of helping to make a useful physics project website that helps to educate and inspire many future students, both locally and far away. There are no reasonably foreseeable risks or discomforts caused by participation in this study.

If you, or your son or daughter, have any questions or concerns about this study, please feel free to contact me: Mr. Barry at (951) 789-5690 X 3042 or at rbarry@king.rusd.k12.ca.us . You may also contact Dr. Newberry at (909) 537-5000 X 77630 or at bnewberr@csusb.edu . If you have questions about rights of participants, please contact Michael Gillespie, IRB secretary, at (909) 537-5027 or at mgillesp@csusb.edu .

By placing a check mark in the box below, I acknowledge that I have been informed of, and that I understand, the nature and purpose of this study, and I freely consent to my son or daughter's participation. I also acknowledge that I am at least 18 years of age if I sign on the "Parent/Guardian" signature line.

**Place a check mark here**

Signature: \_\_\_\_\_  
Parent/Guardian (or Participant if at least 18 yrs of age)

Date: \_\_\_\_\_

Signature: \_\_\_\_\_  
Participant (I freely accept participation in this study.)

Date: \_\_\_\_\_

APPENDIX M

WEBSITE EXPERIENCE QUESTIONS FOR PARTICIPANTS



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