Exploring the relationships between Web usability and students’ perceived learning in Web-based multimedia (WBMM) tutorials

Thomas P. Mackey a,*, Jinwon Ho b,1

a Department of Information Studies, College of Computing and Information, University at Albany, State University of New York, Draper Hall, Room 141C, 135 Western Avenue, Albany, NY 12222, USA
b Department of Informatics, College of Computing and Information, University at Albany, State University of New York, 135 Western Avenue, Albany, NY 12222, USA

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Abstract

The purpose of this case study is to better understand the relationships between Web usability and students’ perceived learning in the design and implementation of Web-based multimedia (WBMM) tutorials in blended courses. Much of the current research in this area focuses on the use of multimedia as a replacement for classroom instruction rather than as a complement to teaching practices in courses that meet face-to-face. This study analyzed data collected from 41 undergraduate students who accessed a series of WBMM tutorials to learn Web design in an upper-level undergraduate information science course that combines both in-class and online instruction. We provide a descriptive analysis of student survey responses and apply Kendall’s rank correlation coefficient to examine significant relationships (p < 0.05) between usability factors and students’ perceived learning performance. We also explore the impact of WBMM on other aspects of the course, such as readings, email, office hours, and computer lab. Findings indicate that students responded favorably to most of the usability factors defined in this study and that course lectures and readings may have been enhanced by this virtual resource. In addition, we identified a significant correlation between usability factors of the WBMM tutorials and how students perceive their own learning. This study suggests that multimedia instruction is an effective approach to teaching Web design in blended learning environments that include both face-to-face and Web-based resources.

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1. Introduction

Web-based multimedia (WBMM) combines various elements of text, image, sound, and/or animation in an integrated and dynamic online format. The availability of this technology on the World Wide Web has the
potential to extend instruction beyond traditional class time and to enhance student learning in blended courses. The term “multimedia” is often used to define a range of applications, from the use of CD-ROMs on computer workstations to Web-based animation, but for this article the term describes tutorials that combine moving images of software demonstrations and audio on the Web. This study suggests that WBMM tutorials complement blended classes that include both face-to-face instruction and online components, such as course management systems and/or course Web sites. WBMM tutorials may also be useful in classes and programs that rely entirely on distance or distributed learning environments. In addition, the effectiveness of WBMM is relevant beyond colleges and universities and may have implications for organizational and commercial settings as well.

In this study, we examine the use of WBMM to teach Web design fundamentals in an information science course that combines information literacy and information technology. During the fall 2004 and spring 2005 semesters, a series of 26 WBMM tutorials were developed by the primary author to support lecture and lab demonstrations on how to create Web pages. Each tutorial provides full-motion video of desktop activity, synchronized with audio of the instructor’s narration in a Macromedia Flash file format (.SWF) that is accessible via the Web. Since the delivery method for multimedia in this context is the Web, this case study explores the specific usability dimensions of that medium. In addition, because the tutorials were developed for a course that meets face-to-face, we are interested in the impact of this technology on other aspects of the class, including lecture, readings, email, office hours, and computer lab.

A review of the literature identifies three primary learning theories (behaviorist, constructivist, and cognitive) related to how users learn from multimedia. Although the literature does not reveal a generally agreed upon theory that easily applies to all learning environments, a cognitive approach to multimedia is most closely aligned with the goals of this particular study. The literature also includes numerous case studies that examine the use of this technology in classroom settings and on the Web. The case studies demonstrate a differing approach to how the term “multimedia” itself is defined, which further supports the goals of this study to clearly define the term and better understand its access and use on the Web.

2 Learning theory

2.1 Behaviorist, constructivist, and cognitive

Three central learning theories are often discussed as influences on how we understand the impact of multimedia on learning: behaviorist, constructivist, and cognitive (Baruque & Melo, 2004; Deubel, 2003; Mayer, 2001). Behaviorism has potential implications for instructional designers because as Deubel (2003) suggests “learning is a change in behavior due to experience and function of building associations between the occasion on which the behavior occurred (stimulus event) and the behavior itself (response event)” (p. 65). This theory focuses on the needs and capabilities of the learner (Deubel, 2003). Baruque and Melo (2004) argue that, from a constructivist point of view, “learning is constructed by the complex interaction among students’ existing knowledge, the social context, and the problem to be solved” (p. 346). This perspective challenges educators to develop meaningful problem-solving and collaborative activities that lead to the process of creating new knowledge (Baruque & Melo, 2004). Mayer’s (2001) cognitive approach to multimedia asserts that learners gain a deeper level of understanding through the associations made between words and images in an integrated environment, than is possible when such factors are separate (p. 5). Mayer’s (2001) research has implications for designers because it recognizes the comprehensive nature of this medium and how users engage with this technology to make meaning.

For the purposes of this study, Mayer’s (2001) cognitive approach to multimedia is especially relevant because he explores the impact of this integrative interface on learners (p. 3). Constructivism is also important because students in this course are faced with problem-solving challenges to produce their own Web pages. Our survey, however, is primarily focused on the usability of WBMM and does not directly address issues related to collaboration, social learning, or behavioral change. These other learning theories are clearly pertinent and could be explored in relation to WBMM in future research.

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2 The WBMM tutorials may be accessed via the primary author’s home page at: http://www.albany.edu/~mackey/.
2.2. Cognitive theory

Mayer (2001) defines the term multimedia learning as “learning from words and pictures” and multimedia instruction as a “presentation involving words and pictures that is intended to foster learning” (p. 3). He is interested in the synchronization of words and images in computer mediated environments and asserts that “students are more likely to engage in productive cognitive processing when corresponding words and pictures are presented at the same time” (Mayer, 2002, p. 64). According to Mayer (2002) “active learning processing” involves “selecting relevant words and pictures, organizing them into coherent pictorial and verbal models, and integrating them with each other and appropriate prior knowledge” (p. 60). From Mayer’s perspective, words and pictures are not “equivalent” factors that replace one another, but rather “complementary” considerations in an integrated structure (Mayer, 2001, p. 4). Mayer and Moreno (2002) argue that one of the key principles of multimedia “is that students learn more deeply from animation and narration than from narration alone” (p. 93). In addition, Moreno and Valdez (2005) found “that students learn better when provided with visual and verbal knowledge representations rather than visual or verbal representations alone.” (p. 43). Moreno and Valdez (2005) also argue that “deep learning is not promoted unless careful consideration is given to the effects of different feedback strategies” in an interactive multimedia environment (p. 43). This suggests that while the integration of elements is an important consideration in the design of multimedia, we must also consider the impact of interactivity and feedback on student learning.

In an earlier study that addressed the impact of integrated multimedia design on cognition, Large, Beheshti, Breuleux, and Renaud (1995) found that “design criteria for multimedia products are highly significant in determining their educational effectiveness” (p. 346). In particular, their research suggested that “good integration of text and animation seems crucial” (p. 346). Their cognitive study supports the theory that the combination of multimedia factors is critical to comprehension. The authors concluded that “text enhanced with animation sequences seems to facilitate the understanding of procedural texts such as might be found in certain parts of the curriculum like science and technology” (p. 346). Interestingly, Tabbers, Martens, and van Merriënboer (2004) challenged the importance of integrated multimedia elements in a study that examined the impact of Web-based multimedia on student learning. The authors found that “bi-modal presentation is only advantageous when the system sets the pace of the instructions, whereas visual-only instructions are the preferred format if the learner is in control” (p. 80). Their study contested the assertion of Mayer and others that the combination of multimedia elements improves student comprehension, while also identifying user control as an important factor in the learning process.

3. Web usability

Since the focus of this study is on the use of multimedia tutorials on the Web, we need to examine this resource from a Web usability perspective. The term Web usability is grounded in research focused on human–computer interaction (HCI) and user-centered design (UCD). According to Brinck, Gergle, and Wood (2002) “usability is defined as the degree to which people (users) can perform a set of required tasks (p. 2). They argue that “highly usable Web sites are intuitive” and “transparent” to the user (p. 2). This type of user-centered design makes it easy and efficient for people to achieve their goals without having to deal with an excessively complicated site (Brinck et al., 2002, p. 2). While Lazar (2006) highlights ease-of-use as an equally important usability consideration he also advocates for a balanced approach to Web design that allows for the appropriate use of media elements such as graphics, plug-ins, and animation (p. 6). He asserts that “because the browsing experience is inherently unpredictable, the interface must be as predictable as possible” (Lazar, 2006, p. 8). Likewise, Schneiderman (2002) emphasizes consistency and predictability in interface design that provides for a high level of user control (p. 65). He also considers the variability of the Web experience based on different technologies and inconsistent levels of access and argues for “universal usability, in which everyone can be a successful computer user” (Schneiderman, 2002, p. 67). For Schneiderman, usability extends beyond specific guidelines for developing effective information systems to deeper human issues related to “feelings of mastery, satisfaction with accomplishment, and a sense of
responsibility’’ (p. 65). Ultimately he believes that this potentially empowering experience should be available to everyone.

While definitions of the term Web usability vary, the literature suggests that several key design features are common considerations. We will outline several fundamental Web usability factors that informed the production of the WBMM tutorials examined in this study.

3.1. Content, file size, and response time

Nielsen (2000) argues that, “quality content is one of the two most important determinants of Web usability, the other being whether users can find the page they want” (p. 160). Brinck et al. (2002) emphasize the “quality of information” and argue that “users prefer information with legitimacy, information that is honest, accurate, up to date and based on reliable, expert sources” (p. 264). In terms of providing access to quality online content, response time is an essential Web usability factor that is influenced by the file size of graphics and multimedia, as well as database-driven content and server-side applications (Brinck et al., 2002; Lazar, 2006; Nielsen, 2000). Nielsen (2000) argues that as bandwidth options increase, video produced for the Web will be used “as a supplement to text and images” (Nielsen, 2002, p. 149). This suggestion is consistent with the recommendations of the World Wide Web Consortium’s (W3C) Web Accessibility Initiative (WAI) to provide alternative descriptions for graphics and multimedia content. According to Nielsen (2000) it is important to produce short one-minute video and audio clips on the Web and to use transcripts rather than large video presentations. He also emphasizes good sound quality and contends that audio provides another channel of information to complement visual presentation with speech, music, or sound effects (p. 154). Lazar (2006) argues that if sound or graphics are not absolutely needed the larger file types associated with these features should be avoided or developers should incorporate warnings about the increased download time on the Web page (p. 138).

Concern about response time is informed by realistic access issues, but options for connecting to the Web continue to improve considerably. The Organisation for Economic Cooperation and Development (OECD) provides a global perspective, reporting that “the number of broadband subscriptions throughout the OECD continued to increase in the first half of 2005 from 119 million to 137 million.” In 2006, The Pew Internet & American Life Project found that “the number of Americans who have broadband at home has jumped from 60 million in March 2005 to 84 million in March 2006 – a leap of 40%” (Horrigan, 2006, p. 1). Nielsen//NetRatings (2006), Inc. found that “the number of active broadband users from home increased 28 percent year-over-year, from 74.3 million in February 2005 to 95.5 million in February 2006.” This indicates a substantial increase in broadband usage in which 68 percent of “active internet users” in the United States have potential access to large files that require fast connections. At the same time, however, with 32% or one-third of users accessing the Web via some form of narrowband, many users may have difficulty accessing large files. This suggests that file size and response time continue to be relevant Web usability factors for many users.

3.2. Screen size and display

The display of a Web page is influenced by screen resolution which is variable among different computer monitors. This is a Web usability factor that can be defined by developers in values of pixels or percentages. Niederst (2001) argues that “the page should be accessible (and display properly) to the greatest possible number of people” but she also acknowledges that “there remains some controversy over which resolution is the safest” (p. 25). Although a monitor resolution of 1024 × 768 or 800 × 600 pixels has become a viable option for many developers, others argue for the lowest monitor resolution of 640 × 480 pixels as a common standard (Brinck et al., 2002, pp. 204–205; Niederst, 2001, p. 25). Lazar (2006) recommends testing Web pages “with multiple screen resolutions, to ensure that the pages will appear appropriately in different resolutions” and to design pages with percentages rather than pixel dimensions (p. 142). As with connection speed, monitor resolutions will vary from one user to another. Therefore, it is important to design with an awareness of this variability and to consider the needs of a particular audience.
3.3. User control

User control is another essential usability factor in the development of WBMM (Brinck et al., 2002; Tabbers et al., 2004). Nielsen (2002) states that one of the significant usability improvements of the software program Macromedia Flash MX (http://www.macromedia.com) over previous versions is that it includes “a standard set of interaction controls.” Similarly, Brinck et al. (2002) argue that when developing WBMM with Macromedia Flash “the navigation must be available and accessible to the user” (p. 336). The authors assert that users must be provided with “access to the Macromedia Flash contextual menu (this enables zooming, sound control, rewinding, and adjusting quality to fit local processing power)” (p. 336). In addition, the authors argue for “a status bar to indicate how far along the movie is in its loading process” as well as status information for “total file size” (p. 337). This is similar to Lazar’s recommendation for providing users with a warning about increased download time due to large files (p. 138).

4. Multimedia case studies

Methodologies differ in each case study as do conclusions about the relationship between multimedia and learning outcomes. The intersection between Web usability and learning is not fully examined but researchers in this area tend to argue that teaching with multimedia has a positive impact on student learning. In some cases, multimedia is seen as a possible replacement for in-class instruction, while other cases support the view that multimedia complements existing courses. Definitions of the term ‘multimedia’ vary considerably but this technology can be categorized in two ways: (1) computer based multimedia, which is dependent on a computer workstation and software, and (2) Web-based multimedia, which is dependent on computer access to the Web.

4.1. Computer based multimedia

Crowther, Keller, and Waddoups (2004) evaluated the usability of CD-based modules for an introductory chemistry course. The researchers found that students were frustrated and/or confused by such Web usability factors as navigation, rewind, transitions, and instructions (Crowther et al., 2004). In addition, most students did not see the multimedia modules as a replacement for face-to-face lectures, but rather as “a supplement to the textbook and in-class sessions” (p. 302). Erwin and Rieppi (1999) compared several undergraduate psychology courses in large multimedia classrooms with smaller classrooms that did not utilize multimedia. The authors concluded that “students in the multimedia lecture hall performed, on average, better than students in the traditional classrooms” (p. 60). This approach has implications for colleges and universities with high enrollments because “they can utilize large multimedia classrooms to teach a larger number of students without sacrificing performance” (Erwin & Rieppi, 1999, p. 60).

Smith and Woody (2000) compared a multimedia enhanced version of an introductory psychology course with a section of the same course that did not incorporate multimedia. The multimedia enhanced section featured “video clips and photos that were integrated into the slide show presentations” (p. 221). The authors found that “the effects of multimedia teaching strategies do have some benefits but that these benefits do not fall evenly on all students” (p. 223). In particular, the authors asserted that “those students who prefer visual input to verbal input will benefit more than those who are less visually oriented” (p. 223). In addition, students with a verbal orientation are less likely to improve their academic performance and may even be at a disadvantage in multimedia enhanced environments (Smith & Woody, 2000). This is an interesting finding because it accounts for not only the technology applied and teaching methodology employed, but also the individual profiles of students as visual and/or verbal learners and the impact this may have on their academic success in different classroom environments.

Trinder (2002) evaluates student responses to a multimedia CD-ROM series implemented in a course that teaches the English language for business, with a particular emphasis on negotiation skills. One of the primary goals of this study was to better understand “the respondents’ general attitudes towards using multimedia for language learning purposes” (p. 69). The study focused on user response to specific features and options of the multimedia, and whether or not students thought this approach individualized learning. Trinder argued that “although there are quite a few points of criticism with this particular CD, the majority (two thirds of the
population) would welcome the integration of multimedia into language courses,” but as a supplement to other resources (p. 79). She found that “computers can make valuable contributions by supplementing and complementing whatever the human teacher and the ‘old media’ can bring to the learning environment” (p. 83).

Khine and Lourdusamy (2003) examine the use of multimedia tutorials in a teacher training program in Singapore. While the tutorials were made available to students in a CD-ROM format, a follow-up Web-based discussion board was also implemented to facilitate online discussions among students. Khine and Lourdusamy reported that “the use of the multimedia CD-ROM and discussions are mainly positive and encouraging” (p. 674). They found that the use of multimedia in a blended learning environment that combined “face-to-face instruction, multimedia viewing and online discussion” was an effective way to facilitate one module in their teacher training program (p. 675).

4.2. Web-based multimedia

Kekkonen-Moneta and Moneta (2002) compared a face-to-face lecture course in computing fundamentals with an online version that utilized WBMM for instruction. The authors found that the online version was “at least as effective as the lecture course in terms of students’ learning outcomes” (p. 431). They attributed the ability of the online students to perform well in “applied-conceptual learning” to their engagement with course content through the interactive and design characteristics of the WBMM modules (p. 432). They found that based on student responses the lecture-based version of the course could be replaced by the multimedia version.

Zerger, Bishop, Escobar, and Hunter (2002) evaluated a series of WBMM modules developed for a course in geographic information systems (GIS). The modules were developed as a complement to the existing course and not as a replacement. The authors argue that this approach is promising “because GIS is a technology based on dynamic spatial concepts, it lends itself well to multimedia-based representations and learning” (p. 68). Two problems were identified in this case study. First, the speed of access to the modules was slow due to large file size and second, some students were unwilling to access the materials on the Web.

Kumta, Tsang, Hung, and Cheng (2003) explored the use of clinical case simulations (CCS) on the Web by comparing a study group that used the simulations with a control group that did not have access to the same materials (pp. 269–270). The control group in this study used Web-based lecture notes rather than the Web-based simulations. The researchers found that students in the study group scored significantly higher on the follow-up test than the control group (p. 271). In addition, the simulations had an impact on how students interacted with patients because “students in the study group spent more time in the wards doing self-study and physical examinations as compared to the control-group” (p. 272). The authors concluded that the Web-based simulations “complemented and deepened their understanding of patient care” which increased the time they spent with patients and ultimately improved their test scores (p. 272).

These case studies demonstrate that educators in a variety of disciplines are implementing multimedia to advance student learning. This work is taking place in computer labs and on the Web. There is some disagreement as to whether or not multimedia is an effective replacement for face-to-face instruction. Students’ perceived learning is not empirically analyzed in relation to specific Web usability factors. In addition, the impact multimedia may have on other aspects of an existing course such as office hours, email, and computer lab is not yet fully examined. There is some indication that WBMM may be a complementary resource that influences active learning (Kumta et al., 2003). These case studies do not specifically examine WBMM as a resource for teaching Web development, but the success of this approach in a computing fundamentals course (Kekkonen-Moneta & Moneta, 2002) and in a GIS course (Zerger et al., 2002) indicates that it is possible to learn technology concepts through this method. Several of the case studies reinforce the need to address usability problems, such as navigation and rewind (Crowther et al., 2004), as well as speed of access and file size (Zerger et al., 2002).

This review of prior research supports our assertion that we need to better understand the usability factors of multimedia produced especially for the Web. Our study is focused on the relationships between Web usability factors in WBMM tutorials and students’ perceived learning in a blended course. In addition, we will concentrate on the use of WBMM to teach Web design in a course that combines information literacy and
information technology instruction. Within this context, the multimedia tutorials provide an online resource for students to learn how to create Web content.

5. Web-based multimedia in context

5.1. Course format

ISP301: The Information Environment is an upper-level, discipline-specific course in the School of Information Science & Policy (SISP) at the University at Albany, State University of New York. This course meets the University at Albany’s General Education Information Literacy Requirement and is organized into three integrated modules (see Table 1):

1. Web design and W3C standards,
2. research methods,
3. topics in information science.

In the first module, Web design and W3C standards students learn the fundamentals of how to make a Web page, including: HTML, XHTML, cascading style sheets (CSS), digital imaging, file sharing, file permissions, and UNIX. They are also introduced to Web usability concepts and accessibility principles based on the World Wide Web Consortium’s (W3C) Web Accessibility Initiative (WAI). Students also learn how to validate their Web pages using the W3C’s online Markup Validation Service (http://validator.w3.org/). In the second module, Research Methods, students learn how to access and retrieve information science academic journals in the library and online, how to differentiate between scholarly, popular, and trade sources of information, and how to critically evaluate Web sites. In this module students also learn how to plan and develop a formal information science research paper, and how to properly document sources of information with the American Psychological Association (APA) style guide. In the third module, Topics in Information Science, students explore several information science topics, such as: human–computer interaction (HCI), Web usability, information architecture, digital divide, copyright, fair use, and intellectual property, as well as Internet and PC security. Students also learn how to describe and organize information by developing a basic XML page.

Throughout the course, students develop individual and collaborative Web pages and Web sites. Web design instruction is provided during lecture by the professor and students are encouraged to attend computer labs taught by the teaching assistants. Students also have access to instructional resources available via the course Web site and course management system, WebCT. Since most of the Web design instruction takes place in formal lecture, supporting materials are essential for students to access after class (at home and during computer lab) when they work on the required Web assignments. In spring 2005, students developed three individual Web pages and a final collaborative Web site.

In fall 2004, the primary author developed 16 WBMM tutorials for students in ISP301 and in spring 2005 he produced 10 additional tutorials. Prior to the development of the WBMM tutorials, students in previous semesters had access to static Web pages that provided instructions with text and image (screen captures of

<table>
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<th>Table 1</th>
<th>ISP301 course modules</th>
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<tr>
<td>Module 1: Web design and W3C standards</td>
<td>Module 2: Research methods</td>
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<tr>
<td>• HTML</td>
<td>• Accessing and retrieving information science journals</td>
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<tr>
<td>• XHTML</td>
<td>• Differentiating between scholarly, popular, and trade sources</td>
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<tr>
<td>• Cascading style sheets (CSS)</td>
<td>• Web site evaluation</td>
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<tr>
<td>• File transfer and secure shell (SSH)</td>
<td>• Government documents</td>
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<tr>
<td>• W3C validation (for XHMTL and CSS)</td>
<td>• Research paper planning</td>
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<tr>
<td>• Digital imaging</td>
<td>• Style guides (ALA and MLA)</td>
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<tr>
<td>• UNIX (directory structure, file permissions, basic commands)</td>
<td>• Plagiarism prevention</td>
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key steps). The new tutorials expanded on the static Web pages with full-motion video of screen activity and synchronized audio in a Flash file format (.SWF). The tutorials cover a range of topics, including UNIX, HTML, XHTML, cascading style sheets (CSS), and digital imaging.

5.2. Multimedia software

The WBMM tutorials in ISP301 were produced using version 2 of a screen-capture program Camtasia Studio (2004), which is a software application developed by TechSmith Corporation (http://www.techsmith.com). In prior research, Tombros, Ruthven, and Jose (2004) used this program to simultaneously record “participant utterances” and “desktop activity” in an information-seeking study (p. 330). For our study, this program was used in ISP301 to record screen movements and audio at the same time, producing multiple live action tutorials for the Web (see Fig. 1). The tutorials were recorded either before or after lecture in support of course material and assignments. At times, the tutorials were used in lecture as part of the formal demonstration or mentioned to students in class, during computer lab, and via email as a technical or troubleshooting resource. Some of the tutorials were developed as a response to specific questions by students.

Consistent with Mayer’s (2001) definition of multimedia instruction, the WBMM tutorials in this course combine image, text, and sound in a simultaneous playback mode to advance student learning. The presentation of each tutorial consists of dynamic full-motion screen captures that demonstrate how to use a particular software program. This video playback (in a Flash file format) is synchronized with audio narration provided by the instructor. The tutorials are designed to engage students in active learning because the integrated presentation of audio and video on the Web illustrates in detail how to develop Web pages. Students do not simply watch the tutorials to gain knowledge for taking a test, but rather they access these materials to learn how to produce several Web assignments throughout the semester. The WBMM tutorials are modeled after the same in-class demonstrations provided by the course instructor using a computer and projector for

![Screen-capture of WBMM tutorial for digital imaging lesson.](image)
large screen presentation in a lecture hall. The tutorials build on the students’ knowledge about Web design fundamentals gained during other key aspects of the course such as lecture, computer lab, office hours, and readings. As such, it is important to explore the Web usability factors that influence how these materials are accessed and understood, as well as how students perceive the relationship between the tutorials, other course components, and their learning.

5.3. Web usability factors and the impact on design

Web usability informed the design of the WBMM tutorials in this course (see Table 2). For example, issues of access to these materials and response time influenced the file size and format, the duration of each tutorial, screen size, as well as the video and audio quality (Brinck et al., 2002; Lazar, 2006; Niederst, 2001; Nielsen, 2000). The specific usability considerations for Macromedia Flash introduced by Brinck et al. (2002) also influenced the design of the tutorials. For example, students have control over how these materials are presented through such interactive features as stop, pause, and rewind. They also have access to status information related to file loading and time remaining (Brinck et al., 2002; Lazar, 2006).

File size was an important usability factor for all of the tutorials produced in this course and was kept to a minimum. The 26 tutorials range in size from 1.18 MB to 4.11 MB. The duration of each tutorial was also designed for brevity and ranges from thirty-one seconds (:31) to three minutes and forty-six seconds (3:46). The screen size of each tutorial is set at 640 by 480 pixels to accommodate monitors with the smallest resolution. In addition, all 26 tutorials were available to students on a separate Web page via clearly marked hypertext links. When a student clicks on the links for each tutorial a separate Web page appears and the

<table>
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<tr>
<th>Table 2</th>
<th>Usability factors for WBMM</th>
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<tr>
<td>Content</td>
<td>File size and response time</td>
</tr>
<tr>
<td>Quality content</td>
<td>Small file size</td>
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<tr>
<td>Ease of access</td>
<td>Keep duration of each tutorial brief</td>
</tr>
<tr>
<td>Useful information</td>
<td>Quick response time</td>
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<tr>
<td>Audience considerations</td>
<td>Speed of access</td>
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<tr>
<td>Combine audio and video to deliver content</td>
<td>Good video and sound quality</td>
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<td></td>
<td>Streaming media format</td>
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<td>Provide warnings about download time</td>
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Fig. 2. WBMM tutorial navigation bar.
6. Description of research project

Rubin (1994) provides a practical framework for conducting research about user-centered design. He defines usability testing as “a process that employs participants who are representative of the target population to evaluate the degree to which a product meets specific usability criteria” (p. 25). This is an important consideration for this study because the college students we surveyed are also the target population of the WBMM tutorials produced for this blended course. The feedback offered by our participants is valuable beyond this particular course because it represents the potential response of college students in other settings. Rubin (1994) considers usability testing a developing process and he identifies three fundamental principles of user-centered design to guide research in this area. First, he argues for “an early focus on users and tasks” which requires “a systematic, structured, approach to the collection of information from and about users” (Rubin, 1994, p. 12). Second, he promotes an “empirical measurement of product usage” to measure “ease of learning and ease of use very early in the design process” (Rubin, 1994, p. 12). Third, Rubin (1994) values “iterative design, whereby a product is designed, modified, and tested repeatedly” (p. 12).

As an exploratory study in the early stage of this process, this research study focuses on users of the WBMM tutorials to gain meaningful feedback about the design and use of this resource in a specific blended course. The survey instrument used in this study explores the “ease of learning and ease of use” related to the WBMM tutorials based on Web usability considerations (Rubin, 1994, p. 12). This work is seen as a larger part of an iterative process that will continue to shape the production and implementation of the tutorials based on feedback from our participants. As Rubin (1994) argues, “surveys can be used at any time in the life cycle, but are most often used in the early stages to better understand the potential user” (p. 20). Although this study is limited at this early stage, it is an essential starting point that will impact the direction and design of future research.

6.1. Research questions

This study raises three primary research questions:

1. How did students evaluate the effectiveness of several usability factors related to the WBMM tutorials?
2. Did the WBMM tutorials have an impact on other resources (email, office hours, readings, and computer lab)?
3. Is there a significant ($p < 0.01$) correlation between usability factors and perceived learning performance?

6.2. Survey instrument

Forty-one undergraduate students completed our survey from a total of 65 who were enrolled in ISP301: The Information Environment during the spring 2005 semester. This was a high response rate of 63.1%. Responses to all of the questions were based on a five-step Likert scale and ranged from strongly disagree to strongly agree (see Appendix). Students responded to 20 questions in this voluntary end-of-semester survey via the course management system WebCT. Although WebCT does provide the course instructor with a report of which students completed the survey, student names and identification numbers are not connected with responses in any way. Students completed the survey before final grades in the course were administered.

Students were invited to participate in the survey at the beginning of one of the final class sessions by an ISP301 teaching assistant when the principal investigator was not in the room. The teaching assistant read a
script to the class that explained the research study and the survey, and provided an example of one of the survey questions. The students who agreed to participate in the study were asked to sign two copies of a research study consent form that was approved by the University at Albany’s Institutional Review Board (IRB). The consent form identified the course instructor as the principal investigator, provided a brief description of the project, and explained their participation in the study. They were asked to keep one copy for their records and to turn in the other copy to the teaching assistant. This form was not made available to the principal investigator until after final course grades were submitted. Students were informed that they were not required to participate in the study and that if they chose to participate they could withdraw at any time. They were also made aware that they did not have to answer any question(s) that they did not want to.

6.3. Survey model

The survey itself was modeled after the user evaluation questionnaire in Trinder’s (2002) study that analyzed student reaction to multimedia in a CD-ROM format (p. 74). This study focused extensively on students’ perceptions of multimedia instructional design. Prior research also incorporated students’ perception of learning in analyzing the effectiveness of online instruction (Hughes & Daykin, 2002; Perez-Prado & Thirunarayanan, 2002). We developed our survey based on Trinder’s (2002) model because she was primarily interested in students’ perceptions of the “quality of media” utilized in a course that meets face-to-face (p. 74). This matched our interest in examining the usability of multimedia developed for ISP301, although we are focused on specific Web usability factors. She was also interested in whether or not multimedia replaced or complemented other aspects of the course, which is similar to one of our concerns. In addition, Trinder (2002) recognized separate multimedia elements such as video and audio, but also addressed the simultaneity of these elements in a multimedia format and the potential impact this had on student understanding of content. This was consistent with our interest in exploring the synchronicity of audio and video in a multimedia format and the impact these factors may have on student learning. Overall, we considered Trinder’s (2002) questionnaire an effective model for our study that could be developed as a Web-based survey in WebCT.

6.4. Kendall’s tau

In an effort to further explore the impact the WBMM tutorials may have had on student learning we used Kendall’s tau for finding relationships between usability factors and learning performance. Kendall’s tau, specifically used for paired ordinal data, is a nonparametric equivalent of the Pearson correlation coefficient (Fox, 1998; Morgan & Griego, 1998; Sigel, 1956). Nonparametric analysis is being used for this study because classical data analysis is not appropriate for ordinal data and a nonparametric test is especially appropriate if the level of measurement is ordinal (Gibbons, 1993). Through this approach we also tested the relationship between usability factors of the WBMM tutorials and understanding how to create Web pages.

7. Survey results

7.1. Student responses to survey

A complete summary of the survey questions and student responses is organized into three main categories: usability factors, relationship to other course resources, and student learning (see Table 3). One of the respondents did not provide answers to the following questions: 1, 2, 3, 4, 6, or 14. The answers of this respondent were used in all other questions. Thus, the analysis as noted in the table is either for \( n = 40 \) or \( n = 41 \). Calculations are based on responses to the questions that were fully answered.

7.2. Usability factors

7.2.1. Audio and video

Students responded favorably to most of the usability factors of the WBMM tutorials. 87.8% of the students surveyed either agreed or strongly agreed that the audio quality was good (see Fig. 3). None of
the students surveyed disagreed or strongly disagreed with this assertion. 97.5% either agreed or strongly agreed that the video quality was good (see Fig. 4). Again, none of the students disagreed or strongly disagreed with this statement. More specifically, 87.8% of students either agreed or strongly agreed that the speed of
audio was at an appropriate level of instruction (see Fig. 5). The same percentage of students (87.8%) indicated that the speed of video was at an appropriate level of instruction (see Fig. 6).

### 7.2.2. Synchronicity of audio and video

95.1% of the students surveyed either agreed or strongly agreed that the audio and video were well synchronized (see Fig. 7).

### 7.2.3. Menu control

90.2% of the students surveyed either agreed or strongly agreed that the menu control was convenient (see Fig. 8).

### 7.2.4. Response time, display, and content

85.3% of the students surveyed either agreed or strongly agreed that the multimedia tutorials displayed quickly (see Fig. 9). 90.3% indicated that the screen size of the multimedia tutorials was ideal for viewing.
Similarly, 90.3% either agreed or strongly agreed that the content of the WBMM tutorials is easy to understand (see Fig. 11).

7.3. Relationship to other course resources

7.3.1. Lectures and readings

72.6% of the students surveyed either agreed or strongly agreed that the WBMM tutorials enhanced lectures (see Fig. 12). 65.8% either agreed or strongly agreed that the tutorials supplemented readings (see Fig. 13).

7.3.2. Computer lab, email, and office hours

Student response to a question about whether or not the WBMM tutorials replaced the need to attend computer lab sessions was divided. While 48.8% of students agreed or strongly agreed that the tutorials replaced the need to attend lab, 21.9% disagreed or strongly disagreed with this assertion and 29.3% reported a neutral
Fig. 8. Percentage of students who indicated that the menu control was convenient.

Fig. 9. Percentage of students who indicated that the tutorials displayed quickly.

Fig. 10. Percentage of students who indicated that the screen size was ideal for viewing.
Fig. 11. Percentage of students who indicated that the content is easy to understand.

Fig. 12. Percentage of students who indicated that the WBMM tutorials enhanced lectures.

Fig. 13. Percentage of students who indicated that the WBMM tutorials supplemented readings.
response (see Fig. 14). 73.1% of students surveyed indicated that the WBMM tutorials reduced the need to email instructors about technical questions (see Fig. 15). 56.1% indicated that the tutorials reduced the need to attend office hours, while 24.4% of students disagreed with this assertion (see Fig. 16).

7.4. Student learning

87.8% of the students surveyed either agreed or strongly agreed that the WBMM tutorials were effective in helping them to understand one of the key learning goals of the course, how to create Web pages (see Fig. 17). None of the students surveyed disagreed or strongly disagreed with this assertion. 87.8% of students either agreed or strongly agreed that the tutorials were an efficient way to learn how to create Web pages (see Fig. 18). Overall, 90.3% of students either agreed or strongly agreed with the general assertion that the WBMM tutorials helped to improve their learning (see Fig. 19).

Based on Kendall’s tau (see Table 4), most of the usability factors are significantly associated with students’ perceived learning performance ($p < 0.05$ or $p < 0.01$) except for screen size. In particular, audio speed, video speed, synchronization of audio and video, and prompt screen display when clicked are highly correlated.
Fig. 16. Percentage of students who indicated that the WBMM tutorials reduced the need to attend office hours.

Fig. 17. Percentage of students who indicated that the WBMM tutorials were effective in helping to understand how to create Web pages.

Fig. 18. Percentage of students who indicated that the WBMM tutorials were an efficient way to learn how to create Web pages.
Audio quality, video quality, convenient menu control, and content were also correlated ($p < 0.05$) with learning performance. Audio quality, video quality, convenient menu control, and content were also correlated ($p < 0.05$) with this concept.

Most of the usability factors significantly affect students’ understanding of how to create Web pages ($p < 0.05$ or $p < 0.01$) except screen size and content (see Table 5). In particular, audio quality, audio speed, synchronization of audio and video, and prompt screen display when clicked are highly correlated ($p < 0.01$)

### Table 4
Kendall’s tau: the relationship between Web usability factors and students’ perceived learning performance

<table>
<thead>
<tr>
<th>Web usability factors</th>
<th>Perceived learning performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio quality</td>
<td>$\tau = .345^*$</td>
</tr>
<tr>
<td>Audio speed</td>
<td>$\tau = .584^{**}$</td>
</tr>
<tr>
<td>Video quality</td>
<td>$\tau = .329^*$</td>
</tr>
<tr>
<td>Video speed</td>
<td>$\tau = .527^{**}$</td>
</tr>
<tr>
<td>Synchronization of audio and video</td>
<td>$\tau = .519^{**}$</td>
</tr>
<tr>
<td>Convenient menu control</td>
<td>$\tau = .350^*$</td>
</tr>
<tr>
<td>Prompt screen display when clicked</td>
<td>$\tau = .382^{**}$</td>
</tr>
<tr>
<td>Screen size</td>
<td>$\tau = .163$ (not significant)</td>
</tr>
<tr>
<td>Content</td>
<td>$\tau = .343^*$</td>
</tr>
</tbody>
</table>

$^*$ $p < 0.05$.  
$^{**} p < 0.01$.

### Table 5
Kendall’s tau: the relationship between Web usability factors and understanding how to create Web pages

<table>
<thead>
<tr>
<th>Web usability factors</th>
<th>Understanding how to create Web pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio quality</td>
<td>$\tau = .445^{**}$</td>
</tr>
<tr>
<td>Audio speed</td>
<td>$\tau = .431^{**}$</td>
</tr>
<tr>
<td>Video quality</td>
<td>$\tau = .380^*$</td>
</tr>
<tr>
<td>Video speed</td>
<td>$\tau = .422^{**}$</td>
</tr>
<tr>
<td>Synchronization of audio and video</td>
<td>$\tau = .470^{**}$</td>
</tr>
<tr>
<td>Convenient menu control</td>
<td>$\tau = .311^*$</td>
</tr>
<tr>
<td>Prompt screen display when clicked</td>
<td>$\tau = .437^{**}$</td>
</tr>
<tr>
<td>Screen size</td>
<td>$\tau = .266$ (not significant)</td>
</tr>
<tr>
<td>Content</td>
<td>$\tau = .314$ (not significant)</td>
</tr>
</tbody>
</table>

$^*$ $p < 0.05$.  
$^{**} p < 0.01$.  

Fig. 19. Percentage of students who indicated that the WBMM tutorials helped to improve learning.
with understanding how to create Web pages. Video quality and convenient menu control were also correlated ($p < 0.05$) with this concept.

We also tested whether usability factors influence the efficiency of learning how to create Web pages (see Table 6). In this test, audio and video quality as separate usability factors and video speed were not significantly correlated with efficiency to support this concept. At the same time, however, the synchronization of audio and video, convenient menu control, and prompt screen display when clicked were all highly correlated ($p < 0.01$) with the efficiency of learning how to create Web pages. Screen size and content were also correlated ($p < 0.05$) with this concept.

7.5. Access, frequency of use, and perceived learning performance

The first two questions about where students accessed the tutorials (either on or off campus) could have been developed as yes or no questions (see Table 3). We used a five-step Likert scale rather than a binary format, however, to maintain continuity among all 20 questions and to acknowledge that some students may have accessed the tutorials in both locations or not at all. According to the first two questions, 68.3% of students either agreed or strongly agreed that they accessed the WBMM tutorials when they are on campus and 53.6% either agreed or strongly agreed that they accessed the WBMM tutorials off campus. With an overlap of 21.9% in the response rate to both questions, some students probably accessed the tutorials both on campus and off campus (although we did not ask a specific question about access at both locations).

Students accessed the WBMM tutorials more frequently on campus (68.3%), than they did off campus (53.6%). There is a significant difference in the relationship between these locations and perceived learning performance. According to our analysis using Kendall’s tau, on campus access is strongly related to perceived learning performance ($p < 0.01$); however, the relationship between off campus and perceived learning performance is not significant at all.

Another important factor in students’ perceived learning was frequency of use. Based on our analysis, the more students used the WBMM tutorials, the more they thought their learning was improved ($p < 0.01$). Since the WBMM tutorials are significantly related to perceived learning performance, the frequency of using the tutorials positively affects students’ perceived learning performance as well.

8. Discussion

In this article, we raised three research questions to better understand the impact WBMM tutorials had on an information science course that meets face-to-face. We were interested in how students evaluated the effectiveness of several Web usability factors related to the tutorials and whether or not the tutorials have an impact on other resources, including email, computer lab, and office hours. We were also interested in whether or not a significant correlation existed between Web usability factors and the perceived learning performance of students in the class.
Based on the results of this study, students responded well to most of the usability factors of the WBMM tutorials we identified. This supports our assertion that multimedia developed for the Web must consider the usability factors unique to this medium. In particular, content, file size, response time, audio quality, and video quality are necessary considerations for the development of WBMM and were successfully applied in the tutorials. The favorable response to our terms “speed of audio” and “speed of video” reinforces the need for providing useful and easy-to-access content for a particular audience (Nielsen, 2000, p. 160). The WBMM tutorials displayed quickly for most users and the content was easy to understand. The results of our study also support the idea that user control of Web-based Macromedia Flash files is a relevant usability concern and that students found the menu control to be convenient in the tutorials. We also found that WBMM is an effective format for supplementing and enhancing an existing course that meets face-to-face. The tutorials developed for this class reinforced key Web design concepts demonstrated during lecture and explored in course readings. Most students indicated that the WBMM tutorials enhanced the lectures (73.2%) and supplemented readings (65.8%). Students considered the tutorials an efficient way to learn how to create Web pages.

For many students the WBMM tutorials replaced the need to attend computer lab (48.8%) and reduced the need to email the instructors about technical questions (73.1%). It is possible that some students were able to complete assignments without attending lab or asking the instructors questions via email. Another explanation for these findings is that students accessed the tutorials when they ran into difficulty, before contacting instructors. They may have been familiar enough with the tutorials, and the menu control for pause, play, fast forward and rewind, that they were able to easily locate particular lessons that answered their questions. More than half of the students surveyed (56.1%) indicated that the WBMM tutorials were a replacement for office hours. This suggests that for many students office hours may be an opportunity to ask technical questions related to course assignments and that the tutorials reduced the need to do so in person.

Based on student perception of their own learning, our study indicates that WBMM helps to increase understanding of Web design techniques and to improve learning. This initial effort to find correlations between Web usability factors and perceived learning performance provides interesting and promising findings. Our use of Kendall’s tau suggests that most of the usability factors we identified not only support effective design but also affect students’ perceived learning in a positive way. In particular, it is significant to note that the synchronization of audio and video is highly correlated with students’ perceived learning performance ($\tau = .519; p < 0.01$). This factor was also highly correlated with the more specific assertion of understanding how to create Web pages ($\tau = .470; p < 0.01$). This supports Mayer’s (2001) primary argument that it is the integration of complementary elements in a multimedia interface, and not just separate elements that advance student learning (p. 4). This further supports the need to study the synchronization of audio and video in a Web interface to better understand the impact on student learning.

Interestingly, the usability factor “content” is not significantly associated with the specific skill of understanding how to create Web pages, although it was significantly correlated ($\tau = .343; p < 0.05$) with the more general term learning performance. We believe that the reason for this disparity is because students may understand the basic content associated with how to create a Web page by the time they review the tutorials. Students are introduced to these concepts in lecture, computer lab, and readings. As such, the content of the WBMM tutorials may not be as important to understanding how to create the page as it is to their overall learning performance, which may be more closely related to the active production of their own Web pages. It is also possible that this disparity identifies a limit to this approach that must be further explored in future study.

Students responded in a positive way to screen size as a usability factor in the WBMM tutorials developed for this course, but based on Kendall’s tau this term was not significantly correlated with understanding how to create a Web page or learning performance. This suggests that screen size is not an important usability factor in the design of WBMM or that students did not see a connection between this term and the development of their own Web pages or their overall perceptions of learning in the course. Since the WBMM tutorials developed for this course were produced using the smallest screen resolution ($640 \times 480$) most students were probably able to view the entire presentation space of the tutorials without a problem. As such, they may not have identified this particular Web usability consideration as important to their learning because it was so easily available. Another possible explanation for why students may not have considered screen size an important
usability factor is because the survey question may not have been clear about whether or not we were referring to the browser, the monitor, or the presentation of the tutorial within the browser.

We also identified a difference in the relationships between access (on campus and off campus) and learning performance. While on campus access is significantly associated ($p < 0.01$) with learning performance, our test did not identify a significant correlation between off campus access and learning performance. This finding implies that students may perceive an improvement in learning performance when they are using the tutorials on campus, rather than off campus. Reasons for this apparent disparity may vary. We believe that students preferred using the tutorials on campus due to the fast network connection. This supports the contention of Nielsen and others that response time is an especially important usability consideration for WBMM. It is also possible that students utilized the tutorials more often when they were doing hands-on exercises during computer lab. If so, this suggests that students value face-to-face learning environments such as a computer lab, where they communicate with teaching assistants and other students, and in public user rooms or student housing on campus, where there is potential for additional peer support. The disparity in student response to the questions about on campus and off campus access is an intriguing area of study for future research. We need to learn more about the precise mode of access (dial-up, broadband, DSL, etc.) that students are using off campus and inquire about the level of peer support on campus and off campus.

9. Limitations

Our study is limited because we did not specifically question students about their connection speed off campus, while on campus we know that the connection is fast and is capable of managing the WBMM tutorials developed for this course. The survey instrument is limited because the 20-question format covers such a broad spectrum of usability factors. In addition, some of the terms, such as “screen size,” “efficient,” or “effective” may not be clearly defined for all respondents. For this study, we did not correlate the survey data with other course-related assessments such as final grades, but we are interested in further developing such an approach in future research.

10. Conclusion

Overall, the WBMM tutorials produced for ISP301 were effective in teaching students how to create Web pages. These materials complemented other class resources such as lectures and readings. At the same time, many students saw these online materials as a replacement for computer lab, email and office hours. The specific Web usability factors discussed in this study had an impact on how students used the tutorials and also had a positive impact on how students perceived their own learning. The WBMM tutorials implemented in this course were produced exclusively to teach Web design but the positive impact on perceived learning performance indicates that students may have learned more than the mechanics of how to create a Web page. Future research will need to include a more complete analysis of the cognate skills students gain from using these resources than is currently addressed in this study. In addition, the effectiveness of the tutorials in this case study suggests that WBMM may be useful in teaching a range of topics in other disciplines beyond technology instruction. This study also suggests that the use of WBMM to support instruction may allow for more valuable interactions with students than is possible when a considerable amount of class time is usually devoted to teaching technical concepts and applications.

While previous research in this area describes multimedia in different ways, from computer-based CD-ROMs to Web-based animation, our study clearly defines multimedia in a Web format and addresses several essential usability considerations of this particular medium. This study explores the relationships between students’ perceived learning and Web usability factors and we find that a significant correlation exists. We also avoid the notion that the instructor or the course itself is replaced by multimedia tutorials and instead we assert that this is a complementary resource to enhance other aspects of a blended learning environment. While some aspects of a course may be replaced or supplemented by Web-based instruction, this will allow instructors to spend more time with students on content issues, or other areas of skills development, such as research methods and writing. This study is also unique because it focuses on the use of WBMM to teach
Web design fundamentals in a blended information science course that integrates information literacy instruction.

Although this study is promising it does not fully assess individual learning performance in relation to the usability factors of the WBMM tutorials. Future research must continue to emphasize the unique characteristics of WBMM as an integrated and complementary interface, while developing an individualized assessment strategy to improve upon the ways these materials are designed and implemented.

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Appendix. The survey instrument

Questions
1. I accessed the multimedia tutorials on campus
2. I accessed the multimedia tutorials off campus
3. The audio quality of the multimedia tutorials was good
4. The speed of the audio was at an appropriate level of instruction
5. The video quality of the multimedia tutorials was good
6. The speed of the video was at an appropriate level of instruction
7. The audio and video of the multimedia tutorials were well synchronized
8. Menu control of the multimedia tutorials was convenient
9. Once the links were clicked, the multimedia tutorials displayed quickly
10. The screen size of the multimedia tutorials was ideal for viewing
11. Content is easy to understand
12. The multimedia tutorials were effective in helping me to understand how to create Web pages
13. The multimedia tutorials were an efficient way to learn how to create Web pages
14. The multimedia tutorials enhanced lectures
15. The multimedia tutorials supplemented readings
16. The multimedia tutorials replaced the need to attend computer lab sessions
17. The multimedia tutorials reduced the need to email the instructors about technical questions
18. The multimedia tutorials reduced the need to attend office hours
19. I used the multimedia tutorials frequently
20. Overall, the multimedia tutorials helped to improve my learning

Answers (Likert scale)
1. strongly disagree, 2. disagree, 3. neutral, 4. agree, 5. strongly agree

References
