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An Advanced Web-Based Multimedia Application for Learning Communities

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ABSTRACT
This study had three primary objectives set to overcome the challenges of using multimedia technology efficiently for educational purposes and promote the utilization of this technology in learning environments. The first objective was to design, develop, and implement an advanced Web-based multimedia learning system, called the Multimedia Management and Presentation System (MMPS), with a set of features capable of facilitating multimedia-supported instruction. The second objective was to evaluate learners’ experiences with the MMPS tool and their perceptions on the effectiveness of the tool in supporting their learning activities, and the final objective was to assess the effectiveness of the MMPS tool in facilitating and promoting the use of multimedia in learning communities. Participants’ positive perceptions on the effectiveness of the tool in supporting various learning activities can be given as some of the outcomes of the evaluation process, which took place in a graduate-level learning environment.

Keywords
Web-based multimedia learning system, Multimedia Management and Presentation System, MMPS, multimedia-supported instruction, streaming media.

INTRODUCTION
We hear about the release of a new and advanced information technology (IT) almost everyday. The use of technology has clearly become an essential part of our daily lives. Similarly, the importance of IT has been constantly increasing in various fields. For instance, the amount of IT spending in U.S. companies is a clear sign of how companies value the use of IT (Carr, 2004). IT has also been affecting our educational institutions. As Bransford, National Research Council (U.S.) Committee on Developments in the Science of Learning, and National Research Council (U.S.) Committee on Learning Research and Educational Practice (2000) suggest, “computer-based technologies hold great promise both for increasing access to knowledge and as a means of promoting learning” (p. 229). Although innovative technologies have been introduced to market quickly, educational institutions are slow in utilizing the latest technologies (Scardamalia, 2001). Scardamalia (2001) also points out that institutions start using some consumer technologies (e.g., CD players) quicker than some other technologies designed for organizations (e.g., teleconferencing). The Office of Technology Assessment’s “Teachers and Technology: Making the Connection” report also highlights a similar finding (U.S. Congress, Office of Technology Assessment, 1995):

“Despite technologies available in schools, a substantial number of teachers report little or no use of computers for instruction. Their use of other technologies also varies considerably” (p. 1).

The same report also discovers that:

A majority of teachers report feeling inadequately trained to use technology resources, particularly computer-based technologies. Although many teachers see the value of students learning about computers and other technologies, some are not aware of the resources technology can offer them as professionals in carrying out the many aspects of their jobs (p. 2, italics in original).
As Scardamalia (2001) states, educational institutions need to focus on “depth of understanding” (p. 173, italics in original), “knowledge creation and knowledge stewardship” (p. 173, italics in original), and “lifelong learning” (p. 173, italics in original) while preparing themselves for tomorrow.

This study had three primary objectives set to overcome the challenges of using multimedia technology efficiently for educational purposes and promote the utilization of this technology in learning environments:

- Design, develop, and implement an advanced Web-based learning system, called the Multimedia Management and Presentation System (MMPS), with a set of features capable of facilitating multimedia-supported instruction.
- Evaluate learners’ experiences with the MMPS tool and their perceptions on the effectiveness of the tool in supporting their learning activities.
- Assess the effectiveness of the MMPS tool in facilitating and promoting the use of multimedia in learning communities.

After analyzing various theories and principles associated with the concepts of learning, instruction, and multimedia, the MMPS tool was designed with a focus on three important issues described below:

1. **Overcome major technical barriers that are related to the use of physical media products** (e.g., DVDs, CDs, videocassettes, or audiotapes) **in the classroom.** Using physical media may potentially limit instructors’ abilities to efficiently utilize multimedia in classrooms due to various reasons. For example, video tapes and audio cassettes normally degrade in quality due to usage. While alternative media, such as DVDs and CDs, have a significantly longer life span, a piece of physical media can also easily be lost or get damaged in an unrecoverable way, and it may not always be possible to replace it, especially if it is an out-of-print material, produced in very limited numbers, or a custom production. In addition to these problems that are solely related to the nature of some physical media, educational institutions may not have available budgets to purchase multiple copies of the same physical media. Therefore, in many institutions, it may not practically be possible for instructors teaching different sections of the same course to use the same media items. As a solution to this problem, the MMPS tool comes with an online library capable of managing and storing all the source (original) multimedia files that users (instructors and learners) can use in their multimedia projects. A multimedia project is a streaming presentation formed of a set of clips, which are segments selected from a single or multiple source multimedia files. The system streams all the clips of a project according to the order originally determined by the user who has created the project. Follansbee (2006) defines streaming as “the continuous transfer of data from one computer to another in real time” (p. 15). Similarly, based on McEvoy (2001), Wilkinson (2006) describes streaming media as “transmitting audio and video from one computer to another” (as cited in Wilkinson, 2006). Although the term streaming media is mainly used to describe audio and video data transmission, it is also possible to use the same term for the transmission of data in other formats, including text (e.g., stock quotes) and static images (Follansbee, 2006).

2. **Encourage the use of multimedia in learning environments.** It is important to point out that instructors may usually need to dedicate extra time to the planning and preparation processes of their multimedia presentations. As Shepherd (2003) states “most educational experts agree that video is best shown in short segments so as to maximise learners’ concentration” (p. 296). However when instructors would like to play only specific video or audio clips from their physical media materials, previewing each of the media items, determining and locating the clips they would like to play in class, and arranging the order of all the selected clips can be very time-consuming activities. The developed multimedia learning system makes it possible for instructors and learners to easily design, create, present, share, and store multimedia projects.

3. **Promote active learning and facilitate knowledge construction.** The MMPS tool was designed to support learning communities that accommodate activities used to achieve goals, including “[…] both individual development and collaborative construction of knowledge, […] sharing knowledge and skills among members of the community, and […] making learning processes visible and articulated” (Bielaczyc & Collins, 1999, p. 274).

**MULTIMEDIA MANAGEMENT AND PRESENTATION SYSTEM (MMPS)**

The developed Web-based multi-user learning system, which runs on a Linux-Apache-My Structured Query Language (MySQL)-Hypertext Preprocessor (PHP) (LAMP) platform (see the LAMP Platform subsection for details), allows users to easily create new multimedia projects or modify existing ones at any time by accessing the system’s Web site. The system also makes it possible for users to have multiple projects. For instance, instructors can prepare multimedia projects to teach
various course topics and also store them in the system as part of their instructional materials for later use. Instructors can also ask learners to first prepare individual and/or team projects about different subjects and then present those projects in class and/or share them with their classmates.

In a learning session, whether or not a learner is involved in behavioral activities, being active in a cognitive sense is essential for the learner in order to be able to successfully understand and learn what is covered in the presented instructional materials. Mayer (2001) calls this accomplishment in learning “meaningful learning” (p. 17). As Mayer (2001) also points out, “multimedia learning is a demanding process that requires selecting relevant words and images, organizing them into coherent verbal and pictorial representations, and integrating the verbal and pictorial representations” (p. 58). These three cognitive processes can lead learners to meaningful learning outcomes. Since the creation process of a multimedia project requires the project owner(s) to get actively involved in the same type of cognitive activities, the MMPS tool designed with a learner-centered perspective can help learners conduct these cognitive processes while studying multimedia-based learning materials compatible with the tool.

As Bruner (1966) states, “the optimal structure of a body of knowledge is not absolute but relative” (p. 41). So, a multimedia project (prepared by an individual or a team) can be considered as a form of constructed knowledge reflecting the project owner’s understanding of the assigned multimedia materials (source multimedia files), and therefore, in a learning community, learners watching their classmates’ projects can potentially learn from each other. Learners can also use their instructors’ projects or their own projects as self-learning materials and watch them as many times as they want while studying the topics covered in the projects.

Another advantage of the MMPS tool is its efficient source multimedia management and storage feature. As mentioned earlier, the MMPS tool has an online library (hosted on a Helix Server (RealNetworks)) capable of managing and holding source multimedia files provided to users, and it makes it possible for multiple users to use the same set of source multimedia files in their projects without the need to duplicate and store multiple copies of the contents of the library. A user with administrative privileges can also integrate an external source multimedia file (e.g., a streaming video available for public use on the Internet) with the MMPS tool by simply adding its Uniform Resource Locator (URL) address to the online library. For instance, the source multimedia file used in the pilot test of this study was an external file linked to the online library. The MMPS tool, which uses a Helix Server for streaming source multimedia files existing in its online library can stream multiple projects at the same time regardless of whether or not they involve clips that use common source multimedia files from the online library. Similarly, it is also possible to have the MMPS tool simultaneously stream multiple instances of the same project.

LAMP Platform

The LAMP acronym is commonly used for Linux (operating system), Apache (Hypertext Transfer Protocol (HTTP) (Web) server), MySQL (database application), and PHP (scripting language) (Butcher, 2003; Dalheimer & Welsh, 2006; Davis & Phillips, 2007; Greant & Newman, 2006) (see Figure 1 for a representation of a traditional LAMP platform). In addition to PHP, the P in LAMP can also represent the Practical Extraction and Report Language (Perl) (programming language) or Python (application language) (Deek & McHugh, 2007; Harrison & Feuerstein, 2006). According Holdener’s (2008) broader perspective, LAMP can include the following components:

- L: Any open source operating system, such as Linux, Free Berkeley Software Distribution (FreeBSD), and Solaris.
- A: Apache.
- M: MySQL or PostgreSQL.
- P: Java, Perl, PHP, Python, or Ruby.
A description of the elements of Figure 1 as follows (Greant & Newman, 2006):

1. The components of the LAMP stack: Linux, Apache, MySQL, and PHP.
2. Requests originated from the network arrive at the Linux operating system to be processed.
3. Requests for Web pages are transferred to the Apache HTTP Server.
4. The Apache HTTP Server forwards requests for PHP pages to the PHP interpreter.
5. A MySQL extension takes care of any MySQL calls existing in the requested PHP pages.
6. The MySQL extension transfers the database related requests to the MySQL C Application Programming Interface (API).
7. A communication link is established from the MySQL C API to the MySQL server.
8. After processing the requests, the MySQL server transfers the output data of the process to the PHP interpreter.
9. After receiving the query results from the MySQL server, the PHP interpreter performs additional operations, and then the requested pages are transferred to the Apache HTTP server to be sent to the network.

**True Streaming**

The MMPS tool utilizes a streaming technology called “true streaming” (Wilkinson, 2006, p. 127) or “real-time streaming” (QuickTime streaming,” 2005, p. 2). The following are the major benefits of true streaming:

- Users of true streaming do not need to wait for media files to be downloaded prior to playing them, and therefore, utilizing this media delivery method makes it possible to stream live events (Adobe Dynamic Media Group, 2001).
- True streaming does not require any download process, and so, users’ machines do not store a copy of the media files that have been streamed (Adobe Dynamic Media Group, 2001). This feature is especially beneficial.
for copyright owners or distributors who would like to protect their content against any kind of illegal user activities and therefore, limit their users’ abilities and permit only one activity that is playing the streamed media (Adobe Dynamic Media Group, 2001). Since its media files are hosted on a streaming media server, it makes it possible for a media distributor to manage how users can access to those media files (Wilkinson, 2006). As Wilkinson (2006) states, “access can be controlled using password, digital rights management (DRM), registration, or some other security feature” (p. 127).

- Media files hosted on a streaming media server are independent entities, and therefore, it is possible to easily modify such files whenever it is necessary (Wilkinson, 2006).

**Synchronized Multimedia Integration Language (SMIL)**

The MMPS tool utilizes the Synchronized Multimedia Integration Language (SMIL) while playing multimedia projects or clips. When a user would like to play a multimedia project (or a single clip in a multimedia project), the tool retrieves the required project (or clip) data from the database and embeds it into a SMIL file that can be played with the tool’s multimedia player.

SMIL is “a text-based, non-proprietary, XML [Extensible Markup Language] standardized format that is woven into the W3C’s [The World Wide Web Consortium] XML-based family of cooperative and interdependent languages” (Bulterman & Rutledge, 2004, p. 3), and people use this language to create interactive multimedia presentations involving various forms of media (Michel, 2008). As Rutledge (2001) points out, “SMIL does not create media, but rather integrates existing multiple media into a single presentation” (p. 79). While an end-user is viewing a SMIL presentation, the end-user’s browser establishes connections to the media files that are part of the presentation and presents them according to the associated settings pre-defined in the SMIL coding (Rutledge, 2001). It is possible for end-users to view SMIL presentations available on their local machines, distributable media (e.g., CD-ROMs), or even remote locations (e.g., streaming media servers) (Bulterman & Rutledge, 2004).

**TECHNICAL LIMITATIONS**

The following technical issues were taken into consideration while designing the MMPS tool in order to be able to avoid or minimize any potential problems that could occur later during the study’s evaluation phase:

1. **Minimum end-user software requirements:** Developing the MMPS tool based on a learner-centered design was critical for the effectiveness of the tool in achieving the study’s objectives. Therefore, it was important to provide ease of use and convenience to users whenever possible. So, the MMPS tool was designed to function with a minimum level of additional software needed by users. As a result, students participated in the study was able to fully operate the tool with only a Web browser that had a RealPlayer plug-in installed on it.

2. **Efficient, scalable, and reliable infrastructure:** Initially, there was a concern about how to design an efficient, scalable, and reliable infrastructure for the MMPS tool so that the Web-based learning system would be able to function properly while participants of the study were performing various tasks on the tool’s Web site. So, the LAMP platform was chosen as the infrastructure of the MMPS tool. LAMP, a popular software architecture that involves a set of components with many unique features and benefits, has been in use by many companies and organizations for various purposes. As mentioned earlier, the MMPS tool also designed to utilize a Helix Server as its streaming media server for hosting the tool’s online library and streaming source multimedia files existing in the library.

3. **Reliable third-party service providers:** It was not possible to set up the developed Web-based learning system on campus where it was evaluated due to various reasons. Therefore, a decision was made to use outside resources. First, it was necessary to find a third-party hosting service provider for the MMPS tool’s LAMP platform. Since there were so many hosting companies available in the market, it was a challenging and time-consuming research activity to find a set of candidate hosting companies, compare their pro’s and con’s, and then pick one of them. Similarly, it was also essential to find a third-party streaming service provider renting spaces on Helix Servers. Unlike hosting service providers, there were a limited number of streaming service providers in the market offering service plans for small-scale streaming projects, and as result, it was possible to choose a streaming service provider with a service plan ideal for the study within a short period of time. It is important to point out that although there were a few companies providing both hosting and streaming services, none of them were suitable for the MMPS tool due to their various technical limitations.

**EVALUATION**

Following the development of the MMPS tool’s first ready-for-test release, a pilot test was conducted where nine graduate
students used the tool in a summer term class to prepare multimedia projects. The instructor of the class picked a streaming video (duration: 1 hr. 40 min.) to be used as the source multimedia for the MMPS tool. In the selected video, two experts were presenting their opinions on a topic that was going to be covered in that class. As part of the course requirements, students had to work in teams (each team had three students) to prepare a team project. So, the instructor asked each team to prepare a multimedia project by using the MMPS tool and integrate that project with the team’s main project. The multimedia project requirements were for each team to determine a series of important segments in the original streaming video and then prepare a project (duration: 10-15 minutes) with the MMPS tool highlighting those segments in an order preferred by the team. Since the goal of the pilot test was primarily to find out if students would be able to successfully use the MMPS tool in a learning environment, providing any kind of feedback on the tool was not a class requirement for the participants of the test. However, many students anonymously provided some feedback about their experience with the tool together with a set of suggestions. The outcome of the pilot test demonstrated that learners were able to successfully use the tool to create multimedia projects and integrate them with their primary class projects. It is also important to point out that the tool’s version used in the pilot test had a series of limitations in terms of its capabilities and user interface design.

Hevner, March, Park, and Ram (2004) state that “[b]ecause design is inherently an iterative and incremental activity, the evaluation phase provides essential feedback to the construction phase as to the quality of the design process and the design product under development” (p. 85). However, modifying the artifact (MMPS) of the study was usually a time-consuming process because of the project’s limited resources. Therefore, it was not feasible to release multiple iterations of the artifact throughout the full-scale test period. As Hevner et al. (2004) point out, “[a] design artifact is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve” (p. 85). So, it was essential to prepare a version of the tool completely ready for the full-scale test. As a result, all major limitations associated with the version of the MMPS tool used for the pilot test were eliminated, and a newer version was released prior to the full-scale test. The new version also came with a series of advanced features that were not available in the earlier version.

A full-scale test was conducted in a fall term class, and the evaluation setting was similar to the one used in the pilot test where a group of graduate students used the MMPS tool to prepare multimedia projects. Based on the guidance and expectations of the instructor of the class, five streaming videos were picked as the source multimedia for the MMPS tool to be used by the participants of the study. The chosen streaming videos had presentations and interviews of experts discussing a series of topics that were going to be covered as part of the class. The duration of each video is listed below:

1. Video A: 22 min. 27 sec.
2. Video B: 7 min. 9 sec.
3. Video C: 1 hr. 1 min. 4 sec.
4. Video D: 1 hr. 2 min. 8 sec.
5. Video E: 1 hr. 7 sec.

The course included a set of exercises, and the instructor asked students to use the MMPS tool in four of them. For each of those four class exercises, each student had to determine a series of important segments in the original streaming video assigned for the exercise and then create an individual project (duration: 10-15 minutes) with the MMPS tool highlighting those sections in an order based on his or her personal preference. At the end of the evaluation process, a survey was given to the participants. There were 12 students enrolled in the class, and although it was not a class requirement for students to provide any kind of feedback on the MMPS tool, eight of them completed the distributed survey. The feedback data anonymously collected through the survey was evaluated in order to determine the effectiveness of the MMPS tool in achieving the primary objectives of the study. The analysis of the evaluation outcomes also revealed the MMPS tool’s strengths and weaknesses and uncovered ways to improve the tool.

According to the results of the survey conducted at the end of the full-scale test, a majority of the participants agreed that the MMPS application had facilitated the use of multimedia in learning environments. 75% of the participants found the tool useful for developing and viewing multimedia projects while the rest of the group did not have any positive or negative opinions on the issue. The same percentage of the participants also reported that using the tool had facilitated self-paced learning, which clearly allowed learners to improve their performance in order to achieve their learning goals (the rest of the group had neither positive nor negative opinions on the issue). According to seven out of eight students, the videos used in their class exercises were valuable. A majority of the participants also agreed with the statement that the tool had helped them easily demonstrate what they had learned from the videos. More than half of the participants shared the same opinion that the MMPS tool had enabled knowledge sharing among students. While half of the participants agreed that multimedia-supported instructional materials would increase their motivation to learn the presented topics, the other half had neither positive nor
negative opinions about the issue. Similarly, 50% of the students agreed with the statement that instructors could easily assess the progress of each student in multimedia-supported class activities via the MMPS tool. The last two outcomes could possibly be related to the fact that it was the first time these learners had been asked to formally use the MMPS tool to prepare a series of multimedia projects in a learning environment, and there was no assessment mechanism in place to grade their progress throughout the development phase of their projects. Instead, the instructor evaluated students’ completed projects at the end of the class and provided general feedback.

While using the tool throughout the full-scale test, learners utilized its online library where all the videos that they used as the source multimedia files in their projects were stored. Therefore, none of the major technical barriers that make the use of physical media products (e.g., DVDs, CDs, videocassettes, or audiotapes) challenging in learning environments were valid for the streaming multimedia files utilized by the MMPS tool.

Although all the participants were able to use the MMPS tool and successfully prepared multimedia projects, according to the survey results, some of them had different views on the ease of use of some features of the tool. Overall, while 75% of the participants surveyed had positive learning experiences with the MMP tool, the rest of the students had neutral opinions about the issue. All the participants surveyed also stated that they would choose to use the tool for another course assuming that it is made available for future semesters.

CONCLUSION

The outcomes of this study demonstrated how the streaming multimedia technology could be easily utilized to provide learners with a significant level of control over the instructional materials. With the help of the MMPS tool, learners were no longer passive recipients of the instructional materials, but instead, they were actively involved in the learning process throughout the tests conducted as part of this study. In this study, the tool was primarily used by learners to create individual or team multimedia projects. As stated earlier, it is also possible to have instructors utilize the tool not only to prepare instructional multimedia projects and integrate them into their curricula, but also to store those projects for future use.

Although the MMPS tool achieved a series of successful results in terms of its different capabilities, findings of this study may not be applicable beyond the learning communities used for the study due to the small number of participants. However the tool’s unique and advanced features designed and evaluated as part of this study may contribute to the knowledge domain of innovative uses of multimedia in learning environments.

Finally, it is important to point out how multimedia-supported learning systems should be designed to fulfill learners’ current needs, and whenever possible, such systems should have a flexible design allowing modifications or upgrades in order to meet learners’ expectations in the near future. So, an effective multimedia-supported learning system is expected to facilitate individuals’ learning activities and help them improve their existing knowledge and skills and/or develop new knowledge and expertise. Therefore, it is essential for educational application developers to have a clear understanding of how human memory works and processes information making it possible for individuals to construct personal knowledge based on that received information. They should also carefully analyze the supportive multimedia technology chosen for their learning systems based on a series of factors (e.g., reliability, ease of use, performance, and availability), which may potentially affect learners’ overall performances and learning experiences.

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