

Tools and Techniques for the Development of Multimedia Instructional Modules

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### Abstract

Given that there are numerous articles dealing with the cognitive aspects of multimedia instructional modules, this paper is written specifically to address the technology side of developing the modules. Over time, different types of multimedia modules, representing in-class lectures and software tutorials, were produced to help implement technology mediated learning at a state university. The hardware and software that were surveyed and selected to produce the modules are compared and discussed in this paper alongside the techniques that were used to improve the quality and fidelity of the modules. In addition, the hosting of the modules using cloud services is presented with a comparison of the different services available for streaming the modules. The tools and techniques listed and discussed in the paper would be useful to those interested in the rapid development of multimedia instructional modules using affordable hardware, software and cloud services.

*Keywords:* e-learning, blended learning, multimedia, learning technologies, instructional design

## Tools and Techniques for Designing Multimedia Instructional Modules

### **Introduction**

The development of the multimedia modules began several years ago as part of an e-learning initiative. Initially, the efforts were largely confined to recording lectures based on PowerPoint slides. Due to advancements in hardware and software, the development expanded to include the production of multimedia modules that simulated the so-called chalk-and-talk type of lectures and software tutorials. These modules are now streamed and distributed over the Internet aided partly by the emergence of cloud computing services. All along, the focus was on identifying and using affordable hardware, software and cloud services for the rapid development and distribution of multimedia instructional modules (Ganesan, 2007, 2009, 2012 and 2013).

Currently, the modules have become an integral part of an e-learning framework implemented to teach selected courses in Information Systems. The framework consists of three essential components: a collection of multimedia modules, a course website and a virtual lab. The course website functions as a platform for aggregating and disseminating the course contents which consist of PowerPoint slides, Word documents and multimedia instructional modules. The virtual lab component, on the other hand, is still evolving. The recent emergence of cloud services such as Microsoft Azure and Amazon Web Services (AWS) has provided the opportunity to migrate the hands-on computing exercises performed on physical computers in the labs to virtual machines in the cloud.

The impetus for the continued development of the modules came from positive feedback received from students (Ganesan, 2007, Tseklevs, Aggoun, & Cosmas, 2013, Neo & Neo, 2009). Another compelling reason for creating the modules was that the modules developed by the instructor teaching a course were found to have a better impact on student learning compared to

modules produced by others on the same topics covered in a course (Babiker, 2015). Furthermore, the students also indicated that the multimedia modules were helpful in self-paced learning. Since many students in the College commuted to the campus daily, they found all three components of the e-learning framework to be helpful in providing them with a flexible learning environment.

One of the three components of the e-learning framework, the course website, was presented in detail in an earlier publication (Ganesan, 2012). The evolving virtual lab will be discussed at a future time. Only the development and hosting of the multimedia modules are discussed in this paper under the following sections:

- Types of Modules Produced
- Hardware
- Software
- Design Considerations
- Hosting Services
- Content Aggregation
- Discussion
- Conclusion

### **Types of Modules Produced**

Three different types of multimedia instructional modules were produced to capture different scenarios of e-learning. The first and second groups of modules simulated the typical in-class lectures, while the third represented software demonstrations or tutorials. The first group was labelled as the “chalk-and-talk” lectures. In this group, the modules were designed to simulate the in-class learning experience where a whiteboard is routinely used to explain the concepts.

The second group of modules produced were known as the “Short PowerPoint” modules. These modules were used for presenting brief introductions and summaries. The third group of modules represented software tutorials. The focus and purpose of the three types of modules are summarized in Table 1. In addition to these video modules, audio-only modules were produced to help the students review the material covered in the class. These modules were helpful to the students in preparing for the examinations in particular.

Table 1 Types of Instructional Modules Produced

Module	Focus	Purpose
Chalk-and-talk type of lectures	Teach concepts and theory	<ul style="list-style-type: none"> <li>- Designed for teaching theoretical concepts</li> <li>- Able to simulate, to the extent possible, the in-class learning experience</li> <li>- Helpful in overcoming the monotonic nature of multimedia modules based entirely on PowerPoint slides</li> </ul>
Short PowerPoint-based lectures	Present introductions and summaries	<ul style="list-style-type: none"> <li>- Useful for short lectures such as introductions and summaries</li> </ul>
Software tutorials with audio narration	Teach software development and applications	<ul style="list-style-type: none"> <li>- Helpful in creating software tutorials by simulating the functionality of software</li> </ul>
Audio-only modules	Review of topics covered in class	<ul style="list-style-type: none"> <li>- Useful as exam reviews</li> </ul>

### **Hardware**

A three-part survey of the hardware available for the development of the three different types of modules mentioned was conducted. The first part dealt with the selection of the computer system required for recording, editing and rendering the video modules. In the second part, the selection of an appropriate digital input device was explored to simulate the whiteboard used in

the lectures. Peripheral devices such as a microphone and a webcam that were required for recording the modules were explored in the third part. The three-part survey is presented next.

### Computer System

Given that the production of the multimedia modules is a resource intensive activity, a powerful computer system is invariably needed to produce the modules. Table 2 shows the storage and time requirements for rendering a ten-minute long multimedia module using Camtasia, a popular multimedia authoring software. The time requirements shown are for rendering a module from its native .trec file format to the .mp4 and .wmv file formats. Another popular format, the .mov file format, was considered in earlier trials, but excluded from further consideration because of its incompatibility with certain versions of the Windows operating system.

Table 2 Storage, Bandwidth and Rendering Times for a 10-Minute Long Video Module

	.trec Format	.mp4 Format	.wmv Format
Storage in Mbytes	180	22.11	21.74
Bandwidth in Mbps	2.4	0.295	0.29
Rendering time on Surface Pro 2 with i5 processor (Mins:Secs)	N/A	7:24	18:03
Rendering time on Surface Pro 3 with i7 processor (Mins:Secs)	N/A	5:31	11:52

One of the computer systems used in the comparison was powered by an i5 processor and the other by a more powerful i7 processor. Figure 1 shows the comparison of the rendering time on the two computer systems, underscoring the need for a powerful processor, adequate memory and sufficient disk capacity for the development of multimedia modules. Earlier comparison studies focused on less powerful desktop computers that were available at that time (Ganesan, 2007). Based on the results of these studies, a computer with an i7 processor, 8 GB of memory and

256 GB of hard disk storage was selected as the baseline configuration for developing and deploying the modules. A balance was sought between computing power and the cost of the computer while deciding on the system configuration mentioned earlier.

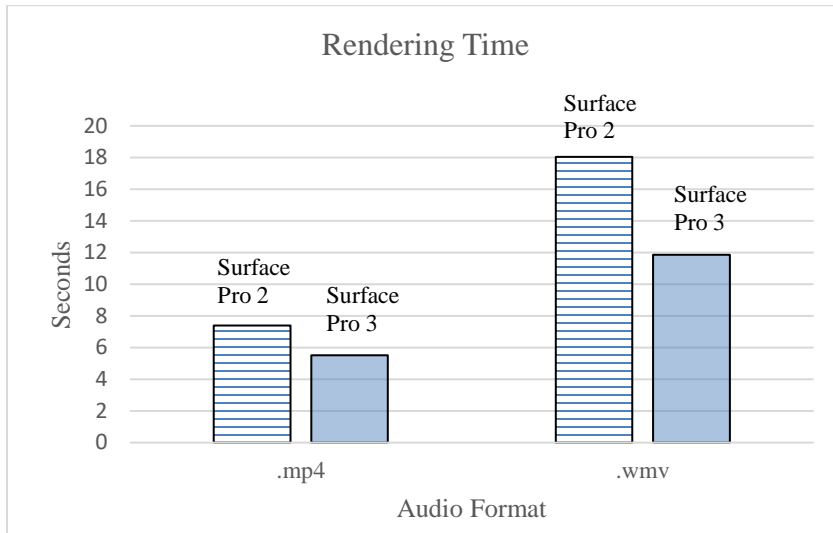


Figure 1 Comparison of Rendering Times for Audio Formats and Computer Types

### Digitizing Devices

The second category of hardware surveyed was the digitizing devices needed to simulate a whiteboard. An electronic whiteboard is necessary to record the chalk-and-talk type of lectures. In the pre-tablet era, the selection of an appropriate digitizing device was largely limited to the availability of digitizer pads. Different types of digitizer pads, such as the Seiko InkLink pad and the DigiMemo pad, were used earlier in the production of the multimedia modules. These pads met the basic requirements of a whiteboard, but fell short of offering good screen resolutions for recording the screen activities.

The drawbacks associated with the digitizer pads have recently been overcome by tablet computers that generally support a stylus for writing on the screen. Many tablet computers now offer excellent screen resolutions and precise stylus sensitivity giving the tablets an edge over lower cost digitizer pads for simulating an electronic whiteboard. On the other hand, there are

arguments in favor of using expensive digitizer tablets over mainstream tablet computers, but such arguments are concerned with the production of high quality graphics art (Forums, 2014).

In choosing an appropriate tablet computer, it is important to note that the computer must support an active stylus to be able to simulate the whiteboard. A passive stylus is unsuitable for simulating a whiteboard as it only emulates the touch of a screen with a finger. For all activities that involve writing, scribbling or drawing on a computer screen, an active stylus is required.

Except for the latest iPad Pro, all previous iPad models support only a passive stylus. The iPad Pro's stylus, known as the Apple Pencil, is different in the sense that it functions as an active stylus that can be used for simulating a whiteboard. In the case of the earlier versions of the iPad tablets, a digitizer pad such as the Wacom Cintiq is needed to simulate an electronic whiteboard (Dong, 2015). An alternative to the iPad is the Surface Pro tablet that also supports an active stylus. For developing the multimedia modules, the Surface Pro was a better choice because it was built specifically for the Windows operating system. Windows, incidentally, is the de facto operating system supported on many of the computers on the campus.

### **Recording Studio on a Tablet**

The Surface Pro can be easily configured to function as an affordable recording studio by adding a microphone and a webcam. A good quality microphone is essential to ensure that the fidelity of the audio in the multimedia modules is of high quality. Sub-standard audio alone can distract the students from focusing on the contents presented in the modules (Deaking Team, 2014 & Papas, 2013). Given the importance of audio quality, several microphones were surveyed and tested. The results of the survey and the selection of an appropriate microphone for recording the modules are discussed in the next section.



## **Microphone**

In terms of price-to-performance ratio, a USB microphone offered better quality audio recording compared to the traditional microphone that is connected to an audio jack on the computer (White, 2007). Based on the reviews of popular USB microphones, a few were selected for in-house comparison. The selection included microphones made by Shure, Samson, MXL, Blue and Revlon. Although the reviews generally favored the microphones produced by Blue, the MXL Conference microphone was chosen for recording the modules (Henry, 2014 & Purdy & Dragan, 2016). MXL not only offered high quality recording, but also the possibility of the microphone being used in a classroom environment to record the lectures. The beam-forming technology used in this microphone gave the instructor the freedom to move around the classroom while recording a lecture.

## **Webcam**

Unlike in the case of microphones where there were many choices, most of the reviews of webcams focused primarily on products made by Logitech and Microsoft. In most reviews, the Logitech C920 webcam is listed as the best webcam followed by Microsoft's LifeCam Studio (Henry, 2012 & Marks 2016). These two webcams, along with the Logitech Orbit webcam, were chosen for comparison.

The Orbit webcam was initially included in the study because of its face-tracking technology that could track the face of the presenter while he or she moved around a classroom. Despite the face-tracking capability of Orbit, it was later dropped from further consideration because of the lack of software drivers for the newer versions of the Windows operating system and the unpredictability of the face-tracking feature.

Among the two remaining webcams, the Logitech C920 webcam produced marginally better-quality video (Marks 2016). Despite this slight advantage, the Microsoft LifeCam was chosen mainly because of the availability of drivers for all versions of the Windows operating system. Driver availability was considered important for the webcam to be used interchangeably with different types of computers located in the lecture halls and the computer labs.

### **Production System**

Based on the survey of hardware discussed in the previous sections, the computer system configured for the development of the multimedia modules is shown in Figure 2. This system functioned effectively as a portable recording studio. The important components of the system are a Surface Pro tablet computer, an MXL USB conference microphone, a passive USB hub and a Microsoft LifeCam Studio webcam. This configuration allowed the system to be easily moved between the labs and the lecture halls.

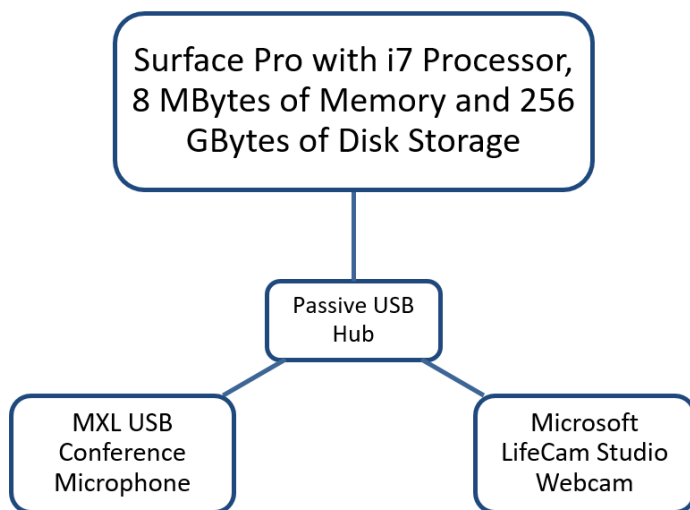


Figure 2. Configuration of a Recording Studio on a Tablet Computer

## **Software**

The system configuration listed in the previous section influenced the choice of the software needed to produce the multimedia modules. An electronic whiteboard software, an audio editing software and a multimedia authoring software were considered necessary for producing the modules. The software surveyed in each of these three categories and the software chosen under each category are discussed in the following sections.

### **Whiteboard Software**

A note taking software known as Windows Journal, available as a utility program in the Windows operating system, was used initially for simulating the whiteboard in the multimedia modules. It incorporated only the basic note taking features. More powerful and feature-rich whiteboard software, such as Open Snakore, NetPen, Whyteboard and OneNote, have since emerged as better alternatives to Windows Journal (Khan, 2015). Among them, Open Snakore, NetPen and Whyteboard are all custom-designed to function as whiteboard software. OneNote, on the other hand, is capable of functioning both as a note taking software and as a whiteboard software. Due to its versatility and the fact that the notebooks created using OneNote can easily be stored in the cloud and shared, OneNote was chosen as the software for simulating the whiteboard.

### **Audio Recording Software**

The second category of software surveyed was the audio recording and editing software. Several reasonably priced, if not free, audio editing software are available in the market (Henry 2012 & Arjun 2016). Among them, Audacity, Sound Forge Audio Studio and Adobe Audition CC were chosen and used at various stages of the development of the audio modules. Audacity is a public domain software with excellent audio recording and editing capabilities (Williams, 2016).

Sound Forge, priced affordably, supports additional features compared to Audacity. The more advanced Adobe Audition CC is designed for professional level audio recording.

During the early stages of development, both Audacity and Sound Forge Audio Studio were used interchangeably and extensively to record the audio modules. Adobe Audition CC, now available as part of the Adobe Creative Cloud suite, is presently being used to produce the audio modules. The selection of Adobe Audition CC for recording the audio modules was partly prompted by the rich audio editing features of the software and the low subscription price offered by Adobe to educators. Another reason for choosing Audition CC was its noise reduction capabilities that were very useful and effective in producing high fidelity audio modules. If the cost of Adobe Audition CC is a concern, the public domain software Audacity can be used equally effectively for recording the audio modules.

### **Multimedia Authoring Software**

Compared to the previous two software products, choosing a multimedia authoring software required intense scrutiny because it was considered crucial to the production of the instructional modules. There are several screen casting software packages available, such as Camtasia, Captivate Camstudio, EZvid, Jing and Screencast-O-Matic, for producing the multimedia modules (Rubey, 2016 Henry2011). Most of them are intended for screen recording and screen casting, except Camtasia and Captivate that are specifically designed for authoring multimedia modules. As such, only Camtasia and Captivate were chosen for further comparison. Their relative strengths and weaknesses are summarized in Table 3 (Albrecht, 2013).

Table 3 Comparison of Captivate and Camtasia

Captivate	Camtasia
<ul style="list-style-type: none"> <li>- Good for creating interactive simulations</li> <li>- Has better features for designing software tutorials</li> <li>- Allows different outcome scenarios to be programmed based on student interaction with the multimedia modules</li> <li>- Incorporates extensive, but complex testing options</li> <li>- Supports quizzes</li> <li>- Steeper learning curve</li> <li>- Higher cost</li> </ul>	<ul style="list-style-type: none"> <li>- Supports the production of video modules for multiple purposes such as capturing screen activity, producing tutorials etc.</li> <li>- Supports quizzes</li> <li>- Good for producing, hosting and streaming video</li> <li>- Easy to learn</li> <li>- Less expensive than Captivate</li> </ul>

Among the two software products compared, Camtasia Studio emerged as the software of choice. An important consideration in choosing Camtasia was that it readily supported the production of the chalk-and-talk type of lecture modules, PowerPoint-based lecture modules and software tutorials with minimum complexity. Overall, it was less costly and easy to learn. The reasons for not choosing Captivate were that it was somewhat difficult to learn, complex to use and costly. Also, the advanced features of Captivate were not needed to produce the three types of modules discussed earlier.

### **Design Considerations**

Several intricate technical details pertaining to the recording of the audio and video modules had to be addressed during the production of the multimedia modules. Such details are yet to receive widespread attention in the literature. Given that the audio and video quality of the modules is crucial to engaging the students in the learning process, due attention must be given to the selection of appropriate settings for recording the modules.

## Audio Settings

Audio settings not only influence the quality of the recordings but also the storage requirements and the bandwidth needed to stream the modules. A balance between quality and bandwidth was sought while choosing appropriate settings for recording the audio. The audio settings that require attention in this case are the sampling frequency, sampling depth and number of channels. The sampling frequency is expressed in Hz and the sampling depth in bits. Depending on whether the audio is to be recorded in mono or stereo format, the number of channels chosen for recording the audio can vary from 1 to 2. The higher the values of these parameters, the better the quality of the audio and higher the storage space and bandwidth requirements.

Table 4 shows the typical settings for CD-quality and telephone-quality audio recordings (Smith, 2011). After experimenting with a range of settings, a sampling frequency of 22,000 Hz and a sampling depth of 16-bits were chosen for recording the audio. These settings stand midway between telephone and CD-quality audio as shown in Figure 3. The settings were chosen based partly on the perception of the sound quality and partly on the need to have a balance between the sound quality and the bandwidth requirements. Furthermore, there was no compelling reason to record the instructional modules in stereo format.

Table 4 Audio Settings Quality

	Phone Quality	Multimedia Modules	CD Quality
Sampling Frequency (KHz)	8	22	44.1
Sampling Depth (bit)	12	16	16
Channels	1	1	2
Bit rate (bps) per Channel	96K	352K	706K
Remarks	Adequate for voice only	Good audio quality for producing multimedia modules	Excellent audio quality for recording high fidelity music

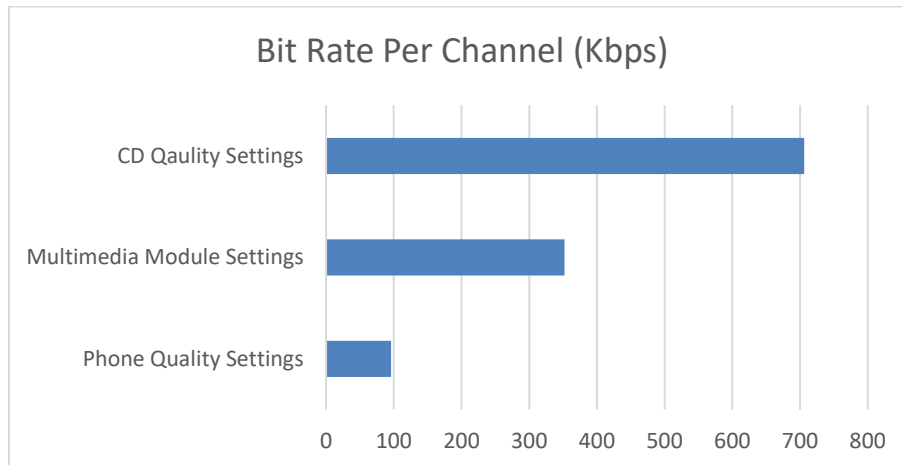


Figure 3 Bit Rate Per Channel for Different Quality Audio Settings

After recording the audio modules based on the recommended settings, they were converted to the .mp4 streaming format before uploading them to OneDrive. An advantage of uploading the modules in the .mp4 format was that OneDrive, by default, streams .mp4 video modules from the cloud, thus eliminating the need to host the modules on a dedicated media server. This is also one of the key advantages of hosting the modules on OneDrive.

### Video Settings

In the case of the video modules, the recording parameters that require attention are somewhat different from those discussed previously for the audio modules. The two important parameters that apply to the production of the video modules are the streaming file format and the screen resolution. Audio settings also play a role in the production of the video modules, but they are largely determined by the choice of the video format. For comparison, the instructional modules were produced in different media file formats and screen resolutions. They were then hosted on different streaming services and compared in terms of the video and audio qualities of the modules streamed. The outcome from the comparison study are summarized in Table 5. The

table also contains the media format, screen resolution and streaming service chosen eventually to produce the multimedia modules.

Table 5 Comparison Criteria for Video Settings

Comparison Criterion	Options Considered	Option Chosen
Media format	- .wmv - .mp4	.mp4
Screen resolution	- 800 by 600 pixels - 1028 by 768 pixels - 1280 by 1024 pixels	1280 by 1024 pixels
Streaming service	- YouTube - OneDrive	OneDrive

Although the .wmv and .mp4 streaming formats were initially chosen for comparison, Microsoft's proprietary .wmv streaming format was removed from further consideration because its popularity has waned recently in favor of the universal .mp4 format. Most streaming services, including OneDrive, now readily support the .mp4 format, which incidentally is the emerging de facto standard for streaming multimedia contents over the Internet (Mozilla Foundation, 2016). The .mp4 format, which incorporates the H.264 video codec and the AAC audio codec, is supported by mainstream browsers such as Firefox, Internet Explorer, Edge and Safari. Furthermore, the .mp4 modules require less time to render and produce (Table 2). Given the advantages of the .mp4 format over the other streaming formats, it was chosen as the de facto format for producing the multimedia modules.

The second criterion used for comparison was the resolution of the computer screen for recording the multimedia modules. For comparison, the screen resolutions chosen were limited to 1280 by 1024 pixels, 1024 by 768 pixels and 800 by 600 pixels. The higher end screen resolution



of 1280 by 1024 pixels produced clear screen images. Selecting a screen resolution higher than 1280 by 1024 pixels did not offer any noticeable visual advantage.

The lower end screen resolution of 800 by 600 pixels produced screen images that were visibly blurry at times, especially when the video modules were streamed in full-screen mode. For comparison purpose therefore, the screen resolutions were subsequently limited to 1280 by 1024 pixels and 1024 by 769 pixels. Since the former offered crispier screen image and was better suited for the elongated aspect ratio of the newer monitors, the screen resolution of 1280 by 1024 pixels was chosen for recording the multimedia modules. The decision to adopt this screen resolution was prompted partly by the need to achieve a balance between video quality and storage/bandwidth requirements.

### **Hosting Services**

The modules that were produced in the .mp4 format with a screen resolution of 1280 by 1024 pixels were uploaded to YouTube and OneDrive and streamed. Table 6 lists the reasons for choosing these two services for the comparison study. Overall, the good streaming quality of OneDrive and the fact that the modules could be organized and stored alongside other course material in OneDrive folders resulted in OneDrive being chosen as the cloud platform for storing and streaming the multimedia modules. Unlike YouTube, OneDrive is also free of commercials. On the other hand, an advantage of using YouTube for storing and streaming the modules was that it would automatically retrieve and list, on the side pane, a collection of video modules on topics that were similar to the one being watched. This gave the students the opportunity to select and watch instructional modules on the same topic produced by other instructors.

Table 6 Comparison of YouTube and OneDrive for Hosting the Modules

Streaming Service	Reasons for Choosing the Service for Comparison
YouTube	<ul style="list-style-type: none"> <li>- Most widely accessed video hosting service</li> <li>- Good quality streaming of video</li> <li>- Facilitates timely uploading of videos</li> <li>- Accepts a variety of video formats and CODECS</li> <li>- Provides limited but useful online programming tools</li> <li>- Displays links to modules produced by other instructors on the same topic</li> </ul>
OneDrive	<ul style="list-style-type: none"> <li>- Better streaming quality</li> <li>- Higher screen resolution under normal streaming</li> <li>- Faster uploading of modules</li> <li>- Large storage space</li> <li>- Modules can be organized into folders</li> <li>- Other course material such as PowerPoint slides can be stored easily on OneDrive and opened directly for editing</li> </ul>

### Content Aggregation

Following the production of the modules, an index had to be created for the students to access the modules stored in the cloud. Various options were considered for creating the index. One was to simply provide the students with a map of the folders containing the multimedia modules so that they could navigate their way to a particular module. The second option was to use a Learning Management System (LMS), such as Moodle, to maintain a table of contents showing the links to the modules hosted on OneDrive. The advantage of using the table of contents is that the indexes could be grouped and arranged according to each week’s coverage or according to different topics covered in a course.

The third option considered was to create a course website using a free website hosting service such as Google Sites and then provide the students with access to the multimedia modules via a table of contents. Google Sites, incidentally, is a free web hosting service that falls under the

Software as a Service (SaaS) category of cloud computing (He, Cernusca & Abdus, 2011). It provides four very useful templates entitled Web Pages, Lists, Announcements, and File Cabinets for designing a course website.

From the three content aggregation options explored, the development of a course website to host the table of contents was chosen. The course website developed using Google Sites also offered many other useful features for hosting a comprehensive course website (Ganesan, 2012). By using the templates in Google Sites in conjunction with the appropriate web apps, an effective course website can be created without having to write any computer code. For review, the website created is accessible at: <http://www.ganesan.com>.

### **Discussion**

The emergence of cloud services and the recent advances made in hardware and software technologies have helped simplify the development and deployment of multimedia instructional modules. This was not the case in the past. Computer systems had to be custom-built with powerful processors and better sound and video capabilities to produce acceptable quality multimedia instructional modules (Ganesan, 2007). Earlier versions of screen capture software crashed frequently while recording the modules. A considerable amount of time and effort therefore had to be spent on producing the modules. Furthermore, the multimedia modules produced had to be distributed on CDs to the students due to the absence of cloud services for streaming the modules over the Internet.

Recently, the availability of newer software and services such as OneNote, Adobe Audition CC, Camtasia Studio and OneDrive, has eased the task of recording, editing and distributing the multimedia modules. All in all, the software tools discussed in this paper, except Adobe Audition CC, are easy to learn and use. Nearly all the software and services mentioned are available either

at no cost or at minimal cost to an instructor. Also, licensing agreements with many campuses provide easy access to software such as Office 365, Camtasia and Adobe Audition CC.

Office 365, for example, is now available to instructors and students in many campuses, enabling the instructors to benefit from the Office suite of software and the accompanying cloud storage of 5 Tera Bytes. In the case of campuses that do not offer the products and services mentioned, many of them can be obtained at reduced cost by taking advantage of educational discounts offered by the vendors. Furthermore, less powerful computers and free cloud services can also be used to reduce the cost of producing and distributing the multimedia modules. The trade-off, in this case, would be an increase in the time required to produce and distribute the modules.

### **Conclusion**

Overall, the demand for better and faster technologies and online services for learning is bound to increase with time as students entering higher learning intuitions expect online learning to be part of their learning experience. All indications are that the current generation of students, exposed to smart phones and other smart devices, are better equipped and prepared to benefit from online learning resources. Therefore, it is important to continue with the research on the development of online learning resources such as multimedia instructional modules and course websites.

The areas of future research, in this case, may include exploring the benefits of incorporating online quizzes within the multimedia modules and studying the effectiveness of online support forums for the instructional modules. Comparing the efficacies of multimedia modules produced by instructors teaching a particular subject with similar modules hosted on websites, such as lynda.com, would be another useful area of research to pursue.

Finally, while the impact of multimedia modules on student learning has been well researched and documented from a cognitive perspective, the tools and techniques available to produce such modules are yet to receive widespread attention in the literature. This paper hopefully fills a void by discussing the hardware, software and cloud services available for the rapid development and deployment of instructional multimedia modules. Although this article provides only a snap-shot view of the technologies, tools and techniques available at present, it hopefully points to a path for future research and for the continued development of multimedia instructional modules.

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