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Development of Multimedia Knowledge Object for Digital Pathology/Hematology Fixed Learning Module (FLM) as Resource for a Collaborative E-Learning System

Dissertation submitted in partial fulfillment for the Degree of Bachelor of Health Sciences (Biomedicine)

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CERTIFICATE

This is to certify that the dissertation entitled

"Development of Multimedia Knowledge Object for Digital Pathology/Hematology Fixed Learning Module (FLM) as Resource for a Collaborative E-Learning System"

is the bonafide record of research work done by

Mr. Md. Ariff bin Md. Ismail

during the period 27th August 2003 to 15th March 2004

under my supervision.

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ABSTRACT

The advent of multimedia and the Internet initiated a revolution and has changed the way we perceive our world. In the field of education, for example, this revolution has given rise to a new form of instructional mode - one that revolves itself around the Internet, termed simply as 'E – learning'. This powerful new tool is neither hindered nor obscured by great distances, capable of catering for just about any academic or corporate educational need. E – learning applications offer a highly variable, diversified and flexible instructional method, allowing the individual user more freedom and flexibility in acquiring information. Presentation of instructional text is made attractive by means of dynamic presentations such as simulations and animations, and provides a good complement to the standard class or lecture. E-learning has already been introduced as an instructional method within the Universiti Sains Malaysia Health Campus in several forms, such as the Pathology instructional website established by the School of Medical Sciences and the online LearningSpace initiated by the School of Health Sciences.

Despite numerous acclaims, however, the use of e-learning is not without its flaws. Applying multimedia in the instructional environment poses interdisciplinary demands, particularly those that concern computer technology, psychology and pedagogy. It is necessary to acquire background knowledge of factors such as hardware and software constraints, the end-user's computer experience and method of instructional presentation. This research attempts to present an outline for the design, development and implementation of multimedia knowledge objects which will ultimately be integrated into an e-learning system based on a multimedia fixed learning module relating to routine laboratory procedures.

INTRODUCTION

The rapid development of technology in the field of information and communication has subtly yet progressively changed instructional and educational methods by means of applying multimedia. The role of multimedia itself was seen as inevitable. It is arguably the most versatile form of asynchronous communication on the planet. The impact of multimedia has now been multiplied tenfold, thanks to its integrations with the Internet, in the form of e-learning.

Definitions

In order to be able to follow the progress of information presentations that are integral to this thesis, it is important to begin by defining the terminology most frequently used in issues pertaining to multimedia development.

- **Digital Multimedia** – Any combination of two or more media (be it audio, video, text, graphics or animation) represented in a digital form, sufficiently well integrated to be presented via a single interface or manipulated by a single computer program. (Chapman & Chapman, 2000)
- **Knowledge Object** – an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts. (Polsani, 2003)
- **Learning** – the process by which people acquire new skills or knowledge for the purpose of enhancing their performance. (Rosenberg, 2002)
- **E-Learning** – E-learning is Internet-enabled learning. Components can include content delivery in multiple formats, management of the learning experience, and a networked community of learners, content developers and experts. (Gunasekaran, McNeil and Shaul, 2002)

- **Collaborative E-learning** – a cooperative and closely aligned process wherein the students and subject matter experts use each other's knowledge to create ideas, make them visually compelling and store them in databases for access and manipulation. (Polsani, 2003)
- **Synchronous communication** – Real time communication (possessing speed and immediacy) that doesn't necessarily involve face-to-face interaction. Includes communications via one-to-one and one-to-many e.g. classroom, lecture, on-line. (Foreman, 2003)
- **Asynchronous communication** – Delayed communication done over a distance or span of time, which is then, followed up by subsequent interactions e.g. email, threaded discussions. (Foreman, 2003)

Overview

As I have stressed before, it is important for us to recognize the importance of multimedia and its application in the educational field. The next issue that comes to mind would be the specific choice of using an e-learning system. There are four reasons behind the selection of this mode of presentation (Bates, 1997):

- Improves the quality of learning
- Improves access to education and training
- Reduces the costs of education
- Improves the cost-effectiveness of education.

With this realization comes the question of how to go about applying multimedia and the Internet as means of providing education. This project attempts to answer that question by

creating a model for the design and implementation of an e-Learning system. Specifically, the system is aimed to indoctrinate medical laboratory staff members & students - both health sciences and medical alike - and educating them on the protocols and techniques inherent to the respective medical laboratories. In deciding between the two labs currently under view, Pathology and Hematology, it has been decided that the module would be concentrating on the Hematology laboratory procedures due to its relevance in the occupational field and the necessity of precision as it will be dealing directly with the lives of patients. This module was built with basic educational experience in mind, and thus has been limited to only to the basic routine tests that are carried out by the Hematology laboratory. The tests that were selected are:

- Full Blood Count
- Prothrombin Time Test
- Thrombin Time Test
- Activated Partial Thromboplastin Time Test
- Coagulation factor deficiency assays
- Von Willebrand Factor studies

The tests listed above are carried out routinely and some even on a daily basis. Thus, it is essential for every member of the staff to be able to conduct these tests on their own. These tests will be carried on three particular machines, which are the:

- ACL 100
- Sysmex KX – 21N
- ELX 808 Ultra Microplate Reader

These machines are currently the ones being used for applying the aforementioned tests. The Sysmex KX – 21N is capable of carrying out a Full Blood Count, whereas the

ACL - 100 carries out coagulation diagnostic tests. The ELX 808 is used for enzymatic linked immunosorbant assays, ELISA.

The development of this multimedia e-learning module requires the use of systems analysis and design in order to structure out the phases and tasks required. The individual phases are as follows:

- Analysis phase, detailing the initial requirements of the module.
- Development phase, involving the actual fabrication of individual knowledge objects.
- Integration phases, where the separate parts of the module are put together.
- Prototyping phase whereby the newly finished module is tested.
- Implementation phase, during which the module is made available online.
- Maintenance phase, where troubleshooting is carried out.

REVIEW OF LITERATURE

The following are texts that I have found to be crucial in the formation of this thesis, as well as the e-learning module I am have to developed.

Simoff & Maher (2000) were of an opinion that collaborative design environments usually involve the consideration of the technology that enables communication and information sharing. These environments can provide for both synchronous and asynchronous communication

Alexander (2001) stated that a reliable technology system is critical to the success of e-learning initiatives. This system not only includes the technologies themselves, but also the support for staff and students as they learn to use the e-learning projects. It was also emphasized that students will readily give up on a course if they cannot get the technology to work, and they do not receive support.

Where e-learning is contemplated, Alexander and Blight (1996) surmised that the first stage of planning should include the following questions which will provide evidence on which to determine whether implementation will be successful, and guide thinking about the appropriate use of ICT:

- Context of Learning
- Information Technology
- Teaching/Learning design (Instructional Design)

Weller and Mason (1997) discovered that students consistently rate communication and support from faculty and other students as having the major influence on their online learning experience. A second factor is that of time available to devote to the course. The third issue is the student experience of the technology.

Polsani (2003) stated that a Learning Object could avail itself of flexibility, scalability and adaptability offered by information technology only when it is predisposed for reuse by multiple developers in various instructional contexts. Development and operation of Learning Objects should be considered mutually exclusive processes. It is through exchangeability articulated here as reusability that the Learning Objects acquire value.

Calverly (2003) described a good learning resource as one that is 'fit-for-purpose'. 'Fit-for-purpose' is not restricted to the educational aspects inherent in a resource, or to those elements relating to its pedagogical-embedding within a course. It must also include those technical issues that influence its ability to be delivered to its intended audience.

Lock and Voon (2002) stress that implementation of successful multimedia learning systems require well-planned and skillfully written content, attractive and functional graphic design, and rapid implementation at a reasonable and affordable cost. Quality in video production is no longer a luxury; it is a necessity and requires a combination of innovative creative design, precise artistic direction, and strict hands-on project management.

Rosenberg (2003) decreed that knowledge management supports the creation, archiving, and sharing of valued information, expertise, and insight within and across communities, and its benefits include the facilitation of learning with specific information needed at a specific time for a specific purpose and the ability to leverage and grow the collective knowledge of the organization.

Hoffer, George and Valacich (1999) stated that it is beneficial to use a standard set of steps, called a systems development methodology, to develop and support information systems The systems development life cycle is a common methodology for systems development and features several phases that mark the progress of the systems analysis and design effort.

Young (2001) clarified that within a Web-enabled environment; individuals can access courses, individual topics and performance support resources any time - from the office, at home and while traveling. Standard Web browsers offer a consistent and seamless user interface across a wide variety of workstation platforms and networks.

LACUNAE

E learning unveils a revolutionary new era in education and instruction. Incorporation of efficient, cost-effective collaborative e-learning systems capable of catering to the specific needs of individuals is now within sight.

The acquisition of information for specific tasks can now be made available for access online at any time, allowing an individual to get what information he or she needs, whenever the need arises. Being able to access the online information negates the need for having to wait to obtain printed which are copious in number.

Development requires a well-planned project management scheme, isolation of relevant resource material, a convenient procurement platform as well as excellent end user-systems analyst interaction.

OBJECTIVES OF STUDY

This research was carried out with a series of goals in mind. The initial goal of this project was to outline a model for the design and implementation of a digital fixed learning module for Pathology & Hematology laboratory procedures. This module was to be developed in such a way as to be able to cater for the needs of laboratory staff, undergraduates and postgraduates alike. For undergraduates and newly indoctrinated staff members, this module will prove to be an invaluable guide to proper laboratory procedures in the respective labs. It will also serve as a reference point for seasoned staff and postgraduate students who wish to brush up on basic procedures that are carried out.

As it was mentioned before, the procedures for the Hematology laboratory has been given priority over those of the Pathology laboratory, as it was felt that its relevance in the occupational field carried far heavier implications, with minor mishaps leading to a possible endangering of human lives. Thus, the specific objectives of this project are:

1. To identify suitable and reusable multimedia learning objects to be integrated into a fixed learning module for basic Hematology laboratory procedures, of which the contents are targeted to both laboratory staff and students alike.
2. To design and develop the aforementioned multimedia fixed learning module.
3. To make available the aforementioned module for online access as part of the collaborative e-learning system, compatible with both IBM PC and Macintosh platforms.

The tests that were selected to be included in the module were based on the everyday requirements of the laboratory. From inquiry and observation, it has been decided that the following tests are indispensable and should be made an educational priority for students or newly appointed members of the staff:

- Full Blood Count (FBC)
- Prothrombin Time Test (PT)
- Thrombin Time Test (TT)
- Activated Partial Thromboplastin Time Test (APTT)
- Coagulation deficiency in extrinsic and intrinsic pathway factors
- Von Willebrand Factor studies

Most of these tests are carried out daily and some are carried out according to order. Thus, it is essential for every member of the staff to be able to conduct these tests on their own without the aid of another person. Situations such as on call duty requires for this. These tests will be carried on three particular machines, which are the:

- Automated Coagulation Laboratory Analyzer, ACL 100
- Sysmex KX – 21N
- ELX 808 Ultra Microplate Reader

The Sysmex KX-21N will soon be replacing the Coulter JT unit as the main machine conducting the Full Blood Count. The ACL 100 is used for coagulation studies and the ELX 808 is used for Von Willebrand assays.

MATERIALS & METHODOLOGY

Conducting an ICT based research requires the use of multiple forms of media in order to present the end-user with an interactive learning module that provides for an engaging educational environment. The following list contains the necessary hardware and software that I have found indispensable throughout my entire project:

Hardware:

- AMD Personal Computer (Athlon 1.1MHz)
- Macintosh iMAC and PowerMac G3
- Canon SP-100 printer
- Sony DCR-TRV340E digital video camera
- Sony DSC-F505 digital still camera
- Apacer Mega Steno 2.0 card reader

Software:

- Macromedia Dreamweaver MX
- Macromedia Flash MX
- Macromedia Fireworks MX
- Microsoft Word 2000 v. 9.0.2720
- Microsoft Internet Explorer
- Microsoft Windows XP
- Mac OS 9.2
- Mac OS X
- iMovie

This project was carried out according to the outlines for systems analysis and design put forward by Hoffer, George & Valacich[16]. The various phases and sub phases that constitute this project are:

1. **Analysis**
    i. Requirement analysis
    ii. Syllabus analysis
    iii. Identifying multimedia objects
2. **Design**
    i. Storyboarding
    ii. Modeling
3. **Development**
    i. Text objects
    ii. Graphic objects
    iii. Interactive objects
    iv. Audio visual objects
4. **Integration**
    i. Text objects
    ii. Graphic objects
    iii. Interactive objects
    iv. Audio visual objects
5. **Prototyping**
    i. Platform testing
    ii. User testing

6. **Implementation**

    i. Upload onto LearningSpace

7. **Maintenance**

    i. End-user feedback

    ii. Troubleshooting

The phases outlined above will be explained in further detail in the following pages. This section will now begin by describing the phases and sub phases as they progress:

ANALYSIS

i. Requirement Analysis

This is the initial phase of any multimedia development project. During this phase, information was gathered on the subject of the project, the ICT capability and experience of the end-user and finally the multimedia objects that would be developed.

The requirement analysis phase began with the need for an accurate gauge of computer literacy among the possible end-users[5]. In order to obtain this information, a qualitative research analysis was carried out. The question posed by this analysis was "Are the possible end-users well versed in Information and Communication Technology?" This is a very valid and critical question indeed, for technology in all its might and grandeur, would be useless without the capacity to use it and make it work[1]. Thus, for the purpose of discovering the answer to this query, a questionnaire had to be developed. The sample population consisted of two entities:

i. Hematology Laboratory Staff (13 laboratory technicians).

ii. Third year Biomedical Science Undergraduates (33 students)

Two sets of questionnaires with similar series of questions were prepared for these two separate populations. A simple random sampling method[12] was applied in order to choose sample candidates for the questionnaire. The questionnaire itself was divided into 7 subsections, each assessing:

i. Basic personal information such as age, gender, place of origin.

ii. General competency and hours of computer usage for various purposes such as doing assignments, looking for information, communicating and entertainment. Also included are questions on experience with various computer peripherals such as printers, scanners and the like.

iii. Level of computer training, including participation in formal computer courses, and experience in using specific computer programs.

iv. Experience in Information and Communication Technology. Subjects are asked about their favorite web browsers, search engines and level of expertise in using Internet communication. They are also inquired as to their experience in attending online e-learning programs.

v. Basic computer operations such as cut-and-paste, creating a new folder and using help functions.

vi. Experience using different forms of multimedia formats such as Real media, Flash and QuickTime.

vii. How they generally acquire information and their opinions on ICT.

ii. Syllabus analysis

Once the level of end-user proficiency has been determined, it is now necessary to narrow the syllabus list of the e-learning module[7]. The Hematology laboratory in the University Hospital is a high tech facility equipped with multimillion-ringgit machines capable of conducting a wide plethora of tests, be they diagnostic or even research. Considering that the scope of this e-learning module is mainly to be targeted for newly indoctrinated staff members and students, the list of tests to be included within this module has been narrowed down to those that are essentially important. The following tests have been selected due to the fact that they most frequently carried out, and as such, the skill to conduct these tests must be acquired:

- Full Blood Count
- Prothrombin Time Test
- Thrombin Time Test
- Activated Partial Thromboplastin Time Test
- Coagulation factor deficiency tests
- Von Willebrand Factor studies

Since all these tests are automated, it is relevant that the syllabus deal directly with performing the tests aided by the respective diagnostic machines. The three chief diagnostic machines that will be used are:

- Automated Coagulation Laboratory Analyzer, ACL- 100
- Sysmex KX – 21N
- ELX 808 Ultra Microplate Reader

The Sysmex KX – 21N will soon be the main diagnostic machine being used to conduct Full Blood Count tests whereas the ACL 100 is used to conduct coagulation studies and Von Willebrand Factor studies.

The KX – 21N is a versatile analytical instrument and is capable of delivering a wide range of analysis parameters. Among the parameters include:

- Red Blood Cell (RBC) count
- Lymphocyte count
- Mixed Field count consisting of eosinophils, basophils and monocytes.
- Neutrophil count
- Hemoglobin volume
- Hematocrit value
- Mean RBC Volume (MCV)
- Mean RBC Hemoglobin (MCH)
- Mean RBC Hemoglobin Concentration (MCHC)
- Platelet count

The procedure of conducting the test itself requires a whole blood sample to be taken from the patient and stored in a tube containing EDTA anticoagulant. Refrigerated blood is to be left to warm to room temperature before analysis. The sample probe of the analyzing instrument is then put into the tube to take the appropriate readings.

In the case of coagulation studies, the Automated Coagulation Laboratory Analyzer, ACL- 100, is used. The ACL – 100 is a nephelometric centrifugal analyzer that measures the intensity of light scattered by a plasma sample before, during and after clot formation. This instrument is capable of running up to as many as 18 plasma samples at a time. The samples

are loaded into wells, numbered 1 – 18. The appropriate reagent is then placed into the reagent reservoir and the test required is selected from the program menu on the display screen. Depending on the diagnostic kit used, this analytical instrument is capable of assessing several parameters pertaining to coagulation factor deficiencies, including deficiencies of Factors II, V, VII, VIII, IX, X, XI and XII.

The ELX 808 is a microplate reader, which enables rapid and accurate assessments of enzyme linked immunosorbant assays (ELISA). The plates are incubated with the reagents of the intended assay. Upon completion, the microtitre plate is loaded onto the reader where it scans and provides the necessary readings.

Protocols for conducting these test procedures are obtained from the Hematology Laboratory. Manuals containing standard operating procedures are perused to identify the specific test methods and diagnostic kits that will be used in these tests. Further interviewing of the staff members were then carried to inquire about the protocols of analysis that are applied in the laboratory[13].

iii. Identifying Multimedia Objects

As the term implies, multimedia is the fusion of various forms of communicative media, and is designed to get a message across, that is, from the developer to the end user[18]. With reference to this project, the message is in the form of practical instruction in laboratory procedures. By combining multiple forms of media into a designated module, not only can we attract the potential end user's attention, we can also enable him or her to interact with the module, thus reinforcing the lesson and heightening the effectiveness of their learning experience[9].

However, despite the temptation to cram the module with as much forms of multimedia as we humanely possible, it is pertinent that we analyze first the constraints that affect the development and application of various individual forms of multimedia[19]. It becomes clear, if we were to view it from the ground point up, that the development and application of some multimedia formats would pose significant obstacles, both to the developer and the possible end user.

The general mode of access available to the possible end user would be computers, operating both on the IBM PC platform or the Macintosh platform, and with an Internet connection or a link to the local area network. The advent of recent software development now enables some measure of interchangeability between platforms, thus allowing one to view platform specific media file formats. A suitable example would be the *. AIFF and *. TIF audio and graphic formats, which were, until only a couple of years ago, only accessible through Macintosh applications. Among the various forms of media components that were taken into consideration are:

- Audio
- Video
- Photographs
- Texts

Audio and video are combined forms of media, consisting of a graphical representation accompanied by a sound or narrative. The option to use digital audio and video was made available by means of a digital video camera and the necessary software to manipulate it. Human perception naturally relies on watching and listening, and in this age of information and technology, it has become a realistic medium that humans are comfortable with. As it was

mentioned before, the urge to use this highly effective form of media may prove quite compelling. However, the constraints involved must be taken into consideration[10].

Since this project was intended for providing online accessibility, the size of the video, the quality that is intended and the speed of the network become constraining factors. The television has served as the major form of multimedia presentation for many years. Its development over the last few decades, from mere black and white to liquid crystal displays serve as the standard for quality of audio and visual presentation. People have become used to high quality visuals, and in this, we discover our first obstacle. The general expectation of the end user would be fairly high and they would be extremely critical of any shortcomings. In here lies the first problem tour equation - poor visual and audio quality. To avoid this, one would consider producing a video with a greater degree of definition. A possible choice would be employing the MPEG-2 format, with resolution qualities that can exceed 640x480, and with a decent audio layer to match. A format of such quality however, would take its toll in the form of a large file size, and in here, lies our next problem – bandwidth. The speed of transfer relies on the network bandwidth, the larger it is, the better. This is not a luxury that most individuals or organizations can afford. Thus, it is necessary to take all these three aspects into careful consideration when developing a video and audio media presentation. This project will utilize video in QuickTime format.

Photographs enable us to employ visual media without having to worry much about the constraints of the video format. Despite the advantage in occupying space, however, it is important to note that substituting a video with a still picture retracts from the effectiveness of the presentation. The uses of photographs are made available by the means of a digital camera. In this project, photos are used to describe specific objects such as test reagents or instruments.

It serves to specify an action, and when combined with text application, helps reinforce the matter in question. The formats for photo files are numerous, such as *. JPG, *. GIF and *. PNG to name just a few. Each format serves a particular function, and possesses a certain range of characteristics. Thus, it becomes necessary to be selective of the type of format used in order to present a high quality graphic while economizing on space. This project will utilize either *.JPG or edited photos in the form of *.PNG.

Text is an integral part of any application. It is an inseparable and important media component, with a diversity of roles in the offline and online environment that has evolved over the years. Despite its incessant usage, it tends to be overlooked more often than not. Usages of texts invoke several crucial issues that are worth considering. The quality of typography is an important aspect of text usage in multimedia applications. The end user would be highly critical of poor typography if it doesn't appear to be inline with the quality of the overall multimedia application. Even if the other multimedia components were of superior quality, a poor typography would prove detrimental and would retract the overall effectiveness of the module. The layout, size and legibility of the text serve as the chief markers. The user must be able to read and perceive the text in order for it to have an effect. Thus, organization and displaying of texts in the interactive environment need to be well thought out. This project utilizes texts of various sizes, generally in Times New Roman font.

DESIGN

i. Storyboarding

Where as the previous phase consisted of analysis of the required information system, this phase will deal exclusively with its design and architecture.

The proposed information system would be a multimedia fixed learning module in the form of a website, which consists of several sections pertaining to the various tests involved. Two additional sections will be included, one on the instruments used and another to assess the user's level of understanding.

This website will serve as an integration platform for the various multimedia knowledge objects that are to be developed[23]. Further details pertaining to the aspect of integration will be discussed in greater length in the Integration Phase. As specified in the previous phase, the forms of multimedia that will be used are audio, video, photographs and texts. For interactive purposes, Flash applications will be employed to integrate the separate knowledge objects. Thus, the basic component structure of the website can be viewed diagrammatically as follows:

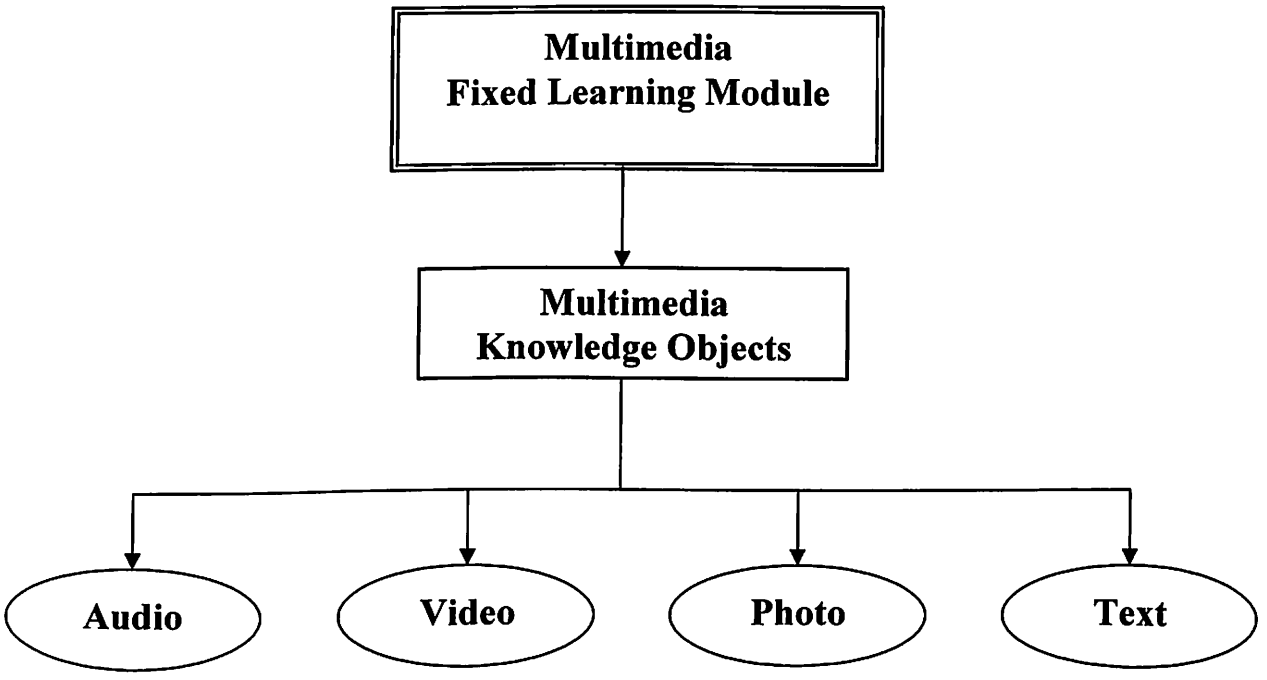

Figure 1: Components of multimedia FLM

The website which houses the module can be broken down into several sections:

- The home or default page where the user begins his or her session.
- The Full Blood Count section
- The Coagulation Studies section
- The Von Willebrand Studies section
- The Instrument section
- The Assessment section

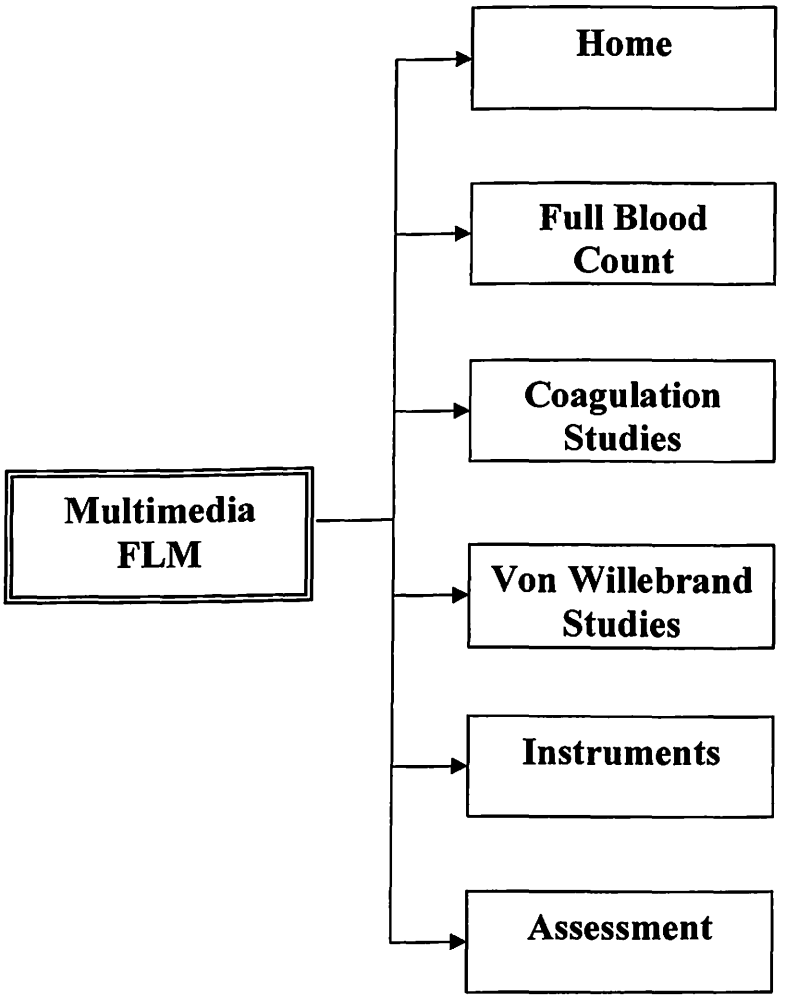

Figure 2: Overall module organization

With the exception of the Home section, each of the sections mentioned above is further broken down into subsections. These subsections will contain instructional texts, video or photos relevant to the individual test.

The **Full Blood Count** (FBC) section is fairly straightforward and consists of:

- The main FBC page which allows users to navigate to the other subsections
- The introductory page
- The procedures page containing instructional material
- The video link which directs the user to the instructional video

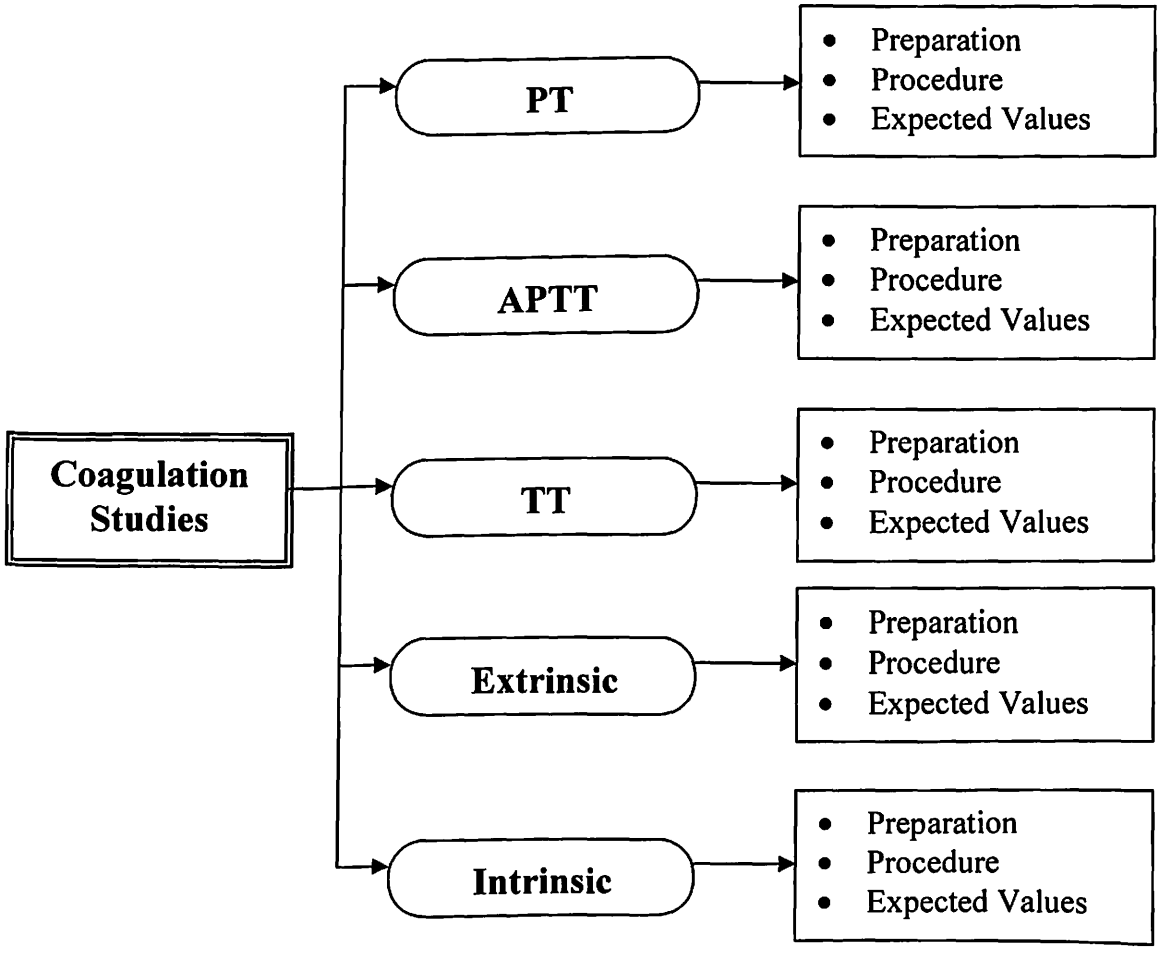

Figure 3: Organization of Coagulation Studies subsections