2.0 Introduction.

This section presents the theories behind the development process and describes various tools required to develop interactive multimedia applications. Design in Multimedia is introduced, followed by a section on User Interface Design and Metaphors. Audio and video are discussed before Section 2 closes with a description of development tools.

2.1 Design in Multimedia.

Designing and developing in multimedia incorporates elements from other disciplines such as graphic, video and screen design, Human Computer Interface (HCI) development, instructional and curriculum design, computer science and software engineering. Principles and methods from computer games design, storytelling and theatre are used to create compelling content and interactivity. Interactivity is the primary focus of multimedia. Elements of control, consistency and context should be identifiable when evaluating whether the production is interactive and if the interactivity design has been successful.

Users should have control of the application. They should be able to control where they are going, how to go back, how to stop and start over. Good navigational aids and interaction styles are imperative if implementation is to be considered successful. Interactivity should have a context, it should relate to the surrounding material and not be included for its own sake Controls for activating and stopping sound, video and animation are desirable. Consistent use of media elements and program behaviour is fundamental to good design practice and reduces the time spent learning how the application works. Graphics, audio and video should also have a context. They should provide further information and relate to other on-screen material to be effective.

2.2 Methods of Design in Multimedia

Storyboards and structure charts are the main tools for designing multimedia applications. They are used for determining the navigation structure and the content of the production. The idea of storyboards has been imported into multimedia application design from the film industry. Storyboards and structure charts can be hand-drawn or rendered digitally on a computer.

2.2.1 Structure Charts (Navigation maps).

Structure charts are a diagrammatic layout of the application that is to be designed. Their purpose is to make it easy for the reader to understand the functionality that the production offers and how the navigation system works. Naming screens in the diagrams can also easily identify the scope of the application content. Structure charts are utilised early in the planning stage of the project. They provide a table of contents as well as a chart of the logical flow of the multimedia interface. The charts are the main method of documenting the navigational structure. Individual modules in the program may have different navigational structures from others.
Utilising the diagrams quickly identifies how to set up the module or template and how it fits in to the overall design.

There are four basic navigation structures (linear, hierarchical, nonlinear and composite) normally used for developing multimedia applications. The method used to provide users for navigating from one part of the program to another is a crucial part of the user interface.

Linear:- Users navigate sequentially, from one screen to another
Hierarchical:- Users navigate along the branches of a tree structure that is shaped by the natural logic of the content.
Nonlinear:- Users navigate freely through the content of the project, unbound by predetermined routes.
Composite:- Users may navigate freely (nonlinearly), but are occasionally constrained to linear presentations of movies or critical information.

The use of structure charts promote program clarity and simplicity, they help reduce the time and effort required for scripting, debugging and maintenance. These charts provide system documentation showing each level of design and the relationship between the screens, sections and modules that make the application. Each of the maps or charts can be used to design sections of the program and parts within the sections. They provide an overview of the application which is an excellent resource for implementing new or updated material in future versions.

2.2.2 Storyboards

Storyboarding is an invaluable tool for developing multimedia productions. It is a technique that has been adopted from the film and animation industries. Storyboards are a series of sketches depicting the content of each screen, they contain design notes and specifications that are used to develop the application. A number of approaches can be taken to storyboarding. Much time and effort can be spent on the storyboards describing the project in precise detail. The designer could use words and sketches for each and every screen image, sound, rollover effect, transition, navigational choice, responses, colour, font, and position to the exact pixel of each object on screen. This approach is exceptionally useful for development teams that can create prototypes swiftly then rapidly convert them into the completed product. Alternatively less detailed storyboards can be used as a project guide, spending less time on paper and more time rendering the production on the computer. Both methods of storyboarding have benefits, the former approach is normally adopted by clients that wish to control the production processes and staff costs. The latter approach facilitates some degree of creative freedom but may require more time iterating and editing the program when it is being developed.

Storyboards are a good method for outlining out alternative designs and to convey design ideas. They can also be used in a cartoon-like way, to depict the system or device in imagined use. They should be created in colour which helps identify the look and feel of the interface. Sketches should look as close as possible to their final form and contain enough detail to facilitate current and future development of the application having the same look and feel.
2.3 Designing the user interface

The user interface of a multimedia production is a mix of its graphic elements and its navigation system. Users should be allowed to navigate freely and know where they are whilst using the system. Mediocre navigation aids can make the learner feel lost, disorientated or give up using the application. Poor and inferior quality graphics cause apathy and boredom as well as being visually unattractive. The design principles on which user interfaces are based are the same as those used by graphic designers and artists.

2.3.1 The User Interface of the Application

A computing system's interface is developed on the basis of potential users' capabilities and limitations, the users' tasks, and the environment in which those tasks are performed. Effective interfaces are visually apparent and forgiving, instilling in their users a sense of control. Users quickly see the breadth of their options, grasp how to achieve their goals, and do their work. In a sense the interface should be also transparent to the user it should require no special skills to operate and the user should not need to memorise commands or obscure icons.

Factors, which must be considered when creating the user interface, include:- navigation, cognitive optimisation, anticipation, readability, balance and proportion

The developers should aim to use navigation aids and hyperlinks in a consistent way and to use the same type of navigation symbols (icons, buttons or text) throughout.

Because of differences in the way individual learners seek information and acquire knowledge they develop unique styles for accessing and relating to the information available for discovery. These differences may describe how they prefer to interrelate, which mode of navigation they prefer for accessing information, how they recognise new information, or the sequence in which they prefer to gather the information. As a result, navigation is becoming one of the most important design issues in interactive multimedia development. As suitable courseware is designed to impart creeping knowledge, the more information presented in any package, the more powerful the navigation system needs to be.

Tucker (1990) observes, ‘In defining navigation for the interactive multimedia environment, draws an interesting analogy with navigation at sea. The seas, throughout the history of exploration, have been charted and defined. Some of these charts are of different scales and provide different information about the landfalls, current and dangerous reefs. Ships set sail with all this information at hand and as long as they were in sight of land, it was an easy matter to navigate.’
2.3.2 Cognitive Optimisation

Stoney & Wild (1998) propose ‘intrinsic motivation is maximised in users when there is an optimal mismatch between the cognitive structures in the user and the demands of the instructional environment’.

When cognitive demand is minimal the user is unchallenged and likely to become bored. However if the demand is too high the user is overwhelmed and as a consequence may be liable to give up. Cognitive demand is a relative concept and will change in accordance with the target user and the learning environment.

2.2.3 Anticipation

Applications should attempt to anticipate the user’s wants and needs. Do not expect users to search for or gather information or evoke necessary tools. Bring to the user all the information and tools needed for each step of the process.

2.2.4 Colour Blindness

Any time you use colour to convey information in the interface, you should also use clear, secondary cues to convey the information to those who won’t be experiencing any colour coding today.

2.2.5 Consistency

The importance of maintaining strict consistency levels varies. Many people assume that the order of items one through five should be exactly the reverse, leading to applications that look alike, but act completely different in unpredictable ways. Inconsistency is just as important, to be visually inconsistent when things must act differently as it is to be visually consistent when things act the same. Avoid uniformity, make objects consistent with their behaviour. Make objects that act differently look different. The most important consistency is consistency with user expectations. The only way to ascertain user expectations is to do user testing. No amount of study and debate will substitute.

2.2.6 Learnability

Ideally, products would have no learning curve: users would walk up to them for the very first time and achieve instant mastery. In practice, all applications and services, no matter how simple, will display a learning curve. Limit the trade-offs, usability and learnability are not mutually exclusive. First, decide which is the most important and then attack both with vigour. Ease of learning automatically coming at the expense of ease of use is a myth.
2.2.7 Balance and proportion.

Balance and proportion refer to the visual distribution of elements that create the on-screen display. Non-symmetrical form appears heavier than symmetrical form, for elements of the same shape the largest will appear heaviest. Proportion refers to the relationship between the visual elements of the display.

On a computer screen simple uncluttered design is most effective. Complex designs with too many conflicting elements are confusing and cause information overload. Each screen should convey no more than one major topic it should also contain clear titles and headings. Using margins and white space enhances readability and attractiveness of a screen.

White space is useful for subdividing sections of material and graphics from the background. The background is important, it should not distract from the text or the other onscreen material. A solid background in white or a pale colour is preferred by learners and uses less bandwidth for web delivery. A consistent pattern of screen elements, information areas and toolbars helps the learner navigate effectively through an application. The screen should be balanced with each element given the same weight. Colour and white space are useful for attaining good visual balance and clashing colours should be avoided.

Visual balance and imbalance (Figure 2, Boyle 1998)

The interface design will normally consist of rectangular shaped objects in the form of text blocks, control panels, button bars or frames for images. Rectangles are extremely common as elements of graphic design and are especially well-suited elements to use for designing the human computer interface.

Variation in visual balance (Figure 3, Boyle 1998)
The overall graphic balance and organisation of the interface is incisive to drawing the reader into the production. Users see the application first as large masses of shape and colour, with foreground elements contrasted against the background. Then they begin to pick out specific information, first from graphics if they are present, and only afterward do they start parsing the "harder" medium of text and begin to read individual words and phrases. (Yale Style Manual)

### 2.4 Interface metaphors and icons

Metaphors are often employed to help users remember and use various functions in a computer program. They are supposed to symbolise an aspect of the real world, metaphors are popular in GUI environments. For example a user may drop a file or folder in the recycle bin on a computer, the physical world equivalent might be dropping paper in a waste paper basket. Popular metaphors include windows, desktops and buttons. Designers are constantly utilising and creating new metaphors some work, some don’t. They should have a clear meaning or implication and should be used only to facilitate interactivity. A metaphor that is unfamiliar can cause confusion and does not assist the user. It should represent an activity to be performed on the computer or by the user.

### 2.5 Review of the Design with Users

Half of the design process is analysis and creation; the other half is seeking feedback and applying its lessons. To ensure that the users will think your application is great, it is important to get your feedback from real users throughout the design process. Reviewing the design with users gives you the most valid information. It is extremely important to discuss the design with one or more users.

The users should review all systems. The only question is whether you want it to happen while you can still do something about the problems your users discover. It is important to think of user feedback as way to put a pass/fail grade on your system, preferably to think of it as a way to gain new information and insight. Ultimately this will benefit your own design and create a more usable application.

### 2.6 Multimedia Authoring Systems

Authoring systems are the primary tools that developers use to create interactive applications though programming languages such as Visual Basic and Delphi can also be used. Authoring tools combine all the media resources within a structured framework and there are many to choose from. Authoring systems can be divided into three main categories:- Page and Object based, Flowline and Icon based and Time and Script Based.
2.6.1 Page and Object Based Authoring Systems

The most popular card based tools are HyperCard for the Mac and ToolBook for Windows. These systems use an object-oriented approach to building applications. The object oriented approach to software development focuses on applying properties and behaviours to objects. Program control is achieved by these objects passing messages to each other. These programs facilitate highly flexible navigation structures which makes them desirable for multimedia development.

HyperCard is based on a pack of cards metaphor. The application is created using a card based system is made up of one or more stacks of cards. Navigation is based on paging or hypertext links. They are also well suited to producing hypertext documents. Toolbook uses the overall metaphor of a book, which is basically a set of pages. Objects are organised into a series of layers for backgrounds, pages and the basic multimedia elements that appear on screen. Objects can have a default behaviour that can be modified or extended to respond to program events such as mouse clicks. ToolBook incorporates OpenScript (scripting language) which can be utilised to add functionality to add extended development capabilities.

2.6.2 Flowline and Icon Based Authoring Systems

Authorware is cross platform and is the main type of icon based program. Macromedia developed it specifically for the development of educational and training applications by non-programmers. Authorware applications are created by dragging icons from a palette onto a flowline. Each of the icons has a particular function for displaying media elements, decisions, branching, pauses and so forth. The appearance and behaviour of individual elements are controlled through direct manipulation and by filling in dialogue boxes. The overall structure of the application is specified through the flowline which links the icons that the developer has used. Authorware adopts a visual programming approach to development and is not based on a scripting language.

2.6.3 Time and Script Based Authoring Systems

These types of tools use a visual time line on which multimedia events are placed to control the flow of the application. Macromedia Director and Flash are currently very popular examples of these systems, both are cross platform and executable files can be delivered as stand alone applications on optical or floppy disks. Alternatively they can be delivered for the web as Flash or Shockwave movies. Web playback requires the Flash and Shockwave plug-ins.

Director contains a broad set of features for multimedia development, the Lingo scripting language enhances and extends the power of the program. Director is extremely well supported and a number of Xtras are available from third party software vendors which further extend its capabilities. In Director projects are assembled and sequenced using the Cast and Score. The cast is a multimedia database, which contains all media elements. The score is the sequencer for displaying, animating and playing cast members. Many visual effects such as
transitions, adjustment of colour palettes and tempo control can be implemented from the Score.

The Lingo scripting language incorporates expressions, functions, variables and properties that help to manage activities that are not incorporated in the pre-defined Director Behaviour libraries.

Flash also utilises a timeline onto which objects are layered in a hierarchical sequence. Multimedia elements are stored in libraries, they are placed on the timeline which sequences events on a given scene. Actions are assigned to objects and frames using a dialogue box. The developer then chooses one from a list that appears in the pop-up menu.

Web-site creation is the primary focus of Flash, it can deliver vector graphics over the web which offer the benefits of having a small file size and scalability. They are scalable without loss of resolution making them ideally suited to web development.

2.6.4 Web page editors and Dynamic HTML (DHTML)

Web page editors and dynamic HTML are worth mentioning because they provide a feasible alternative to multimedia authoring systems. They provide much of the same functionality and features offered by authoring systems.

Increasingly web page editors are becoming widely available that incorporate many features from multimedia authoring tools (timelines, scripting etc) and cross platform HTML. Cascading Style Sheets and JavaScript functionality are also included. Often the code is hidden from designers but it can still easily be customised by developers from text editors that are built into the application. Macromedia Dreamweaver and Adobe Go Live incorporate a time line to which objects can be animated or change over time. Codes for web publishing (DHTML, JavaScript, CSS, HTML) is generated automatically and requires no specialist knowledge. These types of applications are blurring the boundaries of what a multimedia authoring tool really is since they offer similar functionality and features to the authoring systems discussed above.

DHTML is collective term that encompasses other web technologies such as the Document Object Model (DOM), Cascading Style Sheets 1 (CSS1), JavaScript and HTML. The technologies are used together to enhance and extend the HTML 4 standard. It provides the web author with the ability to expand the possibilities of web page design creating animated, interactive pages that behave in a similar manner to multimedia productions and other desktop applications. DHTML introduces a superior level of interactivity that was not previously possible with HTML alone. DHTML is object oriented, each object has its own properties, methods and events. The properties can be utilised to read and update local attributes of the object. Methods can be used to manipulate an object, and take advantage of the events to trigger pre-defined actions.
2.7 Audio and Video

Audio and video data can add significant value to a multimedia application but its use is primarily determined by the delivery platform of the production. Web delivery is severely limited to bandwidth constraints therefore large-scale use of audio and video is not currently recommended. However this has been recognised by software manufacturers who are currently working on developing solutions and standards for better compression algorithms for web delivery and optical disk. Presently it is possible to use small carefully selected chunks of this media, which can then be streamed to the user. The issues surrounding audio and video use are detailed in the material that follows with emphasis placed on streaming media and MPEG compression.

2.7.1 Audio integration.

Audio files are extremely resource intensive, using much disk space and hogging memory. It is important that audio with a low sampling rate and resolution that is compatible with not only the delivery medium but nature of the audio.

To give an example, the file size any sound file can be calculated using this formula

\[
\text{Size (Kb)} = \text{length (sec)} \times (\frac{\text{resolution}}{8}) \times \frac{\text{Sample rate (Khz)}}{\text{channels}}.
\]

The sampling rate is the frequency at which a sound is converted to digital format. A sampling rate of 44.1Khz means that the sound was sampled 44,100 times each second. This provides CD quality audio when 16-bit stereo (two sound channels) is also used. CD quality though desirable is not recommended for most multimedia applications at present. Factors concerning the size of audio files are more significant where multimedia is concerned. One minute of playback of a CD-quality stereo audio file requires 10 MB of data, approximately enough disk space to capture a small library of books or a 200-page web site. Standard modem speed connections--including cable modems and DSL systems don’t have the capacity to deliver pure, uncompressed CD-quality 16-bit, 44.1 kHz audio. Consequently there must be a trade off between sound quality and file size. It is preferable to capture and archive CD quality files for editing and future use and then re-sample at a lower frequency and bit rate, then compress them using an audio COder/DECoder (CODEC).

The key to using audio is to keep it short and where possible loop playback. Reducing to the sampling rate to 16-bit and the frequency to 11.25Khz provides reasonable quality voice recordings and low file sizes. Reducing the sample further creates a noisy audio file and is not recommended. Files can be compressed using lossless or lossy algorithms. These are discussed further in the streaming, shockwave and MPEG material that follows.
2.7.2 Streaming media.

Steaming media is a method of making audio, video and other multimedia available in real-time over the Internet. In order to stream across the limited bandwidth of the Web, audio has to be compressed and optimized with codecs. Lossy compression schemes reduce file size by discarding some amount of data during the encoding process before it is sent over the Internet. Once received on the client side, the codec attempts to reconstruct the information that was lost or discarded. Lossy audio compression discards frequencies on the high and low end of the spectrum and attempts to locate and remove unnecessary audio data. The technique is often referred to as "perceptual encoding" since the user is unlikely to notice the absence of this information. Lossy compression offers file savings on the order of 10:1.

2.7.3 Streaming media formats

There are many formats for streaming audio over the web. Widely used formats include RealNetworks' RealAudio, streaming MP3, Macromedia's Flash and Director Shockwave, Microsoft's Windows Media, and Apple's QuickTime.

While the high quality of MP3 has sent shockwaves through the recording industry, streaming formats like RealAudio remain the dominant audio technology on the Web right now. Indeed MP3 is being folded into multimedia streaming formats like QuickTime and Windows Media.

2.7.4 RealMedia and RealAudio

RealMedia is the most widely adopted streaming media format on the Web. Its popularity is due in large part to the fact that it was the first streaming technology on the market. But it's popular also because of RealNetworks' laser focus on ease of use, deployment of a wide palette of developer tools, continuous support for the latest multimedia technologies, and support for both Windows and Unix platforms.

2.7.5 Macromedia Shockwave

Shockwave Audio (SWA) compression is used for compressing files to be used for the Internet and optical disks. Like other streaming formats the file will begin to play as it is being downloaded. Shockwave Audio allows compression ratios of up to 176:1, which creates a much smaller file than other sound formats. Some degradation of sound quality occurs but SWA technology changes the file as little as possible. For streaming voice data over the Internet a data transfer rate of 16 Kbps is recommended, this enables users to receive FM mono or AM quality sound on a 28.8 modem. ISDN and CD-ROM files would be compressed at 32 to 56Kbps producing FM stereo to CD quality.
2.7.6 MPEG

During the past eighteen months MPEG1 Layer 3 (MP3) has completely surpassed all other file formats in popularity. Layer three specifically determines audio compression. The rise of MP3 has been meteoric, so much so that hardware has been produced specifically for downloading and playback of MP3 files. MPEG is a lossy scheme CODEC that is accepted as the industry standard for Digital Video Compression (DVC). MPEG can attain compression ratios of up to 180:1.

MPEG 1 is the only cross-industry compression ratio graphic standard that enable the playback of VHS-quality video and CD-quality audio at single-speed CD (150 kb/s) and T-1 (1.544 Mb/s) data transfer rates. It is unique that it ensures a consistent bit rate and can take advantage of today's existing data communications infrastructure.

MPEG2 is a higher ranking standard of MPEG1 which was adopted in 1991 as the standard for CD-ROM. MPEG2 was adopted in 1994 as the universal picture coding system for broadcasting and communications as well as for storage media such as optical disc. Dolby Digital multichannel audio is one of the digital surround sound systems available on DVD discs, other options include dts and MPEG2.

MPEG-4 defines the standard for multi-media applications. Specifically, it defines the transmission standard for multiple video, audio, and graphics data streams and their re-composition on the receiving device. Development is still ongoing but its principle feature is the ability to transfer data over a slow Internet connection.

2.7.7 Video integration

Video is also resource intensive requiring special hardware for capture and software for editing during development. The playback from the web or CD is still severely restricted by bandwidth limitations and the speed of the CD-drive. It is not possible yet to deliver full screen 25 frames per second video from a CD-ROM or via the Internet, although this is feature is being addressed in the MPEG 4 format.

Video requires great amounts of resources, planning and actors. Delivering quality relevant video via a web browser to a student with a modem connection is not likely to be successful. Furthermore the amount of time that is required for editing and attaining optimum compression whilst retaining file quality is not possible at present.