CHAPTER II

CONCEPTUAL OVERVIEW

2.1 HOW PEOPLE LEARN
2.2 DALE’S CONE OF LEARNING
2.3 MULTIMEDIA LEARNING
2.4 COMPUTER GRAPHICS
2.5 COMPUTER ANIMATION
2.6 ROLE OF ANIMATION IN MULTIMEDIA LEARNING
2.7 ANIMATED AND STATIC VISUALS
2.8 HISTORY OF ANIMATION
2.9 PRINCIPLES OF ANIMATION
2.10 THEORETICAL BACKGROUND OF ANIMATION
2.11 TECHNIQUES OF ANIMATION
2.12 2D VERSUS 3D ANIMATION
2.13 FUNCTIONS OF ANIMATION
2.14 THE PHYSICAL NATURE OF ANIMATION- DESIGN
2.15 NATURE OF THE SUBJECT MATTER- DESIGN
2.16 USES OF ANIMATION IN LEARNING
CONCEPTUAL OVERVIEW

Computers have become a powerful tool for the rapid and economical production of pictures. There is virtually no area in which graphical displays cannot be used to some advantage, and so it is not surprising to find the use of computer graphics so widespread. Computer graphics methods are now commonly used in making motion pictures, music videos, animations and televisions shows. Graphics does have a place in the educational process and deserves to be accepted as a valuable tool for instruction, either as a discrete unit or as a component of a multimedia methodology of instruction at all levels of education. Provided due attention is paid to patterns of classroom use, to desired educational and curricular objectives, and to salient learner characteristics, the medium of graphics has considerable potential for promoting learning.

The use of static and animated visuals has become pervasive in instructional materials. The use of high quality computer graphics as learning materials is steadily increasing, as the availability of computers in schools, homes and industry proliferates. Electronic learning environments that include visualisations such as animation show great promise for teaching students about the chains of events in dynamic systems. Understanding of these systems involves knowledge of their configuration, behaviour and
function, which can either be communicated by multiple static or by dynamic visualisations. While dynamic visualisations provide external animations that a user can view to learn how a system works, static visualisations require a process of internal or mental animation for comprehension of the system. So whereas learning from animations relies on the students’ ability to perceive the temporal changes in the operation of a system, learning from static graphics relies on the ability to infer these temporal changes.

2.1 HOW PEOPLE LEARN

Research over the last two decades has revealed volumes on the subject of how people best learn. Some important principles that the schools should consider regarding learning are:

**Student preconceptions of curriculum**

Students have preconceptions and prior experiences with many of the areas of study included in the academic standards. These are stored in long-term memory. Often some of those preconceptions turn out to be misconceptions. Student learning is greatly enhanced when each student’s prior knowledge is made visible. It is at that point the student has the opportunity to correct misconceptions, build on prior knowledge, and create schemas of understanding around a topic. Learning is optimised when students can see where new concepts build on prior knowledge.
Expertise through deep understanding

Students learn more when the concepts are personally meaningful to them. In order to deeply understand a topic, learners not only need to know relevant facts, theories and applications, they must also make sense of the topic through organization of those ideas into a framework (schema) of understanding. The development of schema requires that students learn topics in ways that are relevant and meaningful to them. This translates into a need for authentic learning in classrooms.

Learning is optimised when students develop “metacognitive” strategies

To be metacognitive is to be constantly “thinking about one’s own thinking”, in search of optimising and deepening learning. Students who are metacognitive are students who approach problems by automatically trying to predict outcomes, explaining ideas to themselves, noting and learning from failures, and activating prior knowledge. By giving appropriate scaffolding by educators and other adults, all students can learn metacognitive strategies.

2.2 DALE’S CONE OF LEARNING

Much of what human found to be true of direct and indirect experience, and of concrete and abstract experience can be summarized in a pictorial device which can be called the ‘Cone of Experience’. The cone is not offered as a perfect or mechanically flawless picture to be taken with absolute
literalness in its simplified form. It is merely a visual aid in explaining the inter relationships of the various types of audio-visual materials, as well as their individual positions in the learning process. The cone device, then, is a visual metaphor of learning experiences, in which the various types of audio-visual materials are arranged in the order of increasing abstractness as one proceeds from direct experience. Exhibits are nearer to the pinnacle of the cone not because they are more difficult than field trips but only because they provide a more abstract experience.

Figure 2.1 Edgar Dale’s Original Cone
Edgar Dale (1946) is credited for the original linkage between instructional theory and communications media. Unfortunately, he is inaccurately credited with conducting the research behind the bogus ‘data’ associated with his cone. In fact, Dale’s original model of the cone does not include any percentages, and is explicitly described by Dale as a visual aid about audio-visual materials. Dale did not intend to place value on one modality over another. The shape of the cone is not related to retention, but rather to the degree of abstraction.

Many researchers have attempted to rectify the defects of Dale’s Cone by modifying it by including the rate of retention. One such modification is presented below:

![Cone of Learning](image)

Figure 2.2 Cone of Learning
(Developed and revised by Bruce Hyland from material by Edgar Dale)
Experienced teachers recognise that the design of lessons must adapt to the expertise and prior knowledge of the learner, the complexity of the content, and interests of the learner. Experienced researchers recognise that the use of technology and multimedia, resources and lessons can vary in the level of interactivity, modality, sequencing, pacing, guidance, prompt, retention and alignment of student interest, all of which influence the efficiency in learning.

2.3 MULTIMEDIA LEARNING

In the last decade, with the rapid progression of computing capacities and the progress of graphic design technologies, multimedia learning environments have evolved from sequential static text and picture frames to increasing sophisticated visualizations. Multimedia learning environments are widely recognised to hold great potential for improving the way that people learn (Mayer, 1999). In such environments, learners are exposed to material in verbal as well as pictorial form.

2.3.1 Principles related to Multimedia and Modality

(i) Multimedia Principle: Retention is improved through words and pictures rather than through words alone.
(ii) **Spatial Contiguity Principle**: Students learn better when corresponding words and pictures are presented near each other rather than far from each other on the page or screen.

(iii) **Temporal Contiguity Principle**: Students learn better when corresponding words and pictures are presented simultaneously rather than successively.

(iv) **Coherence Principle**: Students learn better when extraneous words, pictures and sounds are excluded rather than included.

(v) **Modality Principle**: Students learn better from animation and narration than from animation and on-screen text.

(vi) **Redundancy Principle**: Students learn better when information is not represented in more than one modality - redundancy interferes with learning.

(vii) **Individual Difference Principle**

   a) Design effects are higher for low-knowledge learners than for high-knowledge learners.

   b) Design effects are higher for high-spatial learners rather than for low-spatial learners.

(viii) **Direct Manipulation Principle**: As the complexity of the material increase, the impact of direct manipulation of the learning materials on transfer also increases.
2.4 COMPUTER GRAPHICS

The term computer graphics includes almost everything on computers that is not text or sound. Today almost every computer can do some graphics, and people have even come to expect to control their computer through icons and pictures rather than just by typing. Computer graphics means the use of computer to produce and manipulate pictorial image on a video screen, as in animation techniques or the production of audiovisual aids.

2.4.1 Forms of Computer Graphics

(i) 2D Computer graphics: It is the computer-based generation of digital images mostly from two-dimensional models, and by techniques specific to them. 2D computer graphics are mainly used in applications that were originally developed upon traditional painting and drawing technologies, such as typography, cartography, technical drawing, advertising, etc. In those applications, the two dimensional image is not just a representation of a real-world object, but an independent artefact with added semantic value; two dimensional models are therefore preferred, because they give more direct control of the image than 3D computer graphics.

2D Graphic Techniques

2D graphic models may combine geometric models, digital images, text to be typeset, mathematical functions and equations, and more. These
components can be modified and manipulated by two-dimensional geometric transformations such as translation, rotation, and scaling. In object-oriented graphics, the image is described indirectly by an object endowed with a self-rendering method—a procedure which assigns colours to the image pixels by an arbitrary algorithm. Complex models can be built by combining simpler objects, in the paradigms of object-oriented programming.

**Direct Painting**

A convenient way to create a complex image is to start with a blank ‘canvas’ filled with some uniform background colour and then ‘draw’, ‘paint’ or ‘paste’ simple patches of colour onto it, in an appropriate order. In particular, the canvas may be the frame buffer for a computer display.

**Extended Colour Models**

Text, shapes and lines are rendered with a client-specified colour. Many libraries and cards provide colour gradients, which are handy for the generation of smoothly-varying backgrounds, shadow effects etc. The pixel colours can also be taken from a texture, e.g. a digital image. Painting a pixel with a given colour usually replaces its previous colour. However, many systems support painting with transparent and translucent colours, which only modify the previous pixel values. The two colours may also be combined in fancier ways. This technique is known as colour inversion, and is often used in graphical user interfaces for highlighting, rubber-band drawing, and other
volatile painting - since re-painting the same shapes with the same colour will restore the original pixel values.

Layers

The models used in 2D computer graphics usually do not provide for three-dimensional shapes, or three-dimensional optical phenomena such as lighting, shadows, reflection, refraction, etc. However, they usually can model multiple layers. The use of multiple layers make it possible to mimic traditional drafting and printing techniques based on film and paper, such as cutting and pasting; and allow the user to edit any layer without affecting the others. Layered models are also used to allow the user to suppress unwanted information when viewing or printing a document.

2D Graphics Hardware

Modern computer graphics card displays almost overwhelmingly use raster techniques, dividing the screen into a rectangular grid of pixels, due to the relatively low cost of raster-based video hardware compared with vector graphic hardware.

2D Graphic Software

Many graphical user interfaces, including Microsoft Windows, the X Window System or the Mac OS, are primarily based on 2D graphical concepts. Such software provides a visual environment for interacting with
the computer, and commonly includes some form of window manager to aid the user in conceptually distinguishing between different applications.

(ii) 3D Computer Graphics

These graphics use a three-dimensional representation of geometric data that is stored in the computer for the purpose of performing calculations and rendering 3D images. Such images may be for later display or for real-time viewing. Despite these differences, 3D computer graphics rely on many of the same algorithms as 2D computer vector graphics in the wire-frame model and 2D computer raster graphics in the final rendered display. In computer graphics software, the distinction between 2D and 3D is occasionally blurred; 2D applications may use 3D techniques to achieve effects such as lighting, and primarily 3D may use 2D rendering techniques.

3D computer graphics are often referred to as 3D models. A 3D model is the mathematical representation of any three-dimensional object – either inanimate or living. A model is not technically a graphic until it is visually displayed.

The process of creating 3D computer graphics can be sequentially divided into three basic phases:

a) **Modelling**: The model describes the process of forming the shape of an object. The two most common sources of 3D models are those originated on
the computer by an artist or engineer using some kind of 3D modelling tool, and those scanned into a computer from real-world objects.

b) **Layout and animation:** Before objects are rendered, they must be placed within a scene. This is what defines the spatial relationship between objects in a scene including location and size. Animation refers to the temporal description of an object, i.e., how it moves and deforms over time. Popular methods include key framing, inverse kinematics, and motion capture, though many of these techniques are used in conjunction with each other.

c) **Rendering:** Rendering converts a model into an image either by simulating light transport to get photorealistic images, or by applying some kind of style as in non-photorealistic rendering. The two basic operations in realistic rendering are transport and scattering, i.e., how much light gets from one place to another and how surfaces interact with light. This step is usually performed using 3D computer graphics software.

### 2.4.2 Types of Computer Graphics

Computer graphics can be categorised into two:

(i) Non-interactive Computer Graphics

(ii) Interactive Computer Graphics
(i) **Non-Interactive Computer Graphics**

In non-interactive computer graphics otherwise known as passive computer graphics, the observer has no control over the image.

(ii) **Interactive Computer Graphics**

It involves two-way communication between computer and user. Hence the observer is given some control over the image by providing him with an input device.

### 2.5 COMPUTER ANIMATION

Computer animation is a subset of both computer graphics and animation technologies. It is the creation of moving images (animation) using computer technology. It includes computer generated animation, where the animation is designed solely on the computer system using animation and 3D graphics software, and computer-assisted animation where traditional animations are computerised.

### 2.6 ROLE OF ANIMATION IN MULTIMEDIA LEARNING

One of the most exciting forms of pictorial presentation is animation. Animation refers to a simulated motion picture depicting movement of drawn or simulated objects. When used mainly as a form of entertainment, an animation can be called a cartoon, but here the focus is on the potential of animation as an educational tool. The consensus among media researchers is
that animation may or may not promote learning, depending on how it is being used.

Computers provide innovative and efficient means for teaching students. As a result, various forms of computer-based instruction and multimedia instruction provide a viable mode of teaching some content. One particularly promising capability provided is the ability to integrate animation as part of instruction. Authoring application programmes have made animation readily accessible to any educator who has the patience to learn how to use the application (Sturman, 1998).

2.7 ANIMATED AND STATIC VISUALS

To understand the nature of animation and its constructive use in computer-based instruction, designers must understand the relationship between animated visuals and static visuals. Animated visuals sometimes are considered as a subset of visual graphics in general; thus, to some extent, the theoretical basis for using animation is the same as the theoretical basis for using pictures and other static visuals (Rieber, 1990). This theoretical relationship has a basis in cognitive theory. Pavio’s (1986) dual coding theory, which argues that text and graphics are encoded in two different cognitive subsystems, seems to suggest that whether the graphics are static or animated is irrelevant. Thus, to some extent, theories of using graphics will apply to both animated and static graphics. In spite of some similarities
between animated and static visuals, animation has the capability of demonstrating movement and trajectory; static visuals do not (Rieber, 1994).

2.8 HISTORY OF ANIMATION

Early examples of attempts to capture the phenomenon of motion drawing can be found in Palaeolithic cave paintings, where animals are depicted with multiple legs in superimposed positions, clearly attempting to convey the perception of motion.

A 5,200 year old earthen bowl found in Iran in Shahr-i-Sokhta has five images of a goat painting along the sides. This has been claimed to be an example of early animation. However, since no equipment existed to show the images in motion, such a series of images cannot be called animation in a true sense of the word.

The phenakistoscope, praxinoscope as well as the common flip book were early popular animation devices invented during the 1800s, while a Chinese zoetrope-type device was invented already in 180 AD. Animation did not really develop much further until the advent of cinematography.

There is no single person who can be considered as the father of the art of film animation, as there were several people doing several projects which could be considered as various types of animation all around the world.
Georges Melies (1896) was a creator of special effect films; he was generally one of the first people to use animation with his technique. He discovered a technique by accident which was to stop the camera rolling to change something in the scene, and then continue rolling the film. This idea was later known as stop-motion animation. Melies discovered this technique accidentally when his camera broke down while shooting a bus driving by. When he had fixed the camera, a hearse happened to be passing by just as Melies restarted rolling the film, his end result was that he had managed to make a bus transform into a hearse. This was just one of the great contributions to animation in the early years.

Another French artist, Emile Cohl, began drawing cartoon strips and created a film in 1908 called Fantasmagorie. The film largely consisted of a stick figure moving about and encountering all manner of morphing objects, such as a wine bottle that transform into a flower. The film was created by drawing each frame on paper and then shooting each frame on to negative film, which gave the picture a blackboard look. This makes Fantasmagorie the first animated film created using what come to be known as traditional (hand-drawn) animation.

The production of animated short films, typically referred to as “cartoons”, became an industry of its own during the 1910s and cartoon shorts were produced to be shown in movie theaters. The most successful early
animation producer was John Randolph Bray, who, along with animator Earl Hurd, patented the cell animation process which dominated the animation industry for the rest of the decade.

Here are some key developments in the history of animation:

- In 1826, one of the first animation gadgets was the thaumatrope. It consisted of a disc with an image painted on each side: a bird and a cage. You would crank it using a string, and when you released the disc it would spin, and the bird would appear to be inside the cage.

- Later in 1874, Eadweard Muybridge was hired by a California governor to see whether or not a trotting horse ever had all four feet off the ground. The California governor needed the proof to settle a bet. Muybridge, with a series of photographs, proved that a trotting horse does indeed have all four hooves off the ground at a certain time. His photographic sequences were one of the origins of motion pictures.

- In 1913, ‘Felix the Cat’ was one of the first animated cartoons to hit the big screen, and by far one of the most popular of its time.

- Then in 1920s, Disney combined animation with sound; shortly after, ‘Mickey Mouse’ was born. His studio also created feature-length animations.

- Much later in 1974, computer animation was employed in “Hunger”, a short computer graphics (CG) movie.
In 1995, Pixar Animation Studios, in collaboration with Disney, created ‘Toy Story’, the first full-length computer graphics movie.

2.9 PRINCIPLES OF ANIMATION

The principles of animation can be summarized as:

- Squash and Stretch
- Anticipation
- Staging
- Pose to pose
- Follow Through
- Slow in and Slow out
- Arcs
- Secondary Action
- Timing
- Exaggeration
- Solid Drawing
- Appeal

2.10 THEORETICAL BACKGROUND OF ANIMATION

Animations tend to aid in high-level cognition situations such as problem solving, incidental learning, critical thinking, etc. rather than aiding students in low-level recall. Primary theoretical support for the use of
animations, as well as still illustration, and their effects on learning comes from the dual-coding theory (Pavio, 1990).

2.10.1 Dual-Coding Theory of Pavio

According to this theory, information is processed and represented by two separate codes known as verbal codes and non-verbal codes. The theory argues that humans understand the world around them through language and non-verbal objects and occurrences. Language is categorized as incoming and outgoing and shares a symbolic relationship to the non-verbal, which can be representative of such things as objects, events and behaviours. The non-verbal code includes all information that can be processed from the senses, which includes non-verbal sounds. These verbal and non-verbal codes can be encoded information from a human’s environment individually or simultaneously.

Verbal and non-verbal coding systems work as a sort of two-lane road in which information travels. As information travels along this roadway, many connections are developed during the process of cognition. As information is acquired, representational connections are made to verbal or non-verbal information received by the learner. The connections, exactly as their name implies, are representative schema that activate prior knowledge or experiences that the learner may have in relation to what is being learned. Associative connections are made within the verbal and non-verbal ‘lanes’
respectively, that is, actual words and an individual’s verbal representations of the words are developed and connected. Also, words that may be associated to one another tend to make connections well. Non-verbals are also connected associatively. Just as with words, smells may conjure visual memories or the sight of certain objects may cause flashbacks to scenes experienced by an individual. Put simply, associations are made, and words are related to other words and images to other images of the same or different sense perception mode. The third type of links are referential connections, which are connections that cross over ‘lanes’ in order to create links between the verbal and non-verbal information. These types of connections are championed by supporters of multimedia instruction for the argument that if information is coded verbally, as well as through another sense such as sight, the information is more likely to be remembered because one representation or reference can activate another.

A dual-coding model for processing animation and speech is given as figure 2.3
According to this theory, the computer is a system for delivering information to learners. The instructional designer’s role is to present information and the learner’s role is to receive the information. A straightforward theory is that learning involves adding information to one’s memory (Mayer, 1996). Adding pictures (such as animation) should have no effect on what is learned if the pictures contain the same information as the words. Thus according to the strict version of the information delivery theory, multimedia presentations should not result in better learning than single-medium presentations. However, if some learners prefer visual presentations
and others prefer verbal presentations, then a multimedia presentation would be effective in delivering information effectively to both kinds of learners. In this way, learners could select the delivery route they prefer. Thus according to a lenient version of the information delivery theory, multimedia presentations should result in better learning than single medium presentations.

### 2.10.3 Cognitive Theory of Multimedia Learning

An alternative idea is that meaningful learning occurs when students mentally construct coherent knowledge representations (Mayer, 1996). The cognitive theory of multimedia learning is based on three assumptions suggested by cognitive research:

(i) **Dual-channel assumption** – the idea that humans have separate channels for processing visual/pictorial representations and auditory/verbal representations (Pavio, 1990).

(ii) **Limited capacity assumption** – the idea that only a few pieces of information can be actively processed at any one time in each channel (Baddeley, 1998) and

(iii) **Active processing** - the idea that meaningful learning occurs when the learner engages in cognitive processes such as selecting relevant material, organising it into a coherent representation, and integrating it with existing knowledge (Mayer, 1996).
The following figure summarises the cognitive theory of multimedia learning:

![Cognitive Theory of Multimedia Learning Diagram]

**Figure 2.4 A cognitive theory of multimedia learning**

According to this theory, the cognitive process of integrating is most likely to occur when the learner has corresponding pictorial and verbal representations in working memory at the same time. Instructional conditions that promote these processes are most likely to result in meaningful learning. This theory predicts that multimedia presentations (such as narrated animation) are more likely to lead to meaningful learning than single-medium presentations.

### 2.11 TECHNIQUES OF ANIMATION

There are two main techniques in animation namely traditional animation and stop-motion.
2.11.1 Traditional Animation

Traditional animation also called cell animation or hand drawn animation was the process used for most animated films of the 20th century. The individual frames of a traditionally animated film are photographs of drawings, which are first drawn on paper. To create the illusion of movement, each drawing differs slightly from the one before it. The animator’s drawings are traced or photocopied onto transparent acetate sheets called cells, which are filled in with paints in assigned colours or tones on the side opposite the line drawings. The completed character cells are photographed one by one onto motion picture film against a painted background by a rostrum camera.

Types of traditional animation

a) Full animation

It refers to the process of producing high quality traditionally animated films, which regularly use detailed drawings and plausible movement.

b) Limited animation

It involves the use of less detailed and/or more stylized drawings and methods of movement.
c) Rotoscopying

It is a technique patented by Max Fleischer in 1917, where animators trace live action movement, frame by frame. The source film can be directly copied from actors’ outlines into animated drawings, used as a basis and inspiration for character animation or used in a stylized and expressive manner.

d) Live-action /animation

It is a technique of combining hand-drawn characters into live action shots.

e) Anime

It is a technique used in Japan but originated in USA. It usually consists of detailed characters but more of a stiff animation, mouth movements primarily use 2-3 frames, leg movement use about 6-10 etc. A lot of the time the eyes are very detailed, so sometimes instead of the animator drawing them over again in every frame, two eyes will be drawn in 5-6 angles and pasted on each frame.

2.11.2 Stop motion

Stop motion animation is used to describe animation created by physically manipulating real world objects and photographing them, one frame of film at a time, to create the illusion of movement.
Types of Stop Motion

a) Puppet animation

It typically involves stop-motion puppet figures interacting with each other in a constructed environment, in contrast to the real-world interaction in model animation. The puppets generally have an armature inside of them to keep them still and steady as well as constraining them to move at particular joints.

b) Puppetoon

It is created using techniques developed by George Pal. They are puppet-animated films which typically use a different version of a puppet for different frames, rather than simply manipulating one existing puppet.

c) Clay animation

It is often abbreviate as claymation, uses figures made of clay or a similar malleable material to create stop-motion animation. The figures may have an armature or wire frame inside of them, similar to the related puppet animation, that can be manipulated in order to pose the figures.

d) Cutout animation

It is a type of stop-motion animation produced by moving 2-dimensional pieces of material such as paper or cloth.
e) Silhouette animation

   It is a variant of cut out animation in which the characters are back lit and only visible as silhouette.

f) Model animation

   It refers to stop-motion animation created to interact with and exist as a part of a live-action world. Intercutting, matter effects, and split screens are often employed to blend stop-motion characters or objects with live actors and settings.

g) Go Motion

   It is a variant of model animation which uses various techniques to create motion blur between frames of film, which is not present in traditional stop-motion.

h) Object animation

   It refers to the use of regular inanimate objects in stop-motion animation, as opposed to specially created items.

i) Graphic animation

   It uses non-drawn flat visual graphic material (photographs, newspaper clippings, magazines etc.) which are sometimes manipulated frame-by-frame
to create movement. At other times, the graphics remain stationary, while the stop-motion camera is moved to create on-screen action.

j) Pixilation

It involves the use of live humans as stop motion characters. This allows for a number of surreal effects, including disappearances and reappearances, allowing people to appear to slide across the ground, and other such effects.

2.12 2D VERSUS 3D ANIMATION

A wide variety of techniques are used in the process of creating a complex computer animation. These techniques can be grouped into two main classes: two dimensional (2D) and three dimensional (3D). Although there is some overlap between the two classes, 2D techniques tend to focus on image manipulation while 3D techniques usually build virtual worlds in which characters and objects move and interact.

2.12.1 2D Animation

Two dimensional (2D) animation techniques contribute a great deal to computer animation by providing the tools used for sprite-based animation, blending or morphing between images, embedding graphical objects in video footage, or creating abstract patterns from mathematical equations.
The most common form of 2D animation is *sprite animation*. A Sprite is a bitmap image or a set of images that are composited over a background, producing the illusion of motion. They are usually small with respect to the size of the screen. Sprite-based animation can be done extremely quickly with current graphics hardware, and thus many elements of the scene can be moving simultaneously. The disadvantage of this technique is that the sprites come from a fixed library and subtle changes in lighting and depth cannot be reproduced. Consequently sprite animation is most often used in interactive media where rendering speed is more important than realism.

*Morphing* refers to animation where an image or model of one object is metamorphosed into another. Morphing is remarkable because it provides a startling yet convincing transformation of one image into another. Unfortunately, morphing is labour intensive because the key elements of each image must be specified by hand, although automatic feature detection is an area of active research.

*Embedding* graphical objects into an existing image allows new elements to be added to a scene. Objects can also be removed from a scene. Both these processes are made more difficult if the camera is moving because the alteration must be consistent with the changing viewpoint.

Mathematical equations are often used to create abstract motion sequences. When the values of the mathematical functions are mapped to
colour values and varied with time, the motion of the underlying structure can be quite beautiful.

Morphing and the generation of abstract images from mathematical equations can be generalised for use in 3D. All of these 2D techniques can be used either on their own to create an animation or as a post-processing step to enhance images generated using other techniques.

2.12.2 3D Animation

Three-dimensional animation involves constructing a virtual world in which characters and objects move and interact. The animator must model, animate and render the 3D scene. Briefly stated, modelling involves describing the elements of a scene and placing them appropriately. Animating specifies how the objects should move in the 3D world. Rendering converts the description of the objects and their motion into images. Modelling and rendering are for the most part, independent of their role in the animation process but a few necessary modifications are described below:

Modelling Requirements

To animate motion, the user needs both a static description of an object and information about how that object moves. One common way to specify this additional information is to use an articulated model. It is a collection of objects connected together by joints in a hierarchical, tree-like structure. The
location of an object is determined by the location of the objects above it in
the hierarchy. The object at the top of the hierarchy, or the root of the tree, can
be moved arbitrarily to control the position and orientation of the entire
model.

A second type of model used in animation is a particle system or
collection of points. The motion of the particles through space is determined
by a set of rules. The laws of physics often provide basis for the motion so
that the particles fall under gravity and collide with other objects in the
environment.

Deformable objects are a third type of model and include objects that
do not have well defined articulated joints but nevertheless have too much
structure to be easily represented with a particle system. Water, hair, clothing
and fish are among the systems that have been successfully modelled as
deformable objects.

While each of these model types can be used to describe a wide variety
of objects, complex systems often require hybrid models that combine two or
more types. This approach allows each part of the system to be modelled by
the most appropriate technique.
Rendering Requirements

Motion blur is a rendering technique that is required for animation but not for most still images. Animations usually display images at 24 or 30 frames per second, and thus a continuous motion is being sampled. This sampling process causes the rapid motion of an object to create unpleasant stroking effects, because high frequencies are masquerading as low frequencies.

Motion Generation

The animator must be able to specify subtle details of the motion to convey the personality of a character or the mood of an animation in a compelling fashion. A number of techniques have been developed for specifying motion, but all available tools require a trade off between automation and control. Key framing allows fine control but does little to automatically insure the naturalness of the results. Procedural methods and motion capture generate motion in a fairly automatic fashion but offer little control over fine details.

Key Framing

Key framing requires the animator to outline the motion by specifying key positions for the objects being animated. In a process known as in-betweening, the computer interpolates to determine the positions for the
intermediate frames. The remaining images would be filled in by the computer.

**Procedural Methods**

Current technology is not capable of generating motion automatically for arbitrary objects; nevertheless, algorithms for specific types of motion can be built. These techniques are called procedural methods because a computer follows the steps in an algorithm to generate the motion. Procedural methods have two main advantages over key framing techniques: they make it easy to generate a family of similar motions, and they can be used for systems that would be too complex to animate by hand, such as particle systems or flexible surfaces.

**Motion Capture**

Another technique for generating motion, motion capture, employs special sensors, called trackers, to record the motion of a human performer. The recorded data is then used to generate the motion for an animation. Alternatively, special puppets with joint angle sensors can be used in place of a human performer. Motion capture is a very popular technique because of the relative ease with which many human motions can be recorded.
2.13 FUNCTIONS OF ANIMATION

The functions of animation are listed below:

2.13.1 Cosmetic Function

Animation can have a purely cosmetic function when it is used to make instruction attractive to learners. Cosmetic applications of animation, however, do little to enhance learning. In fact, while cosmetics may have their place, they can distract learners from focusing on the main instructional points of a lesson. When the animation distracts from the learning task, learner misunderstand critical information.

2.13.2 Attention Gaining Function

Another important function of animations is their use to gain attention. It is particularly important to gain the attention of learners at the beginning of a lesson (Gagne, 1985). A second aspect of this function is to signal salient points such as switching topics. The movement created by the animation is useful for capturing the learner’s attention and focusing it on the salient points.

2.13.3 Motivation Function

Focusing on positive motivation through animation is particularly important. A dancing bear, unicycle riding clown or exploding fireworks used as feedback can motivate learners to strive for correct answers.
2.13.4 Presentation Function

The most direct application of animation is to use it as part of the presentation strategy. Since text illustrated with graphics is retained at a higher degree than text alone, one could argue that animation can improve retention of information due to the link between static and dynamic visuals. Animation also can supplement the text by providing examples of or elaborating upon a concept, procedure or rule.

2.13.5 Clarification Function

While closely related to the presentation function, the clarification function employs animation to provide a conceptual understanding without providing new information. That is, animation clarifies relationships through visual means. Animation can help to clarify abstract relationships that might otherwise be difficult to understand.

2.14 THE PHYSICAL NATURE OF ANIMATION- IMPLICATIONS FOR DESIGN

The nature of animation has clear implications for the effective use of animation in computer-based instruction. Research results do not allow us to provide denotative rules for applying animation based on its nature; however the following figure can heuristically guide practitioners in considering the nature of animation.
Figure 2.5 The nature of animation: Implications for design

Will the trajectory and movement inherent to animation enhance your Computer Based Instruction?

No

Animation may not be necessary to teach the content. What purpose would animation serve?

None

Consider a presentation that does not contain animation.

Yes

What is the inherent function of animation in your Computer Based Instruction?

None

Cosmetic

Attention getting

Motivating

Understand that animation is not serving a substantive role in your CBI. Consider using it sparingly or not at all.

Cosmetic

Attention getting

Motivating

Presentation

Clarification

Animation may not be necessary to adequately teach your content. The surface structure and fidelity level are important considerations, but the subject matter is a factor in determining these.
2.15 NATURE OF THE SUBJECT MATTER - IMPLICATIONS FOR DESIGN

If animation can be used in a presentation or clarification role, the subject matter must be classified. Classification occurs in one of three categories. The first category includes facts, principles, and attitudes. The second category includes concepts. The final category includes subject matter that can best be classified as procedural. It is a classification of subject matter in one of these latter two categories that might indicate a need for animation. The following figure can guide the practitioners in considering the nature of subject matter suitable for animation.
Based on Figure 2.5, is animation inherently tied to your subject in a substantive way (either in a presentation or clarification role)?

Figure 2.5 is sufficient information for deciding if animation is necessary in your CBI.

Yes

Be sure animation is presented concurrently with the text and that the text cues the learners toward the animation. What subject structure is the best classification for your text?

- Facts requiring memorization
- Principle/Rules requiring a simple explanation
- Attitudes or Interpersonal Skills

Concepts

Do the concepts involve:
- Systems impacted by simultaneous influences?
- Change over time? OR
- Systems not visible to the naked eye.

Yes

Animation will be useful in communicating the concepts. Realism and fidelity should be adjusted based on the learner’s need for detail.

No

Animation might not be useful in your CBI.

Procedures

Do the procedures involve equipment or contexts not readily available?

Yes

Animation might be useful in helping your audience understand the steps in the procedure. Realism and fidelity should be high so that learners have a simulated procedure.

No

Your CBI does not need animation to effectively teach the subject matter.
2.16 USES OF ANIMATION IN LEARNING

The main concern for instructional designers and educational practitioners can be summarized by the simple question: When and how should animation be used to improve learning? Three main uses of animation in learning situation can be distinguished.

2.16.1 Supporting the visualization and the mental representation process

Animation provides a visualisation of a dynamic phenomenon, when it is not easily observable in real space and time scales (e.g. circulatory system, or weather maps), when the real phenomenon is partially impossible to realise in a learning situation (too dangerous or too costly), or when it is not inherently visual (e.g. electrical circuit, or representation of forces).

2.16.2 Producing a cognitive conflict

Animation can be used to visualise phenomena that are not spontaneously conceived the way they are in the scientific domain. In this case an instructional scenario can provide several animations of the same phenomenon and ask the learner to pick up the correct situation.

2.16.3 Enabling learners to explore a phenomenon

Here, the learner actively explores the animation in order to understand and memorise the phenomenon. Here interactivity is a key factor.
The real challenge before educators today is to establish learning environments, teaching practices, curricula, and resources that leverage what the people now know about the limitations of human physiology and the capacity explained by the cognitive sciences to augment deep learning in students.