Chapter IV

Development of Courseware
CHAPTER IV

DEVELOPMENT OF COURSEWARE

4.1. Problem overview
4.2. Computers in higher education
4.3. Individualized instruction through multimedia based digital learning technology
4.4. Categories of multimedia layer
4.5. Role of multimedia web based computer courseware in colleges
4.6. Global structure of multimedia web based digital learning technology
4.7. System development approaches
   4.7.1. Software engineering
   4.7.2. Artificial neural network software
   4.7.3. Software engineering paradigms
4.8. Software engineering life cycle
4.9. Software specifications
   4.9.1. Minimum software requirements
4.10. Hardware specifications of the developing environment
   4.10.1. Minimum hardware requirements
   4.10.2. Hardware configuration of learning environment
   4.10.3. Networking environment
   4.10.4. Transmission of multimedia web based digital learning technology
4.11. Client server architecture in multimedia web based digital learning technology
4.12. Linking with other technologies
4.13. Language overview
4.14. Graphical user interface
4.15. Factors influencing visual basic
4.16. Graphical enhancements of visual basic
4.17. Event driven programming
   4.17.1. Trigger events
   4.17.2. Keyboard events
4.18. Properties in visual basic
4.19. User interface of visual basic
4.20. Forms in visual basic
4.21. Custom controls in visual basic
4.22. Overview of the software package
4.23. Adobe PhotoShop
4.24. Significance of adobe PhotoShop
4.25. Macromedia director
4.26. Macromedia Dream weaver
4.27. Windows advanced server
4.28. Active server pages
4.29. Client server model
4.30. Client side server side scripting technologies
4.31. Role of active server pages in multimedia web based digital learning technology
4.32. Logical view of multimedia web based digital learning technology
4.33. Requirement analysis
4.34. Logical design of multimedia web based digital learning technology
4.35. Content of the courseware
   4.35.1 Introduction to plant taxonomy
   4.35.2 Key to the identification of the families of angiosperms – Bentham and Hooker’s system
   4.35.3 Method of describing a flowering plant
   4.35.4 Botanical description of selected flowering plants
      4.35.4.1 Rutaceae
      4.35.4.2 Leguminosae
      4.35.4.3 Cucurbitaceae
      4.35.4.4 Compositae (Asteraceae)
      4.35.4.5 Rosaceae
      4.35.4.6 Solanaceae
      4.35.4.7 Scrophulariaceae
      4.35.4.8 Euphorbiaceae
      4.35.4.9 Orchidaceae
      4.35.4.10 Liliaceae
4.36. Physical design of multimedia web based digital learning technology courseware
4.37. System testing and software validation
   4.37.1. White box testing
   4.37.2. Black box testing
   4.37.3. Path testing
   4.37.4. Condition testing
   4.37.5. Data flow testing
   4.37.6. Loop testing
   4.37.7. Top down testing
   4.37.8. Bottom up testing
4.38. First level field testing
4.39. Second level field testing
4.40. Conclusion
CHAPTER IV

DEVELOPMENT OF COURSEWARE

4.1 PROBLEM OVERVIEW

The ultimate aim of this study is to achieve the goal of developing a Multimedia Based Digital Learning Technology courseware for B.Sc. Plant Biology and Plant Biotechnology learners in teaching 'Plant Taxonomy' and finding out its effectiveness. The overall process and procedures involved in the development of Multimedia Web Based digital learning technology courseware in teaching 'Plant Taxonomy' are presented.

The courseware was developed based on the B.Sc. Plant Biology and Plant Biotechnology 'Plant Taxonomy' syllabus of NGM College, an Autonomous College which is affiliated to Bharathiar University, Coimbatore, TamilNadu. The courseware was developed by the investigator of her own, along with the Taxonomical expertise obtained from the experts of Botanical Survey of India, and Expert Center for Taxonomical Identification (ETI), University of Amsterdam, Netherlands, who have a wide knowledge and identification know-how about the plants which are distributed geographically over the universe.

Plant Taxonomy was selected for the study, because most learners find very difficult in identifying the plants and in following the keys of identification. Some plants are not commonly available, and the learners may not have the opportunity to gain knowledge of the different plants distributed over a geographical location.
In the Information and Communication era, most of the Higher Education institutions have sufficient computers to cater to the needs of the learners. Computers are provided individually to the learners; these learners are really blessed to have an individual computer. But in most of the cases, the computers are not fully utilized by the learners. Computers were used only to teach the practical concepts included in the curriculum. The present study enables the learners learn theoretical concepts of a subject using Multimedia Web Based Digital Learning Technology. The provision of individual computers to learners and teachers in a classroom says something about what the teacher values; it symbolizes the teacher's interest in modern trends (Computers in society) and the teacher's capacity to cope with the modern advanced teaching technologies (computers in classroom).

Kinshuk Yang (2003) examines current limitations of Web-based learning systems (WBLS) in higher education and describes a prototype Web-based Asynchronous Synchronous Environment (WASE) that is designed to circumvent those limitations. Dickerson Cathy (2000) has suggested that every computer for student use should have software for multimedia production. All students should be using high quality Internet resources in core content learning. The Global College Network can help teachers become part of Internet based exchange projects. Teachers are key to integrating technology with classroom curricula. Gary Robert (1994) investigated the use of interactive multimedia language learning material within a classroom. The study demonstrated the significant role of a whole and cohesive learning environment in which the teacher, students, and computer interacted together so that the students could have independent and responsible learning in this environment. Viali (1998) provides a background of the development of hypermedia technology and describes a hypermedia system that could be used to teach probability and statistics.
through a web-based interface. Michael Grimley (1999) assessed the effectiveness of CD-ROM multimedia packages on science topics. The study ended in positive results.

According to Ellis (1974), students particularly in higher education and those studying science and technology also benefit from being able to use the computer as a computational tool. They learn a programming language and write program to solve some of their course work problems treating the computer as an aid in much the same way as a slide rule or a set of mathematical tables.

4.3 INDIVIDUALIZED INSTRUCTION THROUGH MULTIMEDIA BASED DIGITAL LEARNING TECHNOLOGY

The most existing innovation in the educational technology is Computer Assisted Instruction (CAI). The characteristic aspect of the CAI is its capacity to initiate flexible interactions with the learner, which is not possible in the teaching machine. A complete package of information stored in the system is presented sequentially. Computer use in colleges varies markedly, and computer based instruction is a generic term that has several different forms.

The computer serves primarily to reinforce concepts of drill and practice, already introduced in the classroom. In the early grades of schools, where this form predominates, an example would be the learning of spelling or arithmetic facts. Learning, the process of long division and providing practice in doing it, is an example from the later grades. The dialogue is a newer and more sophisticated method because the student and computer can interact or establish an intelligent conversation. The student can ask questions during the sequence of instruction, thus permitting enhanced and personalized learning. These several forms have been collectively called
Computer Assisted Instruction. The CAI starts by identifying the way student seems to have learnt best. Computer Assisted Instruction is therefore not merely a sophisticated type of programmed instruction, but a different kind of instruction and it also uses electronic data processing, data communication and concepts of audio-visual and media theory, communication theory, system theory and learning theory. This way the computer systems deliver instruction directly to students by allowing them to interact with lessons programmed into the system; this is specially referred to as Computer Assisted Instruction.

A multimedia system is characterized by computer controlled, integrated production, manipulation, presentation, storage and communication of independent information, which is encoded at least through a continuous (time dependent) and a discrete (time independent) medium. (Ralf Steinmetz, 2001)

The emergence of multimedia is similar to what happened when talkies replaced silent movies. Talkies were distinctly more lifelike and natural. Multimedia does the same for computing technology along with integration of sound, animation, graphics, still images, video, text and music. (Hofstetter, 1998).

Multimedia is defined as a tool of integrating the traditional media (text, image) and continuous media (video, audio) and to provide the possibility for a spectrum of new applications, with global communication, social and legal implications. (Schurmann, 2001).

Multimedia is an integrated system with different components, which intends to process different kinds of data, with different relations and to synchronize among the media. (Nierstra, 1999)
Multimedia is a technology of connections and binding different components partially and in isolation from each other. (Traw and Smith, 1993)

Multimedia delivers information in a variety of ways but achieves greatest effectiveness through interaction. In the first case, packing, music and informative knowledge combine to convey the message. In the second case, technology provides a more effective presentation for less expensive; information, images and sounds are technically and aesthetically integrated and then focused on the single specific purpose. In short, multimedia systems, which are computer based tools for generating and displaying textual graphics and pictorial material, have diverse potential roles within education. In brief, the term 'multimedia' describes the use of different media and technologies to present information. There are very many ways to utilize and represent the information from the pool of instructional resources; Multimedia threads an efficient way in presenting information for a courseware unit.

Another valuable tool in multimedia is Animation; a sequence of still images introduces a new dimension, time for generating, a sequence of frames to give the impression of motion. The frames consist of graphical images. Some examples are films made by photographic drawing, puppets etc., with only a slight difference in the contents of individual frames. When these are projected on to a screen in a sequence, the impression of movement is produced.

In the case of computer animation, one can take the analogy of a computer art supply store to a programmer's library consisting of graphic symbols. The graphic symbols can be taken as generic components to create specialized components, characters, scenery, cartoons, trees, logos, etc.; These require the use of suitable data structures together with
interactive structures and the concept of 2-dimensional and 3-dimensional graphics. Computer animation and art are two applications of graphics, which require not only technical expertise but also artistic talents.

4.4. CATEGORIES OF MULTIMEDIA LAYER

Based on the applications, multimedia can be divided into three categories; they are Fun material, Powerful material and Creative material. The fun material is obvious—games, incredible animation sequences and realistic sounds. The second category, powerful material is a well designed software that enables computers to do things. It ranges from intelligent software like Multimedia Beethoven, Encyclopedia on CD-ROM, reference work, literature and even magazines with audio and video. The creative material includes software that enables the users create their own multimedia programs, presentations and tools.

The various properties of Multimedia are presented as different layers, which can be overlapped or sequenced based on the users’ interest and application significance. Some of the layers which are commonly identified are sound, images, platforms, and overlapping aspects.

Basically there are two types of sound files that can be handled in multimedia. They are Waveform sound files and Non-waveform sound files. Sound is energy that is transferred in the form of waves. These waves are big, small, long and short. Each kind of wave causes a different sound. A waveform file with extension simply stores a digital representation of sound waves. These files may not be directly interfaced with any of the musical instruments or playback devices. Non-waveform sound files, also called the MIDI (Musical Instrument Digital Interface) files, store instructions regarding musical notes and their duration instead of waveform data. A MIDI file with
extension is generally used to store musical information in the form of musical notes only.

Digital images have become an important part of multimedia due to the availability of sophisticated image related hardware and software. There are three basic steps involved in using images on a computer; they are Acquiring an image, Modifying the image and Incorporating the image into a document, presentation, or program. The wide term used to acquire an image, modify an image and to present an image is termed as morphing, which is most commonly applied in commercial films and advertisements, which use multimedia technology. Morphing is a concept, which invokes the technique of virtual reality into images.

The use of sound, images and full motion video in an interactive multimedia application requires the conversion of analog signals into digital form for manipulating and processing in a computer. In order to achieve this, the hardware must provide minimum processing speed, internal memory capacity and disk storage volume. Multimedia platform standards include the following: Digital Video Interactive Technology (DVI), Multimedia PC and Multimedia software package. Intel’s DVI or Digital Video Interactive Technology is a multimedia platform consisting of add-on boards and software for IBM machines. The key to DVI technology converts analog video signals into digital form. Audio can be captured and presented with the video. Still images can be captured and stored in the form of true color images. DVI technology can be implemented to achieve interactive Multimedia Web Based applications. The multimedia PC will be accompanied with the minimum hardware configuration required to interface between the various multimedia devices, along with the required device drivers. Multimedia software packages are available in customized and tailor made packages. Some of the multimedia packages available are Macromedia Authorware, Dreamweaver, Fireworks, Macromedia Director,
Quest, Adobe PhotoShop, Quick time, Ultimate knockout, Cameraman, Quake, Flash, 3D MAX and Multimedia Tool Book.

From the applications and technology viewpoints of multimedia systems, the ongoing migration process and the evolution of the different industrial branches, drastically increases and widens in all dimensions. Multimedia has found new migrations into telecommunications, consumer electronics, recording studios, TV producers and many publishing houses. Telephone networks have changed gradually from digital networks into multimedia digital image networks. The consumer products like CD player have advanced technologically into high end Multimedia Web Based DVD players. TV producers have started producing movies and advertisements based on digital graphics and digital imaging which are other forms of multimedia. Publishing houses have introduced multimedia publishing to enhance rich graphics into their publishing materials; earlier these houses used DTP software.

From the technical perspective, besides handling the huge amount of data, the timing requirement among all components of the data computation is the major challenge. Another challenge is the integration requirement of different types of media in multimedia application.

4.5 ROLE OF MULTIMEDIA WEB BASED COMPUTER COURSEWARE IN COLLEGES.

The advanced level course modules and training packages are used for higher education. These course modules help students understand from the basics of computing, and have a strong emphasis on development of skills. This includes mouse operations, key strokes, navigating screens, computer art skills, internet basics, computer network architecture, operating system concepts and multimedia environments. Most science softwares
have been designed to try and remedy the difficulties which teachers perceived pupils to have in learning, and which they themselves, had in teaching. Teaching of language through multimedia is really fun to watch, which includes teaching of alphabets, first words, phonics, handwriting, making words, use of dictionary, cross word, word picture matching, and rhymes, which are packed with graphics technique, sound and animation. Similarly, learners who learn concepts through Multimedia Web Based Digital Learning Technology develop skills in key strokes, general applications like MS – Office, database and spread sheets, multimedia authoring, computer environments, programming and the internet.

With the help of multimedia system, learning science education is also made easy with lots of fun. It just takes on few clicks on the mouse and the learners are made thorough with the technical aspects of the subject. The college students have a lot more to access and learn from animated software based on science. Similarly, the physics students can easily come to terms with difficult laws of electricity, force or energy, besides so many other concepts. They can design their circuits on a computer and learn whether it will actually work or not. Students of chemistry can complete their experiment on a computer without worrying about it going awry. Computer simulations can be used in science teaching where an experiment is dangerous, costly or expensive or takes too much time to perform in the laboratory; computers can evaluate with speed and accuracy complicated mathematical expressions through analytical or numerical methods, allowing learners to explore scientific relationships and theories with their own parameter values relevant to their own experience.

It is felt that the application of Multimedia Web Based Digital Learning Technology may create a congenial learning climate in colleges and brings real life situations. It may create interest and motivation among the learners. This inspired the researcher to come out with courseware, which supports
FIG 4.1 GLOBAL STRUCTURE OF MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY
individualized instruction through Multimedia Web Based Digital Learning Technology. The bases for preference for different courseware are the learning environments and the technical constraints associated with each specific instructional technology. The investigator developed the Multimedia Web Based Digital Learning Technology courseware which is compatible for platforms including Windows, Macintosh, and Linux using the GUI Software Visual Basic 6.0 and utilized the software packages Adobe PhotoShop, Macromedia Authorware, Dream weaver, Flash MX, HTML, and Active Server Pages.

4.6 GLOBAL STRUCTURE OF MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY

In Fig 4.1, the global view of the Multimedia Web Based Digital Learning Technology is presented after much iteration in the form of a block diagram. It shows schematically the main fields of multimedia systems. The figure expresses the interactions among the components through spatial proximity. The tools and applications form the Application Domain, the operating systems, database Systems and the communications form the System Domain, and the data compression techniques, data storage, data mining, and distributed data communications form the Device Domain. These Domain interfaces with each other, using a Cross Domain Synchronization Platform.

4.7 SYSTEM DEVELOPMENT APPROACHES

The system environment envisages the hardware and software required for the development of courseware material and its operations. It also defines the inter connectivity of the web server and the user. Further, the various tools used in the design activities of the Multimedia Web Based Digital Learning Technology are also explained. The Software Engineering
paradigms, the Software Engineering Tools, Software Engineering Procedures, Software Engineering lifecycle, System modeling, Data flow models, Transform Analysis, Software development, Integrated CASE (Computer Assisted Software Engineering), Platform Integration, Data Integration, Software Metrics, Software Testing, and Software performance of Multimedia Web Based Digital Learning Technology are clearly furnished below:

4.7.1 Software Engineering

Software can be described as (i) instructions (Computer Programs) that when executed provide desired function and performance (ii) data structures that enable the program to adequately manipulate information and (iii) documents that describe the operation and use of the programs. Software is a logical system element which has to be developed or engineered in the classical sense. Software is custom-built rather than being assembled from existing components. The process of creating software components through a series of translations that map user requirements to machine executable code is often termed as Software Engineering. Software Engineering is also defined as a disciplined approach for software development.

Software Engineering is the outgrowth of hardware and system engineering. It encompasses a set of three key elements – Software Engineering methods, Software Engineering tools, and Software Engineering procedures.

Software Engineering Methods provide the technical know-how for building software. Methods encompass a broad array of tasks that include project planning and estimation, system and software requirements analysis, design of data structure, program architecture and algorithm procedure, coding, testing and maintenance. Methods for Software Engineering often
introduce a special language-oriented or graphical notation and introduce a set of criteria for software quality.

Software Engineering Tools provide automated or semi automated support for methods. Today, tools exist to support each of the methods noted above. Tools are integrated, so that, information created by one tool can be used by another; a system for the support of software development, called Computer-Assisted Software Engineering (CASE) is established. CASE combines software, hardware and a Software Engineering database to create a Software Engineering environment that is analogous to Computer Aided Design / Computer Aided Engineering (CAD/CAE).

Software Engineering procedures hold the methods and the tools together and they enable rational and timely development of computer software. Procedures define the sequence in which methods will be applied, the deliverables that are required, the controls that help ensure quality and coordinate change and the milestone that enables software managers to assess progress.

The software components are the elements that constitute to form a full fledged workable software module. The Software components include the following: Generic category of the process, software design, language, software tools, information structure, software data structure, procedural attributes, related requirements, translator that converts instructions into machine code, reusability, and procedural details of the software (manual).

Reusability is an important characteristic of high quality software, that is, the component should be designed and implemented so that it can be reused in many different programs. A reusable component encapsulates both data and processing in a single package, called as class or object,
enabling the software engineer to create new applications from reusable parts.

4.7.2 Artificial Neural Network Software

The software used in the design of Multimedia Web Based Digital Learning Technology is the Artificial neural Network which is a hybrid model of embedded neural network applications and Artificial Intelligence Applications which are the generic categories of software applications. The Embedded Software resides in the read only memory (ROM) and it is used to control products and systems for the user’s instant access. Embedded Software can perform significant function and control capabilities, which guides and controls the Multimedia Web Based Digital Learning Technology system users. The Artificial Intelligence software makes use of an expert system, knowledge-based system, inference engine and the knowledge domain.

4.7.3 Software Engineering Paradigms

Software Engineering is comprised of a set of steps that encompasses methods, tools and procedures. These steps are often referred to as Software Engineering paradigms. A paradigm for Software Engineering is chosen based on the nature of the project and application, the methods and tools used and the controls and deliverables that are required. The Software Engineering paradigms have improved the software quality, and the software hardware compatibility, introducing comprehensive methods for all phases in software development, introduction of better tools for automation, better techniques for software quality assurance and an overriding philosophy for coordination, control and management of the developed Multimedia Web Based Digital Learning Technology software. The problems involved in the Multimedia Web Based Digital Learning Technology software development
were recognized and the software myths were observed and proper measures were introduced to achieve toward solutions.

4.8 SOFTWARE ENGINEERING LIFE CYCLE

This life cycle paradigm for Software Engineering is also called as "waterfall model", which demands a systematic, sequential approach to software development that begins at the system level and progresses through analysis, design, coding, testing and maintenance. Modeled after the conventional engineering cycle, the life cycle paradigm encompasses the following activities: System engineering and analysis, System requirements analysis, System design, System coding, System testing, and System maintenance.

System engineering and analysis encompasses requirements gathering at the system level with a small amount of top level design and analysis. The requirement gathering process is focused specifically on software. The Software Engineer must render the information domain for the software. Requirements both the system and the software are documented and reviewed with the customer. Software design is actually a multistep process that focuses four distinct attributes of the program. That is, data structure, software architecture, procedural detail and interface characterization. The design process translates requirements into a representation of the software that can be assessed for quality before coding begins. Like requirements, the design is documented and becomes part of the software configuration. The design must be translated into a machine-readable form. The coding step performs this task. If design is performed in a detailed manner, coding can be accomplished mechanistically. Once code has been generated, program testing begins. The testing process focuses on the logical internals of the software ensuring that all statements have been tested and on the functional externals, conducting tests to uncover all errors
and ensure that defined input will produce actual results that agree with required results. Software will undergo changes, because user requires functional or performance enhancements. Software must be adapted to accommodate changes in its external environment. Software maintenance reapplies each of the preceding life cycle steps to an existing program rather than a new code.

4.9 SOFTWARE SPECIFICATIONS

Function and performance of a system are allocated to software during system engineering. Function is the implementation of a sequential procedure for data manipulation; it is the internal coordination and control of other concurrent programs. Performance is defined explicitly in terms of response and wait times. The software specifications of Multimedia Web Based Digital Learning Technology are furnished below:

Visual Basic 6.0, the Graphical User Interface is used for the development of the front end of the Multimedia Web Based Digital Learning Technology. The front end of the software is normally interfaced with the user; it caters to the needs of the user from the resources available in the back end of the system. The backend of the system contains a database server.

Microsoft Access of the Microsoft Office XP product is used for the development of the database server. The database server serves as the back end of the Multimedia Web Based Digital Learning Technology system. Web Client is used in Multimedia Web Based Digital Learning Technology to interact with web server via ASP and to display HTML from web server, It is also used to run Java script. It can be also considered to be a web browser.

Web Server is designed and installed to provide the web content on the Internet. It communicates with web clients through HTTP and FTP. It can
handle CGI, GUI and other interfaces. It also serves the proxy request to application server.

The other software packages used in the design phase of the Multimedia Web Based Digital Learning Technology are Macromedia Authorware, Flash MX, Java Script and Dream weaver.

4.9.1 Minimum Software Requirements

The Multimedia Web Based Digital Learning Technology, which is designed in the Windows platform, is compatible with all the windows family operating systems like Windows 95, Windows 98, Windows 2000, Windows NT and Windows XP. No add on software is required since everything is built in the courseware.

4.10 HARDWARE SPECIFICATIONS OF THE DEVELOPING ENVIRONMENT

The Hardware Configuration used to design the Multimedia Web Based Digital Learning Technology is given below:

<table>
<thead>
<tr>
<th>PROCESSOR</th>
<th>PENTIUM IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED</td>
<td>1.2 GHz</td>
</tr>
<tr>
<td>RAM</td>
<td>256 MB</td>
</tr>
<tr>
<td>HARD DISK DRIVE</td>
<td>120 GB</td>
</tr>
<tr>
<td>FLOPPY DISK DRIVE</td>
<td>1 X 1.44 MB</td>
</tr>
<tr>
<td>OPERATING SYSTEM</td>
<td>WINDOWS 2000</td>
</tr>
<tr>
<td>VISUAL DISPLAY UNIT</td>
<td>SVGA COLOR</td>
</tr>
<tr>
<td>KEYBOARD</td>
<td>110 KEYS</td>
</tr>
<tr>
<td>MOUSE</td>
<td>3 KEY MULTI SCROLL</td>
</tr>
<tr>
<td>PRINTER</td>
<td>HP LASER JET</td>
</tr>
<tr>
<td>CD ROM</td>
<td>CD RW 48 – 32 – 48 X</td>
</tr>
</tbody>
</table>
VOICE : SOUND BLASTER CARD
SOUND : 5.1 MULTIMEDIA STEREO SPEAKERS
GRAPHICS : ACTIVE MOVIE CONTROL CARD
COLOR : 64 BIT COLOR CARD
RESOLUTION : 640 x 480
INTEGRATOR : MULTIMEDIA KIT

4.10.1 Minimum hardware requirements

The Minimum hardware requirements to install the Multimedia Web Based Digital Learning Technology on a stand-alone computer are furnished below:

- Pentium III and above series of Processor
- Processor speed 733 MHz and above
- 620 MB hard disk free space to install the software
- 1.1 GB hard disk free space as swap area
- CD ROM drive 24X and above
- 64 MB RAM
- SVGA color VDU
- Multimedia kit
- Sound blaster card
- Windows based Operating System

4.10.2 Hardware Configuration of Learning environment

The Multimedia Web Based Digital Learning Technology was installed in a dedicated active sub-work station under the main Server of the NGM College Computer center, which is a high end configured system, which has three work stations, namely LINUX work station, WINDOWS NT work station, INTERNET work station. 288 client systems are connected to the server through the central switch known as the “HUB”. The network topology of this client server system is “SNOW FLAKE – COMPLEXED STAR” network. This
type of network is versatile and permits every client to access any of the workstations, including the online internet connections.

This network also permits host network connections through telecommunication media, Radio Frequency (RF) mode or satellite links. The 288 clients are clustered into 7 clusters, each cluster having 40 clients and one client supervisor.

This architecture of client server clustering is a tailor made network to monitor the students at the client machines by the teachers who will be at the client supervisor machines. The learners of Multimedia Web Based Digital Learning Technology were at the client machines and the investigator has monitored the learning process of the learners from the client supervisor machine. The Intranet tool provided in the network was utilized to communicate between the clients, client supervisor, workstations and server.

4.10.3 Networking environment

The network category which was used in the learning process of Multimedia Web Based Digital Learning Technology courseware for teaching Plant Taxonomy is Local Area Networking (LAN) which is supposed to be the most efficient type of the networking available in the global market. The main advantages of this network are stated below:

- The area covered between the systems is up to 10 kilometers
- The data transmission speed on the network is 1-100 Mbits/s
- Open system connectivity, which has high potential to communicate with any device
- Relatively inexpensive
- Resource sharing
- Low error rates
- Multi-user systems environment
4.10.4 Transmission of Multimedia Web Based Digital Learning Technology

In Local Area Network, the speed of the network depends on the transmission channels that are engaged physically. The type of transmission used in Multimedia Web Based Digital Learning Technology to interact with its client is Baseband Transmission, which means that the original signal is transmitted in the LAN media without modulation, i.e., the original frequency of the digital signaling is used. The baseband transmission has a self-clocking synchronization mechanism, which does not depend on other devices, for data encoding. The data encoding system used in Multimedia Web Based Digital Learning Technology is “Manchester encoding”.

4.11 CLIENT SERVER ARCHITECTURE IN MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY

The ultimate aim of any computer network is to share the resources among the server and its clients. The goal of the network is achieved only when the architecture of the client server model is versatile. The Client Server Architecture components are in built within the networking environment in which the Multimedia Web Based Digital Learning Technology is developed. This facilitates the extension of Client Server Architecture into Multimedia Web Based Digital Learning Technology. In Client Server Architecture, the client computers communicate with the server through the work stations in the network. The network plays a major role in determining the performance of a client/server system because it controls how fast the
client requests are carried to the server and how fast results are brought back to the client. In developing the Multimedia Web Based Digital Learning Technology, the investigator has segregated the process between the client and the server in order to minimize network traffic. This system can also support the increased traffic due to the optimal congestion of the network. The client server system increases its users' productivity by providing them with the tools to complete their tasks faster and more easily.

4.12 LINKING WITH OTHER TECHNOLOGIES

The Multimedia Web Based Digital Learning Technology, which is developed by the investigator, complies with the standards of ISO Protocols, IEEE specifications, Gartner Group and Client Server Architecture. Thus the developed system can be automatically integrated with other technologies such as e-mail, document imaging, and groupware to lead to additional productivity gains. When integrated with other technologies, a great deal of manual labor is eliminated and enables processes to be completed with fewer errors.

4.13 LANGUAGE OVERVIEW

Computational process is nothing more than a set of steps, which a machine can perform for solving a task. To describe the solution of a problem to a computer, one needs to know a set of commands that the computer can understand and execute. A programming language is a systematic notation by which one describes computational processes to others. The capabilities constitute the machine language of the computer. But because this language is so far away from the way people think and want to describe solutions to problems, so-called high-level programming languages have been conceived. These languages use less primitive notations than machine language and hence, they require a program which will interpret
their meaning to the computer. This program is not generally a part of the computer's circuitry, but is provided as part of the system software, which is included with the computer.

4.14 GRAPHICAL USER INTERFACE

In a GUI environment, the number of options open to the user is much greater, allowing more freedom to the user and developer. Features such as easier comprehension, user-friendliness, faster application development and many other aspects such as introduction to ActiveX technology and Internet features make Visual Basic an interesting tool to work with. Visual Basic 6.0 is specifically designed to utilize the Internet. It comes with several controls that allow one to create web-based applications called ActiveX executable codes. These codes work just like stand-alone Visual Basic applications, but they are accessed through Microsoft Internet Explorer 4.0 Web browser. Visual Basic is an ideal programming language for developing sophisticated professional applications for Microsoft windows. Visual Basic makes use of Graphical User Interface in which one can visually design the forms and controls that become the building blocks of programmer's applications. Visual Basic supports many useful tools that will help the programmers to be more productive.

Graphical user interface facilitates the user to create GUI packages with less coding and enhanced visual properties. The location and appearance of the interface elements can also be defined with the properties of GUI. Apart from user interface, GUI also facilitates to interface applications and components from other graphical software packages, which is really a gift for the graphical designers. ActiveX style of applications can revise the existing Visual Basic applications and distribute them through the Internet. New to Visual Basic 6.0 are the ISAPI Application and Dynamic
HTML project templates. These templates provide a framework to develop server-side components as well as ‘smart’ web pages and applications.

The visual property of graphical user interface is a principal component of Multimedia System, which was extremely used by the investigator in developing the Multimedia Web Based Digital Learning Technology system. Visual Basic was evolved from the original BASIC language and now contains several hundreds of functions and key words, many of which relate directly to the Windows GUI. The power of Visual Basic allows professionals to accomplish anything that can be accomplished by using other windows programming languages. Visual Basic was developed in the early 1980’s. Visual Basic 6.0 requires at least Microsoft Windows 95 or Windows NT 3.5, with a Pentium processor and a minimum of 64 MB RAM. A complete installation of the most powerful version of Visual Basic 6.0 Enterprise Edition requires more than 540 MB of hard disk space. The Application Edition of Visual Basic programming system is included in Microsoft Excel, Microsoft Access, and many other windows applications. The Visual Basic Scripting Edition (VB Script) is a widely used scripting language and a sub-set of the Visual Basic language. Visual Basic is also capable of creating applications for work group, larger enterprise-wide system, distributed environment and so on, to span the globe through the internet.

4.15 FACTORS INFLUENCING VISUAL BASIC 6.0

The following reasons are attributed for the selection of Visual Basic 6.0 for the development of Multimedia Web Based Digital Learning Technology courseware:

1. Graphical user interface and its visual enhancements are easy to use and easy to implement.

2. Auto coding helps the users in generating code to display the required component.
3. The visual programming environment enables the programmer to pickup the required component from the lists of available components.
4. The visual programming components can be modified at any point of time, during execution of the project.
5. Any number of controls can be accommodated in a form.
6. Visual programming environment enables the programmer create visual interface, such as aligning, moving and resizing the components without have to rewrite the code.
7. The visual interface components provided within the project can be integrated to form new components.

4.16 GRAPHICAL ENHANCEMENTS OF VISUAL BASIC

Visual Basic enables to take full advantage of graphical environments and operating systems, with the following features:

1. Ability to show and hide any number of items at run time.
2. Communication with other Windows and presentation manager applications through Dynamic Data Exchange (DDE), and extensibility via dynamic-link libraries. A user can also call dynamic-link libraries including Windows functions within Visual Basic code.
3. Direct access to the environment clipboard and to the printer.
4. Full sets of the objects need to create Windows applications including command buttons, check boxes, list boxes, scroll bars, frames and menu bars.
5. Graphics statements can be attached to it.
6. Highly flexible mouse and keyboard events at run time, including automated drag-and-drop support.
7. It has got a powerful math and string-handling library.
8. Multiple Windows in an application.
9. Random access and sequential file access are supported by Visual Basic.
10. Sophisticated run time error handling is available.
11. Supports dynamic arrays also.
12. Supports easy-to-use string variables.

Visual Basic makes development easier by providing powerful debugging commands that help to isolate and correct errors in the code. Visual Basic operates as an interpreter instantly translating the statement into ‘executable’ form as soon as it is being typed in, but once completed, it is easy to convert the application into an executable file that is relatively small and fast and can run outside the Visual Basic environment.

Windows is a graphical user interface, hence it is important to have a way to display graphical images in one’s application interface. Visual Basic includes four controls that make it easy to work with graphics; the picture box control, the image control, the shape control and the line control. The image, shape and line controls are sometimes referred to as ‘light weight’ graphical controls. They require less system resources and consequently display somewhat faster than the picture box control; they contain a subset of the properties, methods and events available in the picture box. Each is best suited for a picture box.

**4.17 EVENT DRIVEN PROGRAMMING**

Events are various things that can happen in a Visual Basic program. This will become clearer when studied in contrast to procedural programming. Visual Basic programs are built around events. In procedural languages, an application written is executed by checking for the program logically through the program statements, one after another. For a temporary phase, the control may be transferred to some other point in a program. While in an event driven application, the program statements are executed
only when a particular event calls a specific part of the code that is assigned
to the event.

Events determine the control’s reactions to external conditions. Controls recognize events. A command button will recognize that it is clicked, but it does not react to the event unless a code is provided. In other words, one must tell Visual Basic what to do when the user clicks the specific command button. Once a subroutine for the control’s click event is specified, this subroutine executes each time the control is clicked. The subroutine that determines how a control reacts to an even is called an event handler.

The combination of the control’s name and the event’s name is unique and is the name of the event handler. Each time an event takes place, Visual Basic looks for the subroutine made up of the bane of the control on which the event takes place and the name of the event. If such a handler exists, it is executed. If not, one’s application would not react to the event. The two most common groups of events are mouse events and keyboard events.

4.17.1 Trigger events

The events are triggered by mouse actions that are the most common events in programming with Visual Basic. Most of the elements of the user interface can be manipulated with the mouse, and programming mouse event is the main job of a Visual Basic programmer. However, many users prefer the keyboard event for operations that are simpler to carry out with the mouse.

4.17.2 Key Board Events

Keyboard events are generated by keystrokes. One must program the keyboard events for the controls that can accept text. In addition, the user should provide code for the keyboard events of controls that can be
manipulated with both the mouse and the keyboard, because many users prefer to work with the keyboard most of the time.

4.18 PROPERTIES IN VISUAL BASIC

Properties can be thought of as an object's attributes methods, its actions and events as its responses. A property is a characteristic of an object. For each type of object, Visual Basic predefines a set of properties that apply to the project. Some of the commonly used properties of Visual Basic are: Name, Appearance, Back color, Fore color, Font and Text. Each property has a name and a setting. The setting is the value of the property; for instance, the setting of the background color could be white. The user can change the setting of most properties while building an application and with code when the application runs. Each object, either a form or control in Visual Basic has a predefined set of properties. These properties determine the object's appearance and behavior. When an object is created, its properties are set to initial values, called default settings. There is no need to set the value of every property of an object unless the user intends to vary from the default options.

Normally, properties are set when an object is created. Most control properties are set when the object is created or placed on the form, but the user can change a property later by assigning a new value to it. The user can change a property at design time through the properties window or at run time through the code. Visual Basic assigns default properties to every new control the user places on a form. The default name property, for example is the name of the control, followed by a number of commands (command1, command2 and so on). The background color of most controls is either gray or white. The user can examine the property values of a newly created control in the properties window.
4.19 USER INTERFACE OF VISUAL BASIC

Visual Basic 6.0 offers an excellent mechanism for user interface. The user interface appears in the application’s window when it runs. It consists of various elements with which the user can interact and control the application. The main elements of the user interface are the Forms and Controls. The Form is one of the most basic objects in which the application is developed and the controls are the building blocks on the user application. The main controls normally used by application developers are Pointer, Picture Box Control, Text Box Control, Frames, Labels, Buttons, Lines and Shapes, Scroll Bars, etc.

4.20 FORMS IN VISUAL BASIC 6.0

In Visual Basic, the form object is the foundation of any application that presents an interface. Visual Basic has several different types of objects. The ‘Form’ is one of the most basic objects in which the application is developed. A form is a window that contains application code and has other objects placed on it to create the user interface. The form is a canvas on which a programmer paints his application. This is the main control that will allow the programmer to place controls on top of it to create a window, called an interface that the user can see on the screen. Forms are objects that expose properties, which define their appearance, methods, their behavior, and events, their interaction with the user. It is very important to know that most Visual Basic applications are based on a form. In many cases, there will be more than one form and Visual Basic lets one display and hide forms while the application is running. A form may fill the entire screen or have other forms contained within it, or it may be a custom dialog box. Visual Basic initially includes a default form in each new project. The programmer can change the form’s name and caption to identify the purpose of the form.
Every form is a window and has its own properties, events and methods associated with it.

4.21 CUSTOM CONTROLS IN VISUAL BASIC 6.0

Controls are the building blocks on the user application. They give the user an enhanced functionality and personality that is required to interact with his application. Controls are objects that are contained within form objects. Each type of control has its own set of properties, methods and events that make it suitable for a particular purpose. Some of the controls that are used are best suited for entering or displaying text. Almost every application the programmer develops will have a form on it, and on these forms will be controls.

Custom Control is a significant feature of Visual Basic 6.0, which enables the user to customize an application. Custom controls are the building blocks of a Visual Basic application. Controls allow a form to do more than just sit empty on a screen. Some controls, such as labels or list boxes, give user feedback, while others, like commanding buttons and text boxes, eliciting responses. Other controls sit quietly, invisible to the user, and perform some of the grant works that make the user's application useful. The timer control is one example of an invisible control. Controls are easy to use and, when used properly, can add significant functionality to the programs.

4.22 OVERVIEW OF THE SOFTWARE PACKAGE

The developed software package contains huge volume of Digital Images, to enable the learners understand the concepts in a simple and practical way. Multiple screens needed for the study were designed with the help of the package Adobe PhotoShop. Adobe PhotoShop played a significant role in editing the Digital Images, which were collected from a variety of sources. In the same way, the pictures needed for the Multimedia Web Based Digital Learning Technology courseware for teaching Plant Taxonomy were also scanned from various popular books and
Encyclopaedias. The Hewlett Packard Director and Hewlett Packard Photo and Imaging package also played a dominant role in scanning the images. The scanned Images and Photos were processed using Adobe PhotoShop.

The Macromedia Director, Macromedia Dream Weaver, Macromedia Authorware and Macromedia Flash were also used in the prefacing work of the software package.

4.23 ADOBE PHOTOSHOP

Adobe PhotoShop provides a deep feature set, extensible architecture, multiplexing of images, imaging concepts and enhanced channel masking tools, which have made it an indispensable tool for anyone working in digital imaging and production. Adobe PhotoShop Version 6.0, for Macintosh and Windows, has become even more powerful and useful. Its system of modular palettes allows the user to customize its interface for personal needs and working styles. It supports 24 Alpha Channels and powerful masking tools and is augmented with the capability of supporting upto 99 possible independent image layers and background, allowing greater flexibility for experimentation and creating composite images. Its multiple color modes, color correction and separation capabilities, file format support, and links to high-end systems continue to delight production specialists, and educational technologists.

4.24 SIGNIFICANCE OF ADOBE PHOTOSHOP

Adobe PhotoShop provides a hand full of tools and techniques for processing digital images. Some of the main features of these tools are

As full-editing functions (cut, copy and paste) are supported between documents. Colors and palettes selected and open in one document, apply to other documents, it can be used as a multiple document generator. PhotoShop is one of the high resolutions Macintosh graphics, pro graphics to support multiple open documents. This is great for using the colors in one image as a palette for another.
The image manipulation and enhancement features are found in PhotoShop. Image editing and image composition applications are the powerful capabilities of PhotoShop. These features are also available in Macintosh and PC paint, as Fractal Design Pointer, Pixel paint professional, Corel Photo Paint, Altus Photo Stiller and live picture, but Adobe PhotoShop has a major share in the desktop graphics world. The variety of filters, image processing tools and controls for every aspect of an image can be almost overwhelming.

A unique feature of PhotoShop is that one can open menus and access the program's tool while the screen is being redrawn without having to wait for the redraw to finish. When working with large, high resolution images, the time saving can be quite substantial.

PhotoShop offers a wide variety of tools and methods of selecting areas in an image, saving the selections, and moving them to other parts of the same image or other images. Utilizing its anti-aliasing and feathering controls, selection can have crisp, defined edges or very soft ethereal edges. A selection can be saved as a channel or path for future use.

The concept of Layers and Channels pave way for the new photo imaging technology. Adobe PhotoShop now supports up to 128 image layers that can be edited independently. This feature is a great leap forward for PhotoShop, allowing free experimentation with effects and treatments without altering the overall image. In addition to these "layers", PhotoShop also supports up to 48 alpha channels that can be added to an image in order to edit and store selections called "masks". This is accomplished with video alpha channels-live masks that are implemented in the hardware of the special effect devices used in video production.

In PhotoShop, all operations are calculated in 24 bit. The smoothness of 24-bit color on a monitor, displaying up to 16.7 million colors, will be most apparent in subtle value changes such as skin tones, sky and pastel colors.
Using the Paintbrush, Airbrush or Line tool on a 24-bit monitor will be amazing at the smoothness in the edges of the strokes. PhotoShop is compatible even with 8-bit (256 colors) system, editing images can be performed with a greater bit depth. The amount of color displayed is limited when 8-bit color system is used.

PhotoShop can convert a 24-bit color image into a 256-colour image (8bit) with the highest possible onscreen quality. Users can choose from multiple dithering schemes, or convert to less than 256 colors. In PhotoShop it is possible to obtain best quality in displaying a color image on a 4-bit, 16 color graphics cards, using the sophisticated color tools available.

4.25 MACROMEDIA DIRECTOR

Macromedia Director, a two-dimensional interactive multimedia and animation-authoring program available both for Macintosh and Windows, provides up to 48 layers, or channels, of independent movable objects on the screen at once, as well as simultaneous sound effects from two sound tracks. The Director can import a variety of images and animation file formats, as well as sounds, palettes, and other Director movies to be orchestrated into interactive animated presentations. It helps in creating animated sequences. Any effect applied repeatedly and saved each time as a new file can provide a series of images for a multimedia or video presentation. Director combines video, audio, animation, still images and graphics into movies on both the Macintosh and Windows platforms. Using PhotoShop along with Director, enables the artistic performance in still images, create special effects, produce animated sequences and create transitions.

Any part of video clip from Director can be imported into PhotoShop in the required format through which retouching, filter effects, color correction, image morphing and image resolution enhancement can be made. After editing the filmstrip in PhotoShop, it can be exported back to any Macromedia packages like Director, Flash, Authorware, etc in the filmstrip format. The filmstrip links back with the original sound in Director.
By using PhotoShop in conjunction with Macromedia products, still images and video images can be animated and add a sound track to create a movie presentation. With Macromedia Director and Macromedia Authorware, a leading video editor and authoring tool, educational technologists have a vast resource at their disposal for creating video editing and transitioning effects.

4.26 MACROMEDIA DREAMWEAVER

Macromedia Dreamweaver is a two-dimensional software used to perform two major functions - Creation and Sequencing. Sequencing is nothing but creation of separate frames and running together the frames at a user controlled speed. Each movement is drawn on separate continuous frames and then sequenced.

No special input device is required. The 3 key mouse can be used as an input device apart from the keyboard. All the panel selection in the Dreamweaver screen is manipulated by clicking mouse buttons. Dreamweaver facilitates another option of importing any software package for creating varied multiple effects. Dreamweaver is platform independent and operating system independent. However, the full-fledged Macromedia products can be run on any multimedia based operating systems.

4.27 WINDOWS 2000 ADVANCED SERVER

Windows 2000 advanced server includes all the new features of windows 2000 server, and in addition, offers enhanced memory support, support for additional processors and clustering. Enhanced memory and processor support means the server application can run faster, providing better response for users on the network.

Windows clustering includes multiple clustering technologies, such as Network load balancing clusters and Server clusters. These clustering technologies...
technologies can be set up to work together to provide scalability and high availability for network applications.

Network load balancing clusters provide high scalability and availability for TCP/IP based services and application by combining up to 32 servers running Windows 2000 Advanced Server into a single cluster. The network load balancing service provides a foundation for network load balancing clusters.

Network load balancing clusters can also provide load balancing for servers running COM+ applications. Cluster service provides a foundation for server cluster. Server cluster provides high availability of resources for servers running Windows 2000 Advanced Server.

4.28 ACTIVE SERVER PAGES

Active server pages are Microsoft’s solution to create dynamic web pages. With the explosion of Internet and the World Wide Web into everyday lives, web site creation is quickly becoming one of the fastest growing sectors.

In the early days of World Wide Web, Web site designs consisted primarily of creating pages with fancy graphics and nice-looking, easy to read web pages. As today’s web sites have become users interactive, the steps in the web site design have changed. Although creating a pleasant looking web site is still important, the primary focus has shifted from graphical design to programmatic design.

Initially, the Internet served as a medium for members of government and education institutions to communicate. With the advent of World Wide Web, the Internet has become a multimedia, user-friendly environment. Originally the Internet served as a place for enthusiasts to create personal
home pages, but as more people began going online, the Internet was transformed into an informational resource for common man.

As the Internet has matured into a viable market place, web site has changed in step. In the early days of the World Wide Web, HTML was used to create static Web pages. Dynamic web pages can be created in many ways. Microsoft's solution for this is through the use of Active Server Pages, commonly abbreviates ASP.

Active Server Pages contain two parts: programmatic code and embedded HTML. The programmatic code can be written in a number of scripting languages. A program composed of commands from a particular scripting language is referred to as a script. Some popular web related scripting languages include VB Script and Java Script. When creating an ASP page any of the four programming languages can be used: VB Script, Java Script, PEARL Script, and Python.

Most ASP pages are created through VB Script. VB Script has the English-like syntax of four scripting languages and are similar to visual basic's syntax, which many web developers have experienced with. As an ASP page contains embedded HTML, it allows conversion of existing static pages to dynamic ASP pages. Finally an ASP page must contain a (.ASP) extension.

4.29 CLIENT SERVER MODEL

In a client server model, computers work together to perform a task. A client computer requests some needed information from a server computer. The server returns this information and the client's acts on it. The Internet runs on a client server model, particularly the server being the web server. A web server is a computer that contains all the web pages for a particular website and has special software installed to send this web pages to web
FIG 4.2 CLIENT SERVER DATA TRANSMISSION
browser who requests them. The client, on the Internet, is a web browser. When a static web page is visited through a web browser, the following steps occur:

1. The client locates the web server specified by the part of the URL.
2. The client then requests the static web page specified by the second part of the URL.
3. The web server sends the contents of that particular file to the client in HTML format.
4. The client receives the HTML sent by the server and renders it for the user.

In the client server transaction, the web server acts passively. It sits around idly, waiting for a client to request a static page. After such a page is requested, the web server sends that page to client and then returns to idle Wait State for the next request. With this series of steps, only static web pages can be sent to the client. To allow for dynamic web pages, the web server must play a more active role.

ASP pages contain a combination of HTML and programmatic code. This code, which can be written in many different languages, allows the ASP pages to be dynamic; however, the web server has to process this programmatic code before sending the HTML to the client.

The client cannot feel the difference between an ASP page and a static web page because, in both cases, it receives just HTML. When the web server processes an ASP page, all the programmatic code is interrupted on the server alone, and none of it is sent to the client. Server locates the ASP file on the drive and passes it removing all the ASP script and replacing with HTML script.
These are the two ways a web server can respond to a client’s request. If the request is for a static HTML page, the server simply sends back the contents of the web page. If however, the request is for an ASP page and it sends the resulting HTML output to the client. The web server with the help of the extension determines the difference between the two. That is why when an ASP page is created, it is given extension as .ASP. This way, the web server knows to process the programmatic code before sending the output to the client.

4.30 CLIENT SIDE SERVER SIDE SCRIPTING TECHNOLOGIES

When using ASP, it is vitally important to understand that ASP code exists on the server only. ASP code, which is surrounded by delimiters, is processed completely on the server. The client cannot access this ASP code.

Client side scripting is the programmatic code HTML file that runs on the browser. Client side scripting code is simply HTML code and is denoted by the script <SCRIPT> HTML tag. Client side scripting code is commonly written using the Java script programming language due to the fact that Netscape navigator only supports the Java script programming language for client server scripting.

One can have client side scripting code in ASP page because client side scripting is in HTML code, as far as the web server is concerned. When developing ASP pages, it is important to remember that client side scripting and ASP code are two different things and cannot interact with one another. ASP scripts are server side scripts. Server side scripts are scripts that execute on the web server. These scripts are processed and their results are sent to clients.
4.31 ROLE OF ACTIVE SERVER PAGES IN MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY

Active Server Pages enable HTML authors and web developers to mix HTML with inline scripting using any authoring tool they are accustomed to. The scripts have reference components running on the server to perform complicated processing on the data submitted by the learners of Multimedia Web Based Digital Learning Technology. This enables the learners browse the Multimedia Web Based Digital Learning Technology courseware through internet from any corner of the world.

ASP code, which is used in Multimedia Web Based Digital Learning Technology, is not limited to a particular scripting language. Currently, it supports VB Script and Java Script, but third parties can provide support for the other languages such as REXX, PEARL and so on. In addition, multiple scripting languages can be used interchangeably in the same ASP file. The Multimedia Web Based Digital Learning Technology is designed in such a way that any web based code can be incorporated in future advancements.

4.32 LOGICAL VIEW OF MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY

The investigator designed the Multimedia Web Based Digital Learning Technology courseware, with the help of a team of professionals, including artists, HTML authors, and programmers and so on to design the web sites. One of the challenges in setting up a large web site like Multimedia Web Based Digital Learning Technology is to enable these professionals to work together efficiently. Developing large size with straight HTML and traditional scripting tools leads frequently to one developer cutting into another developer’s work.
The components provided by ASP allowed the team to separate the programming from the design of visual elements. Each developer can focus on his or her part of the process. This separation of the programming logic from the content allowed more flexibility in the web site design.

The output produced by the Multimedia Web Based Digital Learning Technology, which is in ASP, is straight HTML code, which can be viewed with any browser. The application logic needed to generate dynamic content resides on the server. The server side script can be complicated to any extent. However, the learners do not see the complexity, and they are not required to have a specific browser.

4.33 REQUIREMENT ANALYSIS

Requirement Analysis is nothing but Logical Design, from a Software Engineer point of view. Requirement Analysis is a Software Engineering task that bridges the gap between system level software allocation and software design. Requirement Analysis enables the system engineer specify the software function and performance indicates software's interface with other system elements and establishes design constraints that the software must meet. Requirement Analysis provides the software designer with a representation of information and function that can be translated to data, architectural and procedural design. The requirement specification provides the developer and the user with the means to assess quality once the software is built. Software Requirement Analysis of Multimedia Web Based Digital Learning Technology is divided into five areas of effort. They are Problem recognition, Evaluation and synthesis, Modeling, Specification, and Review.

The critical and the non-critical activities involved in the development of the courseware were well recorded in a time scale by the investigator. The
FIG 4.3 SYSTEM APPROACH TO MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY COURSEWARE

START

Technical Concepts that ought to be presented in web based form

KNOWLEDGE BASE WHICH CONTAINS CONCEPTS, STILL IMAGES, VOICE DATA AND WEB LINKS

CONTROL

FUNCTIONS

Multimedia Web Based Digital Learning Technology courseware

- Simulation concepts
- Motivation towards learning technological concepts and skills
- Teacher assistance throughout the session
- Provision of extracting exhaustive information in various forms
- Scroll buttons movements
- Hyper links activation
- Icon creation for effective quick access
- Network administration of the courseware
Requirement Analysis of this courseware were carried out by the investigator and the feasibility of its development was sensitized within the known economic constraints, technical constraints, and the time constraints.

4.34 LOGICAL DESIGN OF MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY

The Multimedia Web Based Digital Learning Technology courseware, in which five units from the Plant Taxonomy, which is a part of the B.Sc. Plant Biology and Plant Biotechnology curriculum of Bharathiar University was programmed into a web based module using the recent software Visual Basic 6.0, Active Server Pages, VB Script, Java script, Dynamic HTML, XML and SQL server for its feasibility and user interface convenience.

The pictures and images required for Multimedia Web Based Digital Learning Technology were scanned from The Marshall Cavendish Illustrated Encyclopedia of Plants and Earth Sciences, obtained from Botanical Survey of India, and some were downloaded from the website of plantstress Inc. All these collected images were given appropriate titles with content orientation so as to keep the information last in the minds of the learners for a long period through intervals.

Utmost care and technical experts' knowledge were obtained in the selection of background and foreground colors of the screen and the selection of the font for the text. The combination of colors on a computer screen and text of the subject matter plays a significant role in ensuring effectiveness of the courseware operation. The color preferences used in the text and different screens sustain the learners' motivation and attention and would provide a congenial learning environment while operating the courseware. The educational technologists also provide greater attention to the colors to be used for computer software. Krisana (1991) made an
interesting study to find out the color preferences of Thai and American
students for the text and background screen color combinations. The study
indicates the importance of color selection for the text as well as for the
screen. The Thai and American students' color combination preferences
were virtually identical. The preferred color combination was a white text with
a blue background. The students also preferred white, yellow and green text
with blue background.

Therefore, in the present study, attention was given both for font
selection and the selection of the colors of the background screens. For the
Computer Assisted Instruction courseware, Navy blue screen with sandal
wood or beige colored text were preferred after extensive discussions made
with the experts and the students who were contacted for this purpose. For
the implementation of different screens in the Multimedia Web Based Digital
Learning Technology courseware, various other screen implementations of
different multimedia packages were referred and the desirable features
exhibited were taken into account. The screen design and the screen layout
strictly comply with the standards and specifications of ISOC – Internet
Society, a world-renowned co-operative organization which specifies the
standards of Internet.

The present courseware itself is a menu driven system and some of
the menus and sub menus were made in such a way to pop up as and when
the cursor hits the domain. Suitable icons and buttons for selecting the
menus were designed, so that they could be self-explanatory and they gained
enough appreciation from the end users. Exclusive cursor images were used
for distinguishing the tasks like menu selection, zooming up, zooming down
and click buttons. The glow effect in the label box buttons indicates the
specific unit from the title index, which is to be selected. The rollover options
of the mouse events were also clearly distinguished to guide the user
navigation in the web site. The images have been displayed in a zoomed
down condition. The original size of the image can be displayed when they are zoomed up by clicking onto it twice and activate the appropriate image link file. The zoom up and zoom down condition of the images is well noticed by the picture box properties.

The menu selection and the interaction with this courseware are facilitated with the movement of the direction keys and the clicking of the mouse. Wherever needed, scroll movements of the screens are enabled for easy and quick access. The content of the text was written in simple and comprehensive English that makes the perception of the technological concepts easy. Appropriate headings were given in the textual medium. The text is always complemented with relevant, titled and labeled color images.

At the end of each unit, the learners can go for an optional quiz scheme. Students can have their own self-evaluation option by responding to the queries in the quiz scheme. The evaluation session can be repeated as many times as the learner desires. This will motivate the students to go through the lessons for sufficient number of times and promote their self-confidence level. A constant reinforcement is being exerted on the students when they attend the quiz program periodically so as to evaluate their abilities to recall and recapitulate the content they learnt. To make the courseware interesting, musical beats were recorded from the clippings of popular albums and the music is played during the intervals. The music was later found to be a hindrance to the learners as their attention was diverted to a greater extent. Music was then made as an option of the central server. Roxana (2000) explores whether adding music and/or sounds to multimedia instructional coursewares would improve the quality of retention and transfer skills of college students. The study demonstrated that the groups receiving both music and sounds performed worse than the groups that never received music and sound. Therefore the learners on the client side were not provided the rights to operate on the music, as it would disturb the fellow learners.
Fig 4.4 SELECTED TOPICS ON THE OUTLINE CLASSIFICATION OF BENTHAM AND HOOKER

**ANGIOSPERMS**

**DICOTYLEDONS**

**POLYPETALAE**

- **THALAMIIFLORAE**
  - Ranales
    - Annonaceae
    - Nymphaeaceae
  
  - Parietales
    - Cruciferae
    - Capparidaceae
  
  - Malvales
    - Malvaceae
    - Sterculiaceae
    - Tiliaceae

- **DISCIFLORAE**
  - Geraniaceae
    - Rutaceae

- **CALYCIFLORAE**
  - Rosales
    - Leguminoseae
    - Rosaceae
    - Passiflorales
      - Cucurbitaceae
      - Umbelliferae
      - Apiaceae

**MONOCOTYLEDONS**

**GAMOPETALAE**

- **INFERAE**
  - Rubiales
    - Rubiceae

  - Asterales
    - Asteraceae

- **HETEROMERAE**

- **BICARPELLATAE**
  - Gentianales
    - Apocynaceae
    - Asclepiadaceae
  
  - Polemoniales
    - Convolvulaceae
    - Solanaceae
  
  - Personales
    - Scrophulariaceae
    - Acanthaceae
    - Lamiales
      - Verbenaceae
      - Labiatae

**MONOCHLAMYDEAE**

- **CURVEMBRYEAE**
  - Amarantaceae

- **UNISEXUALS**
  - Euphorbiaceae
Network played a prominent role in sharing the resources of Multimedia Web Based Digital Learning Technology courseware among the learners on the client machines from the central server and the web server through the workstations. Each and every activities of the learners including the key strokes were monitored by the networking software Novel NetWare, which was centrally controlled by the teacher who was in charge of the learners.

For bringing forth necessary animation in the technological concepts, the sequences of the frames were calculated and stepwise changes were brought in, so that eventual and simultaneous changes in the concept could be displayed clearly. The animation clippings thus developed were converted into media player files to be played as a movie. All the animated images in the form of flick files were merged together to bring out a complete video show of a particular concept. Proper attention was given to present text in such a way to implement the animated video clippings and to make the learning process a complete one through this present Multimedia Web Based Digital Learning Technology courseware. The content of the text was written in simple and comprehensive English to make the perception of the technological concepts easy.

4.35 CONTENT OF THE COURSEWARE

Fig 4.4 explains the topics selected from the syllabus of “Plant Taxonomy” of B.Sc. Plant Biology and Plant Biotechnology Course of NGM College, an autonomous institution affiliated to Bharathiar University, Coimbatore, TamilNadu. A few samples of the ‘Plant Taxonomy’ content are presented for reference. The detailed content is made available in the enclosed CD. Fig 4.5 explains the Home page layout of Multimedia Web Based Digital Learning Technology courseware.
FIG 4.5 HOME PAGE LAYOUT OF MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY COURSEWARE
4.35.1 Introduction to plant taxonomy

Plant Taxonomy is one of the oldest sciences and it could be argued that this profession is one of the oldest practiced by humans because early humans had a much more direct involvement with the natural environment than members of any modern society. Clearly, a substantial knowledge of local plants, collectively known as the "flora" was required in early humans simply for survival reasons. Naturally occurring plants were used for food, shelter, tools, clothing, and other essential needs. These so-called "primitive" humans undoubtedly had a much more extensive knowledge of plants than the typical modern urbanite or suburbanite. While plants and their products still play a critical role in modern human societies, we have become so far removed from the natural environment that few individuals are aware of the importance of plants. This lack of connection with the natural environment has also stunted the development of an appreciation for and knowledge of a unique and irreplaceable flora and fauna that is the product of billions of years of evolutionary processes. One of the greatest legacies that we can leave to future generations is a world with an undiminished biota. We have already destroyed whole environments and driven many species into extinction. One way to reduce and hopefully reverse this wholesale destruction is to educate as many individuals as possible of the value and beauty of natural environments and the organisms that populate them. It is hoped that this course will lead to a greater knowledge and appreciation of the plants that we encounter everyday.

The scientists who study the diversity and variation found in organisms with the purposes of classifying them and understanding their relationships to each other are referred to as Taxonomists or Systematists. While an overwhelming curiosity of the causes of the beauty and diversity found in plants is the major reason that people are drawn to dedicate their life's work
to Plant Taxonomy, there are also many practical aspects to these investigations. These include: (1) production of an inventory of the world's flora, it is important that we know what is out there; (2) production of a classification system that includes all plants, this provides a systematic organization of the diversity found in plants; (3) an understanding of relationships of plants that can be incorporated into classification systems, if we have a plant that has a useful characteristic, a classification system can provide information that may lead to the discovery of related plants with similar characteristics; and (4) provide universal rules and regulations regarding the naming of plants, which is critical to identification and communication. Of course, this knowledge of plants can be used for economic purposes, such as finding plants that are new and better sources of food, shelter, clothes, medicine, etc.

4.35.2 Key to the identification of the families of angiosperms – Bentham and Hooker’s system

Embryo with two cotyledons; stem with open bundles; leaves with netted (reticulate) venation; flowers usually pentamerous.  
**Class: Dicotyledons**

Embryo with a single cotyledon; stem with closed bundles; leaves with parallel venation; flowers usually trimerous.  
**Class: Monocotyledons**

**CLASS: DICOTYLEDONS**

| Sub-class I. | Flowers usually with two whorls of perianth i.e. (calyx and corolla), petals free. | Polypetalae |
| Sub-class II. | Flowers usually with two whorls of perianth i.e. (calyx and corolla), petals united. | Gamopetalae |
| Sub-class III. | Flowers usually with one whorl of perianth, commonly sepaloid or Absent. | Monochlamydeae |

201
Sub-class I – Polypetalae

Series (i)   Petals and stamens hypogynous. Disc absent.  Thalamiflorae

1. Androecium rarely definite, gynoecium free or immersed in torus, rarely united; embryo minute, albuminous.  Ranales
Receptacle neither hollow nor concave; ovary apocarpous Ranunculaceae

2. Gynoecium syncarpous, parietal placentation.  Parietales
Flowers actinomorphic, sepals 2 or 3, sepals twice petals.  Papaveraceae
Corolla cruciform, androecium tetradynamous  Cruciferae
Andro – or gynophore or both present  Capparidaceae
Flower zygomorphic, anterior petal often spurred.  Violaceae

3. Gynoecium syncarpous, free central placentation; Herbs, sepals 5 or 4, petals 5 or 4, stamens twice petals, obdiplostemonous. Caryophyllineae
Gynoecium 3 or 5 carpellary  Caryophyllaceae

4. Flowers rarely irregular; sepals 5, 2 or 4, free or united; petals many; stamens indefinite monadelphous; Gynoecium 3 to indefinite numbers oofcarpels, carpels united Malvales

Series (ii)   Stamens hypogynous, disc present, ovary superior Disciflorae

5. Ovary superior or inferior, syncarpous; stamens twice the number of sepals, in two or one whorl;  Geraniales
Trees or shrubs; leaves gland dotted; sepals 4 or 5, petals 4 or 5; stamens 2, Obdiplostamonous; Gynoecium 4 or 5 or indefinite carpellary, syncarpous.  Rutaceae

Series (iii) Flower perigynous or epigynous; ovary sometimes inferior; ovary enclosed by developments of floral axis.  Calyciflorae
6. Gynoecium one or more carpellary, apocarpous; flower actinomorphic or zygomorphic perigynous  
   Rosales
   Gynoecium monocarpellary, flower zygomorphic; stamens 5 or 5 + 5, united  
   Leguminosae
   Gynoecium polycarpellary, apocarpous, flower regular, sepals 4 or 5, petals 4 or 5, stamens 1 to indefinite, gynoecium 1 to indefinite number of carpels.
   Rosaceae
   Flower regular, usually bisexual; ovary syncarpous, inferior; styles undivided or very rarely styles are free.
   Myrtales
   Everygreen trees or shrubs or creepers, flowers in cymes; flower epigynous, sepals 4 – 5, petals 4 – 5; stamens indefinite, usually free, axile or rarely parietal placentation.
   Myrtaceae

7. Flowers bisexual or unisexual, parietal placentation, styles free or connate.
   Passiflorales
   Ovary trilocular, flowers unisexual.
   Cucurbitaceae

8. Flowers bisexual, locules in ovary one to indefinite number, inflorescence umbel
   Umbellales
   Ovary bicarpellary, bilocular.
   Umbelliferae

SUB-CLASS II – GAMOPETALAE

Series (i) : Ovary inferior, stamens usually as many as petals.
   Inferae

9. Flowers regular or irregular, stamens epipetalous, ovary with 2 – indefinite number of locules.
   Rubiales
   Trees, shrubs, herbs; leaves opposite, inter and intra stipules present; cymose inflorescence, sepals 5 – 4, petals 5 – 4, Gynoecium with one – indefinite carpels, syncarpous, ovary inferior.
   Rubiaceae
10. Flowers regular or irregular, stamens epipetalous, ovary with one locule and one ovule; stamens syngenesious. Asterales
Stamens syngenesious, basal placentation, inflorescence capitulum, stigma bifid. Compositae

Series (ii) : Ovary usually superior; stamens as many as or fewer than corolla lobes, alternipetalous; Gynoecium 2 rarely to 1 – 3 carpellary. Bicarpellatae

11. Flower regular, hypogynous; stamens epipetalous; leaves generally opposite. Gentianales
Latex present; inflorescence panicle, dichasial cyme or cincinnus; flower bisexual, regular, sepals 5, petals 5, fused, usually salver or funnel shaped; stamens 5, alternipetalous, epipetalous. Apocynaceae
Sepals 5, fused; petals 5, fused; stamens 5, Gynoecium bicarpellary, ovary superior; filaments united into a tube, anthers adnate to stigma; gynostegium and translator, pollinia are present. Asclepiadaceae

12. Flower irregular, hypogynous; leaves alternate; stamens epipetalous; ovary 1 – 5 loculed. Polemoniales
Axillary inflorescence; ovary bilocular; indefinite number of ovules per loculus; a swollen placenta obliquely placed to the mother axis, sepals 5, fused; petals 5, fused; stamens 5 Gynoecium bicarpellary. Solanaceae
Placenta not oblique; ovary bilocular with two ovules per loculus later becomes tetralocular and thus one ovule per loculus; sepals 5 free or fused; petals 5, fused; stamens 5; Gynoecium bicarpellary. Convolvulaceae

13. Flowers usually irregular corolla often bilipped; stamens generally fewer than corolla tubes, usually 4, didynamous or 2; ovary 1 – 4 locular, ovules usually indefinite. Personales
14. Indefinite number of ovules per loculus; sepals 5, fused; petals 3 + 2, gamopetalous; stamens 4 or 5, gynoecium bicarpellary, syncarpous. \textit{Acanthaceae}

15. Corolla usually bilipped; flower hypogynous, rarely regular, ovary 2 – 4 loculed, ovules solitary in loculus or rarely more than one; fruit drupe or nutlets. \textit{Lamiales}

Gynobasic style, ovary becomes tetralocular due to the false septum, single ovule in each loculus; sepals 5, fused; petals 5, fused, bilabiate; stamens 4 – 5; gynoecium bicarpellary. \textit{Labiatae}

**SUB-CLASS III – MONOCHLAMYDEAE**

Flowers usually with one whorl of perianth commonly sepaloid or perianth absent.

Series (i). Terrestrial plants with usually bisexual flowers; stamens generally equal in number to perianth lobes; ovules usually solitary; embryo curved with flouncy endosperm. \textit{Curvembryae}

Ochreate stipules; inflorescence racemose or cymose; flowers bisexual, regular, cyclic or acyclic; perianth 3+3; gynoecium tricarpellary. \textit{Polygonaceae}

Series (ii). Flowers unisexual; ovary syncarpous or monocarpellary; ovules solitary or two per carpel. \textit{Unisexualae}

Albumin present or absent in seed; perianth sepaloid, much reduced or absent; a inflorescence cyathium. \textit{Euphorbiaceae}
CLASS MONOCOTYLEDONS

<table>
<thead>
<tr>
<th>Series</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Perianth partly petaloid; ovary usually inferior; endosperm abundant.</td>
<td><strong>Epigynae</strong></td>
</tr>
<tr>
<td></td>
<td>Stem rhizome; flower bisexual or unisexual; inflorescence a spadix.</td>
<td><strong>Musaceae</strong></td>
</tr>
<tr>
<td>ii</td>
<td>Inner perianth petaloid; ovary usually free, superior, endosperm abundant;</td>
<td><strong>Coronariae</strong></td>
</tr>
<tr>
<td></td>
<td>flower bisexual.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flowers regular, bisexual, perianth 3 + 3; stamens 3 + 3, epipetalous;</td>
<td><strong>Liliaceae</strong></td>
</tr>
<tr>
<td></td>
<td>gynoecium tricarpellary, syncarpous, ovary superior.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flowers regular, bisexual, trimerous, blue in color.</td>
<td><strong>Commelinaceae</strong></td>
</tr>
<tr>
<td>iii</td>
<td>Perianth sepaloid, herbaceous or membranous; ovary usually inferior;</td>
<td><strong>Calycinae</strong></td>
</tr>
<tr>
<td></td>
<td>flowers usually unisexual.</td>
<td><strong>Palmae</strong></td>
</tr>
<tr>
<td>iv</td>
<td>Flowers solitary, sessile in the axils of bracts and arranged in heads or</td>
<td><strong>Glumaceae</strong></td>
</tr>
<tr>
<td></td>
<td>spikelets with bracts; perianth of scales or no perianth; ovary usually</td>
<td><strong>Gramineae</strong></td>
</tr>
<tr>
<td></td>
<td>unilocular with a single ovule; seed endospermic.</td>
<td></td>
</tr>
</tbody>
</table>

4.35.3 Method of describing a flowering plant

1. **Habitat**
   
The natural abode or locality of the plant i.e., whether cultivated as an ornamental plant or a food crop or occurs wild.

2. **Habit**
   
a) Annual, biennial or perennial
b) Herb, undershrub, shrub or tree
c) Any other peculiarity such as parasite, epiphyte, xerophyte or hydrophyte

3. **Leaf**
   a) Deciduous or evergreen
   b) Alternate, opposite or whorled
   c) Petiolate or sessile
   d) Stipulate or extipulate
   e) Nature of the leaf base
   f) Simple or compound

4. **Inflorescence**
   a) Racemose, cymose, mixed, compound or of any special form

5. **Flower**
   a) Pedicellate or sessile
   b) Bracteate or ebracteate
   c) Complete or incomplete
   d) Bisexual or unisexual
   e) Actinomorphic or zygomorphic
   f) Color of the flowers
   g) Hypogynous, perigynous or epigynous

6. **Calyx**
   a) Number of sepals
   b) Poly- or gamosepalous.
   c) Color of the petals
   d) Inferior or superior
   e) Aestivation of the calyx
7. **Corolla**
   a) Number of petals
   b) Poly-or gamopetalous
   c) Color of the petals
   d) Inferior or superior
   e) Aestivation of the corolla

8. **Perianth**
   a) If perianth is present, describe

9. **Androecium**
   a) Number of stamens
   b) Polyandrous, syngenesious or adelphous
   c) Whether epipetalous or free from the petals
   d) Nature of the filament
   e) Anthers introrse or extrorse
   f) Color, fixation and dehiscence of the anthers

10. **Gynoecium**
    a) Number of carpels
    b) Syncarpous or apocarpous
    c) Ovary superior or inferior
    d) Number of lacule
    e) Number of ovules
    f) Placentation
    g) Nature and form of the style and stigma

11. **Fruit**
    a) Kind of fruit
4.35.4 Botanical description of selected flowering plants

4.35.4.1 Rutaceae

In fig 4.7 the characteristic features of the Rutaceae is explained: (1) Ruta graveolens; (a) shoot with bipinnate leaves and cymose inflorescence; (b) flower; (c) vertical section of ovary; (d) cross section of ovary. (2) Citrus aurantium; (a) L.S. of flower (b) fruit – a pulpy berry. (3) Ptelea trifoliata winged fruit. (4) Citrus limon flowering shoot. (5) Crowea saligna flowering shoot.

DISTRIBUTION: The family contains 120 genera and 1200 species. It is Distributed in temperate and warm regions (tropics).

COMMON PLANTS: Citrus aurantium (orange), Citrus medica (citron), Murraya koenigii (curry leaves), Aegle marmelos (vilvam), Citrus limon (lemon), Toddalia asiatica.

HABIT: Herb-Ruta graveolens, Shrub-Citrus, Murraya exotica, Tree-Feronia, Aegle. Straggler-Toddalia. The plants are with thorns (Citrus, Atalantia) or prickles (Toddalia).

LEAVES: Alternate simple (Atalantia), unifoliately compound (Citrus) trifoliately compound (Toddalia). Imparipinnately compound (Murraya koenigii). The leaflets are gland-dotted and aromatic. Winged petiole in Citrus. In the leaf axil of Citrus a thorn occurs. It is a modified axillary bud.

INFLORESCENCE: Cymes or Panicles, terminal corymb e.g. Murraya koenigii. Panicle e.g. Toddalia.

FLOWER: Bisexual, actinomorphic, hypogynous, tetrameraus or pentameraus (unisexual on Toddalia), polygamous in Feronia.
Fig 4.7. Rutaceae
**CALYX**: 4 or 5 sepals, polysepalous, valvate or imbricate.

**ANDROECIUM**: Stamens 8 (Ruta) or 10 (Murraya and Ruta), free, obdiplostemonous, 5 in Toddalia. Aegle has 30-60 stamens. In Citrus numerous stamens inserted round the disc. Polyadelphous condition is seen in Citrus. anthers dithecous, introrse.

**GYNOECIUM**: Gynoecium is present on the disc. Tetra or pentacarpellary syncarpous (Ruta), multicarpellary syncarpous (Cirtus), numerous ovules on axile placentation. The style is usually pillar like. Stigma is capitate. The ovule has ventral raphe. Toddalia - style absent, stigma capitate. Murraya - style elongate, stigma capitate.

**FRUIT**: Hesperidium (Citrus), Berry (Murraya). In Feronia the fruit is a large globose 1-celled many seeded berry with rough woody rind. Polyembryony is common in Citrus. From the cells of nucellus embryos are formed.

### 4.35.4.2 Leguminosae

The diagnostic and characteristic features of Leguminosae are explained in fig 4.8 as follows: (1) Spartium junceum inflorescence – a raceme. (2) Piptanthus nepalensis shoot bearing trifoliolate leaves with stipules, flowers and fruit. (3) Onobrychis radiata inflorescence and pinnate leaf. 4. Erythrina humeana inflorescence. (5) Erythrina abyssinica dehiscing fruit. (6) Phaseolus vulgaris (a) shoot bearing flowers and immature fruit; (b) mature fruit with half of pod removed to show seeds. (7) Lathyrus sylvestris shoot bearing leaves, tendrils and inflorescence. (8) Ulex europaeus, half flower showing hairy sepals.
Fig 4.8. Leguminosae
**DISTRIBUTION:** About 700 genera and 17000 species represent Leguminosae. Mostly tropical, subtropical and temperate in distribution.

**COMMON PLANTS:** Spartium junceum, Piptanthus nepalensis, Erthrina humeana, Phaseolus vulgaris, Lathyrus sylvestris, Ulex europaeus, Caesalpinia gilliesii, Mimosa pudica, Bauhinia gilpinii, Acacia podalyriifolia.

**HABIT:** Mainly trees shrubs or herbs. Some are stragglers and few are twinning forms.

**LEAVES:** Simple or pinnately compound in Papilionaceae, compound or bicompond in Caesalpinioidae and bicompond in Mimosoideae, stipulate, stipules are free and lateral or adnate, pinnately reticulate venation.

**INFLORESCENCE:** Terminal or axillary, racemose type, corymb in Caesalpinioidae, globose head in Mimosoideae.

**FLOWERS:** Bisexual, rarely unisexual, actinomorphic in Mimosoideae, slightly zygomorphic in Caesalpinioidae and strongly zygomorphic in Papilionaceae, hypogynous or perigynous, bracteate and bracteolate.

**COROLLA:** Consists of 5 petals, free, in Mimosoideae united, aestivation is valvate in Mimosoideae, ascendingly imbricate in Caesalpinioidae and descendingly imbricate in Papilionaceae. The petals are regular but in Papilionaceae, they are very irregular. There is a standard petal in the posterior position. It is vertically disposed and the two lateral petals are horizontally arranged (wings) and the anterior two petals are boat-shaped and are close by attached along the lower margins to form the keel.

**ANDROECIUM:** Diplostemonous, rarely haplostemonous. Stamens are numerous, in several genera of Mimosoideae. In Papilionaceae the stamens are united by their filaments to form one bundle (monodelphous), or two
bundles (diadelphous) of 9 and 1. In Caesalpinioideae, the stamens are quite free. In Mimosoideae, the stamens are usually united to form one bundle, monadelphous. The anthers are dithecous, basifixed, sometimes gland-tipped.

**GYNOECIUM:** Single carpel with a short stalk. Style is terminal with a capitate stigma. Bicarpellary, apocarpous in abnormal flowers of Saraca.

**FRUIT:** Legume, samara-Pterelobium and Dalbergia, lomentum in Acacia...

### 4.35.4.3 Cucurbitaceae

The characteristic features of Cucurbitaceae are explained in fig 4.9 as follows: (1) Gurania speciosa female flowers. (2) Curcurbita moschata (a) male flower; (b) cross section of the ovary; (c) female flower with petals and sepals removed. (3) Sechium edule (a) female flower with discoid stigma; (b) stamens partly joined in a single column; (c) vertical section of ovary with single pendulous ovule. (4) Kedrostis xiurtaellensis male flower opened out. (5) Trichosanthes tricuspidata leaf, tendril and female flower. (6) Gynostemma pentaphyllum (a) female flower; (b) young fruit with remains of style; (c) leafy shoot with tendrils and inflorescence. (7) Zanonia indica (a) winged seed; (b) fruits. (8) Echinocystis lobata fruit. (9) Coccinea grandis leaves, tendrils, female flowers and fruit.

**DISTRIBUTION:** Cucurbitaceae Consists of 100 genera and about 800 species

**COMMON PLANTS:** Cucurbita, Coccinia, Cucumis, Citrullus, Momordica, Lagenaria, Melothria.
HABIT: Tendril Climbers – Coccinia, Cucumis, Citrullus, Melothria; Prostrate Herb – Ecballium, Small tree – Dendrosicyos.

LEAVES: Simple, palmately lobed, alternate, exstipulate, palmately reticulately Venation (Two strong lateral veins are present).

MORPHOLOGY OF TENDRILS: Tendrils are slender, spirally coiled spring like structures with the help of which plants climb on the support. The tendrils are branched or unbranched in Cucurbitaceae.

INFLORESCENCE: Axillary, solitary or in cyme (cymose cluster)

FLOWERS: Unisexual, pedicellate, cyclic, actinomorphic.

MALE FLOWER:

CALYX: Sepals 5, free of united, valvate.

COROLLA: Petals 5, usually gamopetalous, polypetalous in Luffa and Fevillaea, campanulate, valvate or imbricate.

ANDROECIUM:

a) FEVILLEA: Five free stamens, dithecous anthers.

b) THALADJANTHA: Four of the five stamens are closely approximated in the basal portions of the filaments in to two pairs with the fifth stamen standing apart. Two pairs of the stamens are closely approximated in the lower part of the filament, the fifth standing apart.

c) SICYNIUM: Two pairs of stamens have their filaments united below. Fifth stamen is free.
d) BRYONIA, MOMORDICA, CITRULLUS: Fusion of two pairs of stamens is complete. Androecium appear to have 3 stamens—2 with 4 cells and 1 with 2 cells.

e) CUCURBITA: Stamens 3 (2 anthers with 4 cells, 1 with 2 cells). Anthers are curved, connectives are united. The anthers are united into a central column. Filaments all connate except sometimes at the extreme base. Synandrous condition is seen. Stamens and filaments are united completely.

f) LAGENARIA: This resembles Cucurbita but anthers are irregularly curved. In Sechium the filaments are united into a column bearing the anthers which are remarkably curved.

g) CYCLANTHERA: In this the stamens are completely united into a central column with 2 ring-like pollen containing chambers running round the top.

**FEMALE FLOWER:** Epigynous, pedicellate, cyclic, actinomorphic.

**CALYX:** Sepals 5, valvate.

**COROLLA:** Petals 5, gamopetalous, valvate.

**ANDROECIUM:** It is represented by staminodes.

**GYNOECIUM:** Carpels 3, tricarpellary syncarpous, ovary inferior, unilocular, many anatropous ovules on parietal placentation. The parietal placenta are thick and fleshy. They are intruding into the ovary chamber and are bifurcating. E.g. Cucumis. Style 1, stigma 3-lobed, each lobe bifid. In Sechium unilocular ovary with a single ovule.

**FRUIT:** Pepo.
4.35.4.4 Compositae (Asteraceae)

In fig 4.10 the diagnostic features of Asteraceae are explained as follows: (1) Gazania linearis. (2) Mutisia oligodon (a) alternate leaves with tendrils and terminal capitulum; (b) bisexual bilabiate floret. (3) Cichorium intybus (a) flowering shoot with capitula of ligulate florets (b) ligulate floret; (c) ligulate floret – stamens inserted in the corolla tube and anthers united in a tube around the style. (4) Liatris graminifolia (a) flowering shoot bearing discoid capitula; (b) disk floret with a five lobed corolla. (5) Centaurea montana leaf and terminal capitulaum of disk florets.

**DISTRIBUTION:** Compositae is a very large cosmopolitan family containing about one-tenth of the total number of flowering plants. The family consists of about 950 genera and 20,000 species. They are distributed over most of the earth and in almost all habitats.

**HABIT:** Herb - Vernonia cinerea, Eclipta, Acanthospermum, Zinnia, Aster, Erigeron, Sphaeranthus, Launaea, Chrysanthemum, Eupatorium, Tridex, Vicoa, Xanthium, Lagassa mollis, Synedrella, Bidens, Senecio ludens. Shrub - Artemisia vulgaris. Climber - Senecio scandens, Tree-senecio sps. Latex is seen in the tribe Cichorieae (Lactuca, Taraxacum). Glandular hairs – Senecio viscosa, stellate hairs are frequent in Hieracium. In Helianthus the hairs are surrounded at the base by silicified cells which after the fall of the hairs render the surface rough.

**LEAVES:** Alternate; lobed, e.g. Xanthium. Palmately reticulate Venation, opposite, entire – Eclipta, pinnately reticulate venation; (decurrent leaf-base Sphaeranthus). In Sphaeranthus the leaf-bases adnate with part of internode. Such leaves are called decurrent. Leaves are fleshy—Notonia, exstipulate.
Fig 4.10. Compositae (Asteraceae)
INFLORESCENCE: Capitulum consists of few to many flowers. The flowers are small called florets. (The inflorescence is reduced to a single flower in Echinops.) The Capitulum is an indefinite inflorescence, the flowers opening in acropetal succession, the youngest being in the center. They are surrounded by an involucre of bracts. Bracts are yellow or pink in Helichrysum. The number of flowers in the head is from thousands (Helianthus) to a single flower (Echinops, Vernonia uniflora) The involucre may consist of a very large indefinite number of spirally arranged bracts—200 or even more. Only 4 bracts are in Milkania. Capitula or heads may be arranged in racemose, corymbose or cymose manner. The receptable may be flat or convex or concave. The florets may be subtended by scaly bracts known as palea e.g. sunflower.

1) HOMOGAMOUS HEAD:
a) All florets-bisexual, actinomorphic and tubular - Vernonia.
b) All florets - bisexual, zygomorphic and ligulate – Launaea.

2) HETEROGAMOUS HEAD: e.g. Helianthus, Tridax. The outer florets are ligulate and pistillate--ray florets, zygomorphic. The inner florets are tubular, actinomorphic and bisexual disc florets.

3) Male and female florets on separate heads in the same plant - Xanthium.
4) Male and female heads on distinct plants - Bandaris.

TUBULAR FLORETS: Bisexual, actinomorphic, epigynous, pentamerous in homogenous and heterogenous heads.

CALYX: Absent or represented by pappus hairs. They help in dispersal of fruits.

COROLLA: Petals 5, gamopetalous, tubular, lobes valvate.
ANDROECIUM: Stamens5, epipetalous with syngenesious anthers, anthers dithecous, basifixed, introrse, longitudinal dehiscense, anther lobes often tailed at the base.

GYNOECIUM: Bicarpellary, syncarpous, ovary inferior, one celled with one erect basal ovule. Style simple, stigma bifid. The inner surface of stigma is receptive.

FRUIT: Cypsela

LIGULATE FLORETS: Zygomorphic, where all the florets of a head are ligulate and bisexual. Where there is a distinction into disc and ligulate florets (heterogamous head) the ligulate florets are either pistillate or sterile, epigynous.

CALYX: Pappus hairs.

COROLLA: Ligulate or strap-shaped, usually 3-lobed.

ANDROECIUM: As in tubular florets.

GYNOECIUM: As in tubular florets.

4.35.4.5 Rosaceae

The diagnostic and characteristic features of Rosaceae are explained in fig 4.11 as follows: (1) Rubus ulmifolius (a) flowering shoot; (b) fleshy fruits. (2) Rubus occidentalis half flower showing hypogynous arrangement of parts. (3) Fragaria sp. vertical section of false fruit. (4) Sanguisorba minor leafy shoot and fruit. (5) Agrimonia odorata fruit comprising receptacle enclosing the achenes. (6) Rosa sp. vertical section of hep showing urn shaped receptacle enclosing the achenes. (7) Potentilla agrophylla var atrosanguinea

217
flowering shoot. (8) Kerria japonica flowering shoot. (9) Rosa pendulina flowering shoot.

**DISTRIBUTION:** The family consists of about 115 genera and 3200 species. Distributed worldwide, the chief center being temperate zone of the northern hemisphere.

**HABIT:** Evergreen trees, shrubs or herbs. They are annuals or perennials. Some are creepers, runners or stragglers.

**LEAVES:** Simple or compound (pinnately or palmately), alternate (opposite in Rhodotypos), stipulate, stipules being free lateral or adnate.

**INFLORESCENCE:** Flowers are produced singly (Kerria japonica), or in simple racemes (Agrimonia), or in dense heads (Poterium), or in corymbose cymes (Ulmaria).

**FLOWERS:** Bisexual, sometimes polygamous, rarely unisexual; monoecious or dioecious, actinomorphic, but zygomorphic in Hirterlla, perigynous or epigynous. The thalamus shows much variation. It may be flat, saucer-shaped (Rubus), cup-shaped (Prunus) or urn-shaped (Rosa), with the free gynoecium in the center. The thalamus forms a club-shaped structure in the center and bears numerous free carpels at the surface as in Rubus and Fragaria.

**CALYX:** Sepal 5, poly or gamo sepalous, valvate or imbricate, sometimes the sepals or foliaceous. The stipules of the sepals are united in pair in Fragaria to form epicalyx.

**COROLLA:** Petals 5, free, aestivation valvate or imbricate. Corolla absent in Alchemilla and Poterium.
ANDROECIUM: Stamens variable in number arranged in various ways. They are in regular whorls (1, 2, 3 or 4) each consisting of as many or twice as many stamens as or the perianth lobes in one whorl. When 10 stamens are present in one whorl (Rose), they are in pairs and the pairs may be alternating with (Nuttalia) or opposite (Spiraea) the petals. Stamens are bent inwards in the bud. Filaments are free but monadelphous in Chrysobalanus. Anthers are dithecous, dehiscing by longitudinal slips.

GYNOECIUM: Numerous, sometimes a few carpels; usually apocarpous, rarely syncarpous as in Pomoideae. Ovary is inferior or superior. Styles free, basal (Fragaria), lateral or terminal. Ovules 1 – many in each chamber; axile, ventral, basal or apical in placentation.

FRUIT: Simple or aggregate. Simple fruit may be a drupe (Prunus), pome (Pyrus).

4.35.4.6 Solanaceae

In fig 4.12 the diagnostic features of Solanaceae are illustrated as follows: (1) Salpiglossis atropurpurea (a) flowering shoot; (b) open petals with stamens; (c) fruit. (2) Datura stramonium var tatula (a) flowering shoot; (b) fruit - a capsule. (3) Solanum rostratum (a) flowering shoot (b) flower with two petals and two stamens removed. (4) Physalis alkekengi (a) shoot showing fruits enclosed in a persistent orange-red calyx; (b) calyx removed to show the fruit. (5) Nicotiana tabacum cross-section of ovary.

DISTRIBUTION: Solanaceae consists of 85 genera and 2200 species, distributed mainly in the tropical countries.

HABIT: Herb - Solanum nigrum, Physalis, Petunia, Shrub - Cestrum, Datura, Climber - Solanum jasminoides. Plant with prickles - Solanum
Fig 4.12. Solanaceae
xanthocarpum. In Solanum tuberosum stem tubers are present. Stem has bicollateral vascular bundles.

**LEAVES:** Simple, exstipulate, entire or lobed, generally alternate in vegetative parts but opposite in the flowering region. Both branching and leaf arrangements shows many irregularities produced by adnation of leave and shoot in varying degrees.

**ADNATION IN SOLANANCEAE:**

**DATURA TYPE:** Branching is dichasial. The leaf at each node belongs to the node below it.

**ATROPA TYPE:** Branching is monochasial scorpioid.

**INFLORESCENCE:** Usually solitary or a cymose cluster, axillary, terminal or extra-axillary.

**FLOWERS:** Bracteate, bisexual, pedicellate, pentamerous except gynoecium, slightly zygomorphic owing to the oblique position of ovary, hypogynous. In Salphiglossoideae the flowers are zygomorphic.

**CALYX:** Sepals 5, gamosepalous, valvate or imbricate, calyx is persistent in Solanum melongena or peristent accrescent in Physalis.

**COROLLA:** Petals, gamopetalous rotate (Solanum), campanulate (Physalis), infundibuliform (Datura), often plicate, aestivation valvate or twisted. In Schizanthis the corolla is bilabiate.

**ANDROECIUM:** Stamens 5, epipetalous, alternating the corolla lobes, stamens 4 or 2 unequal Salphiglossoideae, anthers dithecous, dehiscence longitudinal (Datura), porous (Solanum).
GYNOECIUM: Bicarpellary, syncarpous, ovary superior bilocular. In Capsicum ovary becomes unilocular in the upper part. In Datura ovary is tetralocular due to the formation of false partition. Numerous ovules in each locule on thick swollen and cushion like axile placenta. The carpels are slightly oblique in the position. Style simple, stigma two lobed. Nectar is secreted at the base of ovary or at the base of corolla tube between the stamens.

FRUIT: Berry (Solanum), septifragal capsule (Datura).

4.35.4.7 Scrophulariaceae

The characteristic features of Scrophulariaceae are explained in fig 4.13 as follows: (1) Erinus alpinus (2) Verbacum betonicfolium shoot with alternate leaves. (3) Rhinanthus minor shoot with opposite leaves and inflorescence. (4) Linaria vulgaris (a) shoot with linear leaves and inflorescence; (b) half flower with spurred corolla and stamens of two lengths. (5) Digitalis obscura leafy shoot and inflorescence. (6) Veronica fruitcans leafy shoot and inflorescence. (7) Scrophularia macrantha (a) lower lip of corolla with stamens; (b) Cross section of ovary. (8) Sibthorpia europaea dehisching fruit – a capsule. (9) Penstemon lyallii leafy shoot with irregular flowers and young fruits.

DISTRIBUTION: The family consists of 205 genera and 2600 species.

LEAVES: Simple alternate - Verbascum, opposite - Stemodia, whorled-Varonicastrum. Lower leaves opposite and upper leaves alternate - Antirrhinum. Heterophyllly in Ambulia, Limnophila heterophylla. The submerged leaves are dissected. The serial leaves are normal.

INFLORESCENCE: Axillary or terminal, usually racemose type, spike in Digitalis. Solitary axillary in Dopatrium, umbel – like in Castilleja.

FLOWERS: Bracteate, bracteolate, bisexual, hypogynous, usually zygomorphic, usually pentamerous, reduction to 4 or sometimes 2 members in the innermost whorl.

FLORAL VARIATION IN SCROPHULARIACEAE:

VERBASCUM: Bracteate, bracteolate, bisexual, hypogynous, actionomorphic, pentamerous except gynoecium. Calyx - sepals 5, polysepalous imbricate, Corolla - petals 5 gamopetalus, more or less equal in size, imbricate. Androecium - stamens 5, epipetalous, dithecous anthers, Gynoecium - Two median carpels, bicarpellary syncarpous, bilocular superior ovary with many anatropous ovules in each locule on swollen axile placentation.

SCROPHULARIA: Bracteate, bisexual, zygomorphic, pentamerous, hypogynous, Calyx - Sepals 5, deeply lobed, Corolla - petals 5, gamepetalous, personate, imbricate, Androecium - Stamens four epipetalous, didynamous, Gynoecium - Bicarpellary, syncarpous, bilocular, superior ovary with many ovules on swollen axile placentation.

LINARIA: Bracteate, bisexual, zygomorphic, hypogynous, Calyx - sepals 5 imbricate, corolla - petals 5 gamepetalous, personate anterior petal is spurred, imbricate, Androecium - stamens 4, epipetalous, didynamous Gynoecium - as in Scrophularia.
VERONICA: In this type there is reduction in the number of floral parts due to fusion, reduction and suppression of floral parts. Bracteate, bisexual, zygomorphic, hypogynous Calyx-sepals 4 due to the suppression of posterior sepal, Corolla-petals 4 due to fusion of the posterior 2 petals. Androecium - stamens 2, epipetalous. Gynoecium as in Scrophularia.

CALCEOLARIA: The anterior two sepals are united. The corolla tube is short and bilipped, the upper lip is small and it is formed by the union of posterior pair and the lower larger lip formed by three petals. Stamens 2, epipetalous, carpels 2. (Gynoecium as in other members)

SCOPARIA DULCIS: Flowers small white or yellow, axillary, bracteate, bisexual, actinomorphic, hypogynous, Calyx - sepals 4 lobed, imbricate, Corolla - petals 4 - lobed, rotate, stamens - 4, style single, stigma capitate (Lindenbergia), 2 - lamellate (Dopatrium).

FRUIT: Capsule.

4.35.4.8 Euphorbiaceae

In fig 4.14 the diagnostic features of Euphorbiaceae are explained as follows: (1) Euphorbia stapfii a cactus like species. (2) Phyllanthus sp. (a) shoot with flat green phylloclades; (b) female flower with single perianth whorl and three-lobed stigma. (3) Acalypha sp (a) leafy shoot and lateral inflorescence; (b) female flower with large, branched styles. (4) Euphorbia amygdaloides (a) flowering shoot; (b) the cyathium bearing horseshoe-shaped glands on the rim; (c) three-lobed fruit. (5) Croton fothergillifolius (a) flowering shoot; (b) fruit.

DISTRIBUTION: The family Euphorbiaceae is a large family of about 220 genera and about 4000 species. Cosmopolitan in distribution.
Fig 4.14. Euphorbiaceae
COMMON PLANTS: Croton sparsiflorus, Codiasuum variegatum (Croton), Acalypha indica, Phyllanthus niruri, Jatropha gossypifolia, Ricinus communis (Castor), Euphorbia hirta, Euphorbia heterophylla, Hevea braziliensis (Rubber), Euphorbia pulcherrima, Phyllanthus emblica (Nelli), Euphorbia tirucalli.


LEAVES: Simple or compound, alternate, opposite or whorled. Palmately lobed in Jatropha, Ricinus. Stipulate – stipules being hairy, glandular (Jatropha) or spinous. In xerophytic members the leaves are modified into scales. Venation is pinnately reticulate or palmately reticulate. Compound leaf in Cicca. Pinnately reticulate venation in Euphorbia hirta. Palmately reticulate in Ricinus. In Phyllanthus niruri the leaves are small and are borne on short branches of limited growth.

INFLORESCENCE: Inflorescence may be terminal or axillary – Raceme, Cyme or Cyathium.

a) In Acalypha inflorescence is catkin with female flowers at the base and male flowers at the top.

b) In Ricinus inflorescence is raceme with male flowers at the base and female flowers above.

c) In Jatropha inflorescence is a dichasial cyme. The central flower is female and the marginal flowers are male.

d) In Euphorbia inflorescence is cyathium. The cyathium of Euphorbia looks like a bisexual flower and is highly specialized. There is a central
naked female flower, which is surrounded by 5 groups of male flowers. The male flowers are arranged in monochasial scorpionoid manner. There are 5 bracts that form an involucre. Involucral cup encloses the flowers. On the outer surface towards the top of the cup may bear one or two nectar secreting glands. A single stamen represents each male flower. It is considered as a reduced flower because of the presence of a joint between the stamen and lower pedicel. A stalked ovary represents the female flower. The ovary is superior trilocular and syncarpous. 1 ovule in each locule on axile placentation.

**FLOWERS:** Unisexual, monoocious or dioecious. Usually monochlamydeous or rarely dichlamydeous (Jatropha), flowers regular/hypogynous, sessile or pedicellate.

**PERIANTH:** One whorl or 2 whorls of perianth lobes. Sometimes distinguished into calyx and corolla. The lobes are sepalloid or petaloid, free or united with valvate or imbricate aestivation. Perianth is absent in Euphorbia (flowers in cyathium). In Manihot utilissima the calyx is large and petaloid.

**ANDROECIUM IN MALE FLOWERS:** Androecium consists of single stamen in Euphorbia, many stamens (80-100) in croton, usually free. They are branched in Ricinus. Synandrium is found in Phyllanthus cyclanthera, anthers dithecous, dehiscence longitudinal or transverse. Nectar secreting glands are present in male flowers.

**GYNOECIUM IN FEMALE FLOWERS:** Tricarpellary syncarpous, trilocular superior ovary with usually 3 distinct terminal styles that are forked. Ovules one or two in each locule on axile placentation.

**FRUIT:** Capsule.
4.35.4.9 Orchidaceae

In fig 4.15 some of the diagnostic features of Orchidaceae are explained; 1. Bulbophyllum barbigerum habit 2. Dendrobium pulchellum habit 3. Saphronitis coccinea habit. 4. Oncidium tigrinum (a) flowers borne in a wiry raceme (b) column – united sexual organs 5. Paphiopedilum concolor (a) evergreen orchid lacking pseudobulbs (b) column side view (c) column front view. 6. Coelogyne parishii (a) aerial shoot with large pseudobulbs (b) column.

**DISTRIBUTION**: Orchidaceae consists of 500 genera and 17000 species, second largest family among monocots, widely distributed in temperate and tropical regions of the world.

**COMMON PLANTS**: Vanda, Habenaria, Orchis, Spathoglottis, Bulbophyllum, Oberonia.

**HABIT**: Annual or Perennial herbs with underground rhizome or bulb. Some are terrestrial e.g. Satyrium, Spathoglottis. Most of them are epiphytic e.g. Bulbophyllum, Coelogyne, Vanda. The roots of saprophytic orchid Neottia are associated with fungus forming mycorrhiza. In Taeniophyllum photosynthetic roots occur. Vanilla is a climber. Epiphytic orchids have clinging roots (for fixation), absorbing roots, and aerial roots with velamen. Pseudobulbs occur in Bulbophyllum. Pseudobulb is a thickened stem internode. In epiphytic forms growth is monopodial, and in terrestrial forms the growth is sympodial.

**LEAVES**: Simple, entire, alternate or opposite, parallel venation.

**INFLORESCENCE**: Usually a spike.
Fig 4.15. Orchidaceae
FLOWER: Bisexual, bracteate, zygomorphic, trimerous and epigynous brightly colored and showy.

PERIANTH: 6 lobes in 2 whorls of 3 each. The inner whorl is petaloid, perianth lobes, free, valvate. Of the three-perianth lobes the inner whorl of the posterior lobe is large and brightly colored labellum. Labellum may be tubular, strap-shaped, variously dissected or slipper shaped (eg. Cypripedium). In Orchis labellum has a tubular structure, spur which stores nectar. Due to the weight of the labellum the flower rotates in its axis through 180°. The process of twisting of the flower through 180° causes the anterior region of the flower to occupy posterior position and vice versa. This process is called resupination or torsion. As a result of resupination the labellum becomes anterior in position.

ESSENTIAL ORGANS: The axis of the flower is continued beyond the perianth into a structure called the column.

ANDROECIUM: Fertile stamens 1 or two. (if one it is the anterior stamen of the outer whorl and if two they are the lateral stamens of inner whorl). Single stamen is fertile in Orchis and two stamens in Cypripedium. (Monandrae – Orchis, Diandrae –Cypripedium). In Monandrae the pollen grains are united to form pollinia. Pollinium has a stalk caudicle and a sticky disk corpusculum. The corpusculum is attached to the sterile stigmatic branch, rostellum forming gynostegium. The number of pollinia varies from 2 (Orchis) to 8 (Spathoglottis).

GYNOECIUM: Tricarpellary, syncarpous, unilocular inferior ovary with 3 parietal placenta. Ovules are many in Monandrae stigma is 3 branched, 2 are fertile while the third one sterile and forms a beak like structure rostellum. In Diandrae all three are receptive.
**FRUIT:** Capsule, seeds small. Germination takes place when associated with fungus.


4.35.4.10 Liliaceae

In fig 4.17 the diagnostic and characteristic features of the Lily family are explained; 1. Lapageria rosea leafy shoot with solitary axillary flower. 2. Allium cyaneum habit showing flower in umbel-like cymes. 3. Calcochirius uniflorus habit showing basal bulb. 4. Aloe jucunda habit showing basal rosette of spined, fleshy leaves. 5. Kniphofia triangularis inflorescence 6. Lilium martagon (a) inflorescence (b) fruit – a capsule. 7. L. canadense half flower showing petaloid perianth segments. Superior ovary. 8. Convallaria majalis fruits – berries. 9. Colchicum callicymbium habit showing basal bulb, leaves beginning to emerge and flower with a six-lobed perianth, six yellow stamens and a trifid style.

**DISTRIBUTION:** Liliaceae consists of 240 genera and 4000 species. Cosmopolitan in distribution.

**COMMON PLANTS:** Allium, Gloriosa, Dracaena, Ruscus, Asparagus, and Smilax.

LEAVES: Simple, alternate, close spiral or radical, parallel venation (Gloriosa), reticulate venation in Smilax.

INFLORESCENCE: Raceme (Aloe), Umbel (Allium), rarely Cyme.

FLOWER: Bisexual (Aloe, Allium, Gloriosa), Unisexual, dioecious (Smilax), actinomorphic, hypogynous, trimerous.

PERIANTH: 3 + 3, united or free (gamophyllous or polyphyllous) Homochlamydeous or inner whorl petaloid, valvate or imbricate.

ANDROECIUM: Stamens arranged in 2 whorls of 3 each. In Ruscus there are only three stamens. In Allium and Aloe 6 stamens. Anthers dithecous dihiscence longitudinal.

GYNOECIUM: Tricarpellary, syncarpous, ovary superior, trilocular, ovules 2 to many in each locule on axile placentation. Style single stigma single or three branched.

FRUIT: Commonly loculicidal capsule, rarely septicidal. In Dracaenae the fruit is a berry.
FIG 4.6 VIEW MENU INTERFACE IN HOME PAGE

Digital image processing

Plant Taxonomy Introduction <-> Categories of Classification

Polypetalae <-> Gamopetalae

Monochlamydeae <-> Monocotyledons

Previous  Back  Next  Stop  Refresh  Home  Audio  Exit  Continue
4.36 PHYSICAL DESIGN OF MULTIMEDIA WEB BASED DIGITAL LEARNING TECHNOLOGY COURSEWARE

The first step is to install the courseware provided in the CD into the D Drive of the computer system, by clicking the setup icon on the CD. The setup process installs the courseware in the Computer. Care must be taken that one of the Internet browsers like Internet Explorer, Netscape Navigator, Mosaic etc. must be made available on the computer. The setup process will place a shortcut icon “e-learn” on the desktop. One can select the Multimedia Web Based Digital Learning Technology courseware by double clicking the shortcut icon “e-learn” on the desktop. The courseware is protected with a user login and password, which will differ from user to user, for the network administration purposes. After selecting the e-learn icon, the home page is displayed with six hyperlinks namely settings, master, help, view, clear, and exit.

The settings link is a supervisory level, which changes the setup of the courseware. This link is protected with an administrator password. The master link is used to select a subject title. The help link is provided to guide the learner throughout the learning session. The view link will display the course contents. The clear link will clear the current screen. The exit link will exit the current session. When one clicks the view link, the entire course contents are displayed in chapter wise hyperlinks. When these chapter links are clicked, the lesson links will be displayed. After clicking the lesson links, the learning process starts. Each lesson displayed on the screen is an ASP page with rich HTML contents; every page is provided with the entire course contents in the form of chapter links and lesson links. Apart from these links, as per the international standards of web page designing, two navigating links are also provided in each and every page, which enable the learner to navigate to the previous and next page. In addition to these links, seven link buttons are provided in each page. They are Back, Next, Stop, Refresh,
Audio, and Exit. The back and next are used for navigation; the stop is used to stop the process; the refresh is used to reload the values; home is used to go to home page; audio is used to hear the voice of the text, and exit is used to exit the current page.

The last lesson of every chapter contains the competency exam in the form of a quiz, which is user oriented and operated. After the quiz is answered, the learner will either submit for evaluation or will reset to redo the quiz. After submission for evaluation, the system evaluates and responds the result immediately, providing the right and the wrong answer by ‘ ‘ or ‘ X ‘ mark. Further the learner has the option to review the wrong answer, and provisions are made in the courseware to redo the wrong part of the text alone by the user if he desires. All buttons and hyperlinks provided in the courseware have the rollover and playback effects.

4.37 SYSTEM TESTING AND SOFTWARE VALIDATION

Testing is a set of activities that can be planned in advance and conducted systematically. Testing is a process of executing a program with the intent of finding an error. The philosophy behind testing is to find out the errors. Actually, testing is a stage of implementation, which is aimed at ensuring whether the system works accurately, efficiently and to ensure the reliability of the courseware before implementation. Therefore, the useful and practical approach to trace the errors is employed in the present study. In this study, different test methods have been done during the development phase of the courseware. The various test methods are stated below:

1. White Box Testing
2. Black Box Testing
3. Path Testing
4. Condition Testing
5. Data Flow Testing
6. Loop Testing
7. Top-Down Testing
8. Bottom-Up Testing

Software validation is achieved through a series of black box tests that demonstrate conformity with requirements. A test plan, which outlines the classes of test to be conducted and a test procedure, is defined to ensure that all functional requirements are satisfied.

4.37.1 White Box Testing

White box testing is a test case design method that uses the control structure of the procedural design to derive test cases. It tests for all independent path within a module and also ensures internal data structure validity.

4.37.2 Black Box Testing

Black Box testing methods focus on the functional requirements of the software. It attempts to find errors in functions, interface, external database access and initialization. This test method is applied to derive a set of test cases for system tolerance and specific combinations of data on system operations.

4.37.3 Path Testing

Path testing enables to derive a logical complexity measure of a procedural design and uses this measure as a guide for defining a basic set of execution paths.
4.37.4 Condition Testing

Condition testing is a test case design method that exercises the logical conditions contained in a program module. It focuses on testing each condition in the program. A number of condition testing strategies have been proposed which includes branch testing, domain testing and parameter testing.

4.37.5 Data Flow Testing

The data flow testing method selects test paths of a program according to the locations of definitions and uses of variables in the program. Data flow testing strategies are useful for selecting test paths of a program containing nested if and loop statements.

4.37.6 Loop Testing

Loops are the cornerstone for the majority of all algorithms implemented in software. Loop testing is a technique that focuses exclusively on the validity of loop constructs like simple loops, concatenated loops, nested loops and unstructured loops.

4.37.7 Top Down Testing

Top down testing is an incremental approach to the construction of program structure. Modules are integrated by moving downward through the control hierarchy beginning with the main control module. Modules subordinate to the main control module are incorporated into the structure in either a depth-first or breadth-first manner.

4.37.8 Bottom Up Testing

Bottom up testing begins construction and testing with atomic modules at the lowest levels in the program structure. Low-level modules are combined into clusters; a driver program is written to coordinate test cases;
then the clusters are tested; finally the drivers are removed and the clusters are combined moving bottom up approach in the program structure.

Having completed all the above in-built methods of test procedures, attempts were made for field testing outside the developed environment.

4.38 FIRST LEVEL FIELD TESTING

For the current study, extensive demonstrations have been carried out in different sites and tested online through the system with the courseware to ascertain whether the courseware works successfully. For this purpose, a four member team of experts including the investigator was formed to undertake the field testing.

The field testing team tested the courseware namely, Multimedia Web Based Digital Learning Technology courseware at three different sites – Department of Plant Biology and Plant Biotechnology, Kongunadu Arts and Science College, Coimbatore, Botanical Survey of India, TamilNadu Agricultural University Campus, Coimbatore, and Department of Biotechnology, GRD College of Arts and Science, Coimbatore with minimum level software and hardware configurations in the Local Area Network (LAN) environment and web server using FTP and TELNET environments.

The field testing team checked the Multimedia Web Based Digital Learning Technology courseware whether the multimedia concepts like text, music of different screen implementations and icon operations were working correctly or not. Also the team checked the vertical scrolling of the text screens along with the animated video clippings with voice narration. The field testing team also checked the various web links and its connectivity. All the integrated and interconnected aspects, which are unique to the courseware, were well tested.
As far as the Multimedia Web Based Digital Learning Technology courseware programmed in VB 6.0 is concerned, the Local Area Network (LAN) environment is a must. The courseware was installed in the web server in a remote login environment and connected it to the LAN server and was distributed to its client users. The field testing team ascertained that the courseware was working well in the distributed environment. The music and the resolution concept were also tested. After such rigorous testing procedures, the courseware was proved to be free from errors. Having satisfied with the performance of the courseware at the first level testing, it was planned to subject the courseware to the second level testing which is the final testing stage.

4.39 SECOND LEVEL FIELD TESTING

In the second level testing, a jury council of experts was constituted to judge the validity of the courseware, namely Multimedia Web Based Digital Learning Technology courseware. A twelve-member jury council was constituted drawing from different fields of study. The following were the experts selected to judge the validity of the courseware.

1. One faculty member from the Department of Botany, Bharathiar University, Coimbatore, who is an expert in Taxonomy and has gained considerable experience in the Biological field.
2. Two faculty members from the Department of Information Science and Management, Kongunadu Arts and Science College, Coimbatore.
3. One faculty member from the Department of Plant Biology and Plant Biotechnology, NGM College, Pollachi
4. A faculty member from the Training Division of Acenet Technologies, who has been taking efforts in developing software in e-learning for college learners.
5. Two faculty members of the Department of Computer Technology of Karunya Deemed University, Coimbatore, who are well versed in Computer Applications.

6. A faculty member of Distance Education and Syndicate Member of the University of Madras, who has made attempts to develop computer packages for distance education.

7. A faculty member and Principal of Government College of Education for women, Coimbatore, who has been concentrating more in developing educational softwares.

8. One faculty member of Microbiology and one faculty member of Bioinformatics, P.S.G. College of Arts and Science, Coimbatore were also drawn. The latter evinces interest in the application of educational technology in general and computer in particular in the teaching-learning process at tertiary level.

9. The guide and supervisor working in the Department of Education, Alagappa University, Karaikudi.

   Based on their suggestions and comments, the web server activities have been refined and the minor corrections regarding the titling aspects and designing were carried out.

   Having achieved the final refinement through the two level testing, the courseware was brought out in the form of permanent compact disc and is ready for usage. The compact disc is enclosed for perusal.
4.40 CONCLUSION

In this chapter, the different stages of the development of the courseware were discussed. The courseware was developed to the fullest satisfaction of the investigator, computer engineers and the members of the jury council. It is substantiated that total perfection was achieved in the production of the courseware in terms of multimedia aspects like sound, text, video displays, vertical scrolling of the text screens and their physical layouts and other integrated implementations. Despite achieving the judgement validity of the courseware developed, it was planned to achieve empirical validity of the developed courseware. In this regard, the following activities were undertaken.

1. Planning, designing and executing the experiment to collect the required data.
2. Analysis and interpretation of collected data through statistical means.

While the first activity is presented in the ensuing chapter (Chapter V), Chapter VI deals with the analysis and interpretation of data.