

Use of Educational Technology in Engineering Education – A Computer Assisted Instruction (Multimedia)Package for Engineering Students

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Abstract: Computer based instructional materials offer great potential for engineering education. The author(designer and developer) has experienced that the development of Multimedia package is a sequential programme which needs deep concentration and consistency to give a proper shape to the product. This paper presents the author's(designer and developer) experience in designing and developing a computer assisted instruction package for teaching multiple integrals to engineering students . The paper describes a systematic approach which has been used to design and develop the Multimedia (Computer Assisted Instruction) Package. Understanding the needs of the target audience and implementing this need the CAI is indeed a challenging task.

Key-Words: - Multimedia, Engineering ,Mathematics , Computer assisted instruction, Design, Development ,Education

1.Introduction:

The importance of Mathematics in Engineering and science is well recognized . Usually a first course in mathematics is about a study of mathematical methods .These are techniques or tools which students will be expected to be able to apply in other engineering modules later in their degree program .Mathematics has always been a core subject in the engineering curriculum .The central role played by Mathematics and Mathematical methods in all areas of Science and Technology, necessitates the importance of providing engineering students with a sound and wide mathematical background. With the increasing emergence of new, challenging interdisciplinary areas of study, new problems are generated . Students seeking entry to engineering programmes are expected to be competent in mathematics and science. One cannot expect engineering students to perceive mathematics in the same way as professional mathematicians usually do, yet the

professional engineer must acquire not only empirical but also abstract understanding of mathematics.[24] Failure to utilize appropriate technological tools while continuing to focus on mastery of symbolic manipulation often encourages memorization and rote algorithm practice at the expense of conceptual and graphical comprehension.[25] While many educators believe that mathematics is important for engineering students, there is a belief among some practicing engineers that the mathematics they learned in college is not applicable to their daily work.[26]

1.1 Technology in Teaching Mathematics

Many a time students find lengthy and abstract topics boring or feel that they are irrelevant . At such times teachers try to resort as much as possible not to deal with theory and only with examples . Therefore it has been felt here that with the use of the CAI even abstract ideas such as examples in Heat ,Mechanics and Electricity can be

given a more concrete form thereby increasing the interest level of the students. There are many studies aimed at the usage of information technologies in science education. Kelleher,[9] 2000, indicated the use and usage of different methods of information technology in his study. The usage liveliness, motion, colour and sound in giving the science topics provided abstract science concepts to be understood better and success to be more in interpreting diagrams or solving problems.

Henry Pollak from Bell Laboratories has been quoted as saying "With technology - some mathematics becomes more important, some mathematics becomes less important, some mathematics becomes possible" (Cohen, 1995). The potential of visually representing abstract mathematical ideas appears to offer promise to educators who realize the computer's capabilities .

Computer based instructional materials offer great potential for engineering education. Using readily available development software ,sophisticated graphics and animations can be created to present engineering topics in ways that are not possible within the confines of the traditional textbook and lecture format. [5] to be effective the software must use the capability of the computer to engage and stimulate students, both visually and through interaction and feedback. There are studies to demonstrate relationships between multimedia materials and successful learning performance.[20] Use of technology as a tool or a support for communicating with others allows learners to play active role rather than the passive role of recipient of information transmitted by a teacher, textbook, or broadcast. The student is actively making choices about how to generate, obtain, manipulate, or display information. Technology use allows many more students to be actively thinking about information, making choices, and executing skills than is typical in teacher-led lessons. Moreover, when technology is used as a tool to support students in performing authentic tasks, the students are in the position of defining their goals, making design decisions, and evaluating their progress.[21]

1.2 Rationale for Developing a CAI Package

The challenges facing Engineering Education are widespread, and often specific to the country or institution, and often involve resources. The opportunities are similarly varied, sometimes being of a general nature but more often specific to the

institution. Many opportunities refer to advanced and novel pedagogical approaches to teaching and facilitating learning.[18]

By using the computer in didactical activity the learning productivity is increased: the necessary information is faster and accurate obtained, process and sends, by eliminate unnecessary time delay.[19]

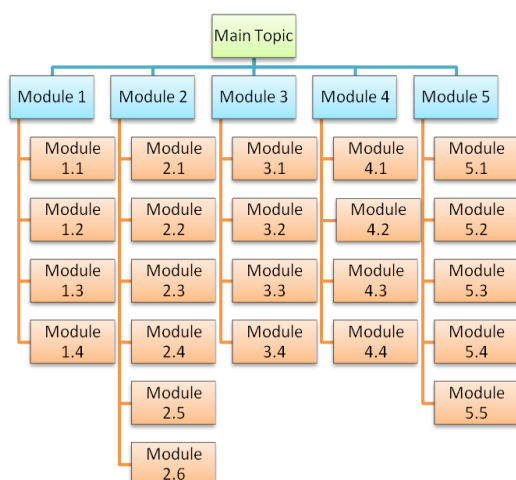
Computerized teaching leaves teacher more time for more creative activities, and/or for educational activity, for pedagogical and professional training, for programme innovating.[22]

- CAI is an efficient way to deliver content. The content equivalent to a one-day traditional lecture can be delivered in as little as one hour using multimedia. There are several studies to indicate that multimedia instruction considerably reduces learning time .
- CAI instructs learners with the same material, presented in the same manner, from learner to learner. The same consistent and technically correct message is received by each learner .
- Content delivery is ensured to be consistent and reliable and does not change in quality depending upon the class or the instructor .
- CAI encourages interactivity in the learning process. This in turn reinforces the learning content and helps the learner to retain the message. A learner can continually go back to the multimedia instruction in order to reinforce the message .
- CAI allows learners, who typically have different abilities and knowledge levels[13,14]

2. Design and Development Stages of the CAI Package :

2.1 Development of modular Structure

Fig. 1. Modular Structure



A Course design based on Modules helps both the Instructor as well as the students . Using the modular approach has certain advantages such as a focus on the components that go into the making of a single module at a time. Each module consists of similar components which increases consistency in the courseware and enables students to use the Package with greater effectiveness .

The description of the five Modules is as follows:

Module 1 - Concept of Integration and its applications

- Integration
- Methods of Integration
- Different types of mathematical curves
- Rectification of curves

Module 2 – Multiple Integrals

- Concept of double and triple integrals
- Geometrical representation
- Properties of the double integral
- Method of finding the limits of integration
- Direct evaluation of multiple integrals
- Evaluation of multiple integrals when the limits are not given

Module 3 - Change of order of integration

- Need of changing order of integration
- Sketching the region of integration
- Finding new limits
- Problems on change of order

Module 4 - Double integrals in polar co-ordinates

- Definition of polar co-ordinate
- Change from Cartesian to polar form
- Direct evaluation of the double integrals
- Evaluation of integrals when the limits are not provided

Module 5 – Applications of multiple integrals

- Area
- Volume
- Mass
- Centre of Gravity
- Moment of Inertia

2.2 Modeling the End-user

The End –user is the group – students, faculty etc. who will use the Multimedia Package .Here a profile of the target audience is created . Successful design results from a sensitive approach to one's subject: trying to see things from the point of view of the end-user, taking into consideration their needs, expectations and motivations, and communicating in a language appropriate to the target user(s). The problem is a complex one, made more difficult by the fact that different people learn best in different ways. If the designer proceeds with the aim of trying to make life simpler and easier for the end-user, even though that means extra design work, the result should be greater user motivation and more effective learning and use of the interactive system. There is an important need, then to accurately model or profile of the end-user, refining the model as the design process proceeds and feedback is obtained through the process of testing and evaluation. Successful design must include sensitivity towards one's subject.

Questions to be answered about the target audience which help in building a model of the user (or user profile) include the following:

- Age: what is the average age or age-range of anticipated users? -
- Background: Is information available about the backgrounds of the user which might help in answering further questions?
- Interests: what are the interests of potential users.
- Skills: what are the background skills and level of knowledge of users regarding the proposed content of the resource?

- Media sophistication: what are the background skills and level of knowledge of users regarding the proposed medium -- multimedia and the use of computers?
- Special Needs: Does the user have any special needs which may affect the presentation of information, and any input-output resulting from user interactions?
- Site: Where is the resource to be used: home, classroom, workplace, public space?
- Contact Time: What is the expected contact time with the resource?
- Learning context: Is there to be only one type of end-user or will there be several? How will the system be used: by one user or by several users simultaneously? Is the resource to be used as a presentation device by a teacher/trainer, as an aid to group discussion, in single-user standalone mode, or across a network?
- Diagnostics: is diagnostic feedback about user performance desirable?
- Password protection: Are interactions by the user to be stored and monitored?
- Confidentiality: If interactions are to be stored, is it likely that materials will be of a confidential variety and will this come under the provisions of the Data Protection Act?
- Distribution medium: will the materials be stored and accessed in standalone fashion or across a network?
- Support Materials: Is the resource to be used alongside other learning materials and, if it is, is its role supplementary or central to the learning experience?
- Will the needs of each user-type change over time, either as a result of interacting with the system or independently of the system[15]

The average age of the users is 18-21. The potential users want to understand and visualize the process of multiple integration and also their relevance in real world applications. The author(designer and developer)(designer) aims to meet the student's needs, which allows the student to get a Virtual peep- in experience of an integral! For this purpose the Multimedia system was selected and the envisaged site is the classroom. Students of engineering have a basic understanding of calculus studied at the 10+2 level. Most of the students are also familiar with computers their awareness

ranging from basics to highly skilled (programming) .

2.3 Drawing up a rule set

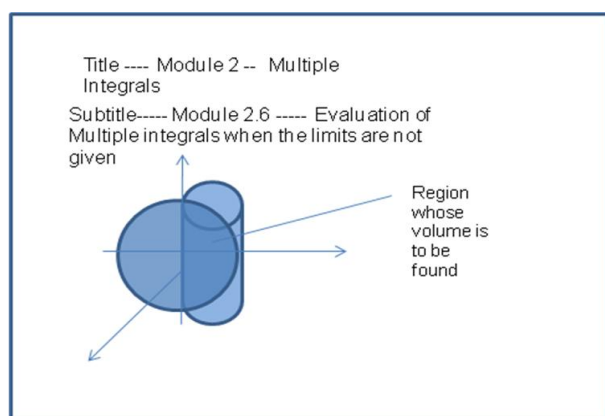
Drawing up a rule set is a stage in the development of instructional course; Rules tend to have a far greater degree of specificity. A rule set includes all the steps of the procedure plus explanatory information and background details. Writing the rule set helps the designer of the programme in a number of ways. First it enables the designer to fix the beginning and ending points of the topic, second, a complete rule set is the framework upon which the final programme is constructed. This applies to examples, exercises, and graphical illustrations. As per the rule set the author(designer and developer) analyzed the content and sequenced the frames first under the heading of Module 1, 2, 3, 4 and 5 and then into sub-modules. The rule decided was that the teacher will start from the Table of contents and then will proceed sequentially from one module to another module. The user would be able to navigate back and forth using the navigation tools provided.

2.4 Storyboarding

Storyboarding could be a very time consuming and intricate process. The widely known form which is used today was developed at the Walt Disney studio in the 1930's. A storyboard describes everything that will be contained in the package -- what will be the appearance of the menu, which images (still and moving) will be seen when and for how long. So the storyboards are the blueprints for the multimedia project. These rough sketches bring together all the elements with the controls and depict the sequence of the action. A major advantage of using storyboards is that it allows the user to experiment with changes in the storyline so as to generate stronger reaction or interest. The use of storyboarding in interactive media is now commonplace. The storyboard especially helps if the Instructional Designer and the Programmer for the CAI are different, as the exact thought of the designer may be first conveyed in the form of rough sketches and then a joint effort by both parties can be made for deciding which features are feasible and how to incorporate them in the package. For this particular package the author is the Instructional Designer as well as the Programmer. However the author still felt the need for storyboards before starting with the process of

programming . As a result of this first the storyboards were prepared for all modules.

Fig.2.Storyboard Figure



2.5 Sequencing the programme structure

The author(designer and developer)(designer and developer) arrived at a reasonable sequence for teaching, by inspection and by discussion with colleagues and experts in the subject matter. Some guidelines for sequencing of instructional design were observed. A few of these are summarized by Dean Christopher and Whitlock Quentin (1988).These guidelines are as follows:

- Proceed from simple to complex.
- Place procedural skill and knowledge in job performance order.
- Introduce pre-requisite skills prior to the time when they must be combined with other skills and than applied.
- Incorporate the relevant knowledge or skills in the task in which they are most likely to be used.

2.6 Report on Destination Site

In designing any interactive system, consideration should be given to the physical environment within which the system is to be used. At the most fundamental level, any health and safety legal requirements must be recognized and observed. Here are some recommendations as to the type of questions to address. [16]

- Where will the system be used: within the home, at work, in a public gallery or arena,

or in a dedicated learning environment such as a classroom?

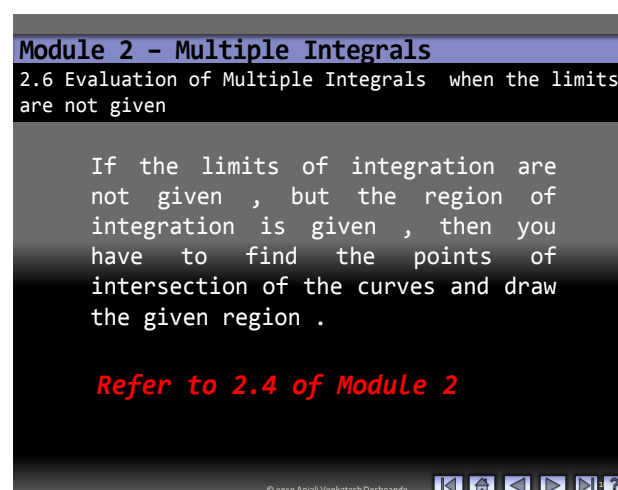
- Will it be a fixed or portable system?
- Will the user be standing, or sitting or lying down?
- Will it be observed by one or several users simultaneously?
- Can ambient lighting be adjusted by the user?
- Is ambient sound a problem in the sense that may distracts or annoy the user?
- Can ambient sound be adjusted by the user? In certain environments, user headphones may be required.
- Will the space be sufficiently ventilated to prevent the equipment from overheating and to ensure the comfort of the user?

2.7 Designing screen from frames

A Multimedia presentation is made up of a series of individual "frames." Those frames have accompanying text or audio narrative and they are presented in sequence.A module consists of series of frames. Some of these will be criterion frames, teaching frames and some testing frames.

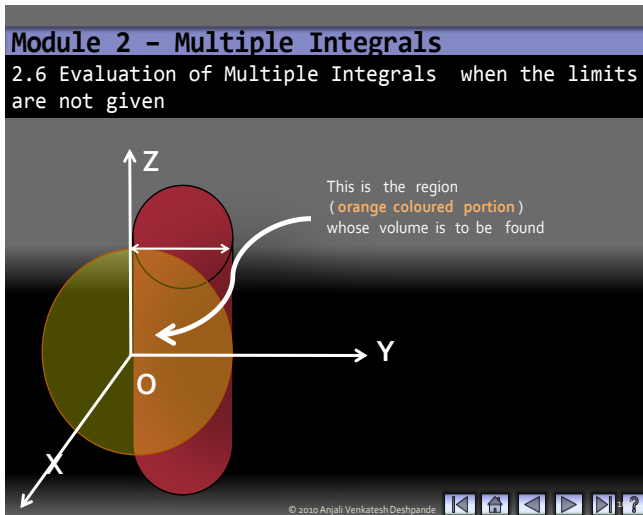
Criterion frames are written before the teaching frames. These frames test the teaching points and no reference material is used in the frame

Fig.3.Criterion frame



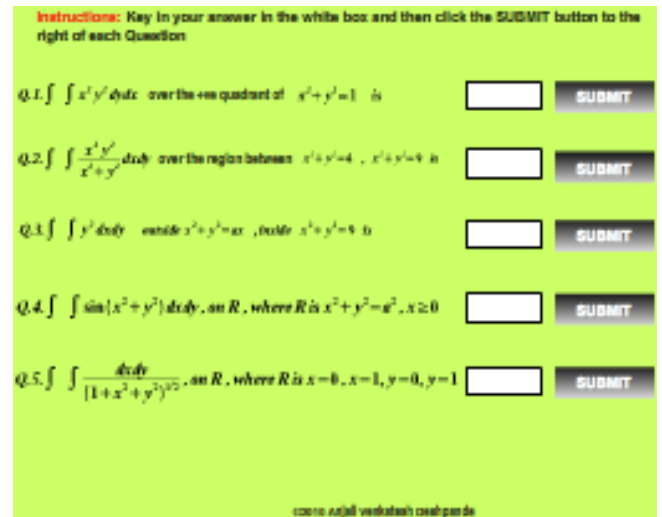
Teaching frames contain all the information needed to complete the course. Fig.4 shows the example of a teaching frame .

Fig.4. Teaching frame



Testing frames Teaching frames are associated with testing frames. Testing frames can have help and hint frames with them. These can be in the form of prompt or a clue. Anticipated wrong answers must be handled properly. Fig.5 is the example of a testing frame .This is a Quiz wherein the student keys in the answer in the box provided and then presses the ‘submit’ button . A response is generated for both correct and incorrect answers. Whereas a correct answer is praised an incorrect one is prompted to try again .

Fig.5. Testing frame

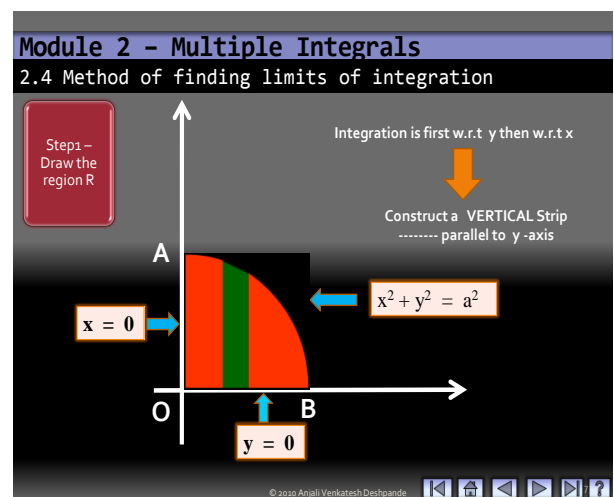


Once the frames are designed, they are converted in a useful manner for screen display. Therefore screen layout forms are designed at this stage.

2.8 Screen layouts

This refers to what is displayed on the screen of the terminal. A few simple rules for good design are stated by Woodhouse David and McDougal Anne (1986). They are as follows: 1) Consistency from one screen to the other. 2) Arrangement of statements in the same order as action to be carried out. 3) Avoiding excessive abbreviation. 4) use spacing generously and wisely. 5) No cluttering of the screen with too much information, or too great variety of symbol, colour or script or inverse colour blocks.

Fig.6. Screen Layout



In general, the minimum amount of information necessary to achieve the purpose is displayed. A small amount of graphical or textual information clearly and effectively presented is more likely to promote understanding. The technique of blinking has been used to catch the learner's eye towards an important concept. New images were displayed on the screen one at a time. However two or more changes simultaneously are not advisable. For example changing the graphics and the text displayed at the same time may not allow the learner to grasp the change. On the other hand a change in the graphic and then a change in the text will give some time for the learner to absorb the message and grasp the relevance of the change. Constant change makes the activity more interesting, avoiding visual boredom and helps in retaining attentiveness. At the same time, visual consistency is important to keep the user confident and comfortable with the conventions adopted, in the sense that the user must know where to look for new information, how to answer questions, etc.

2.9 Text

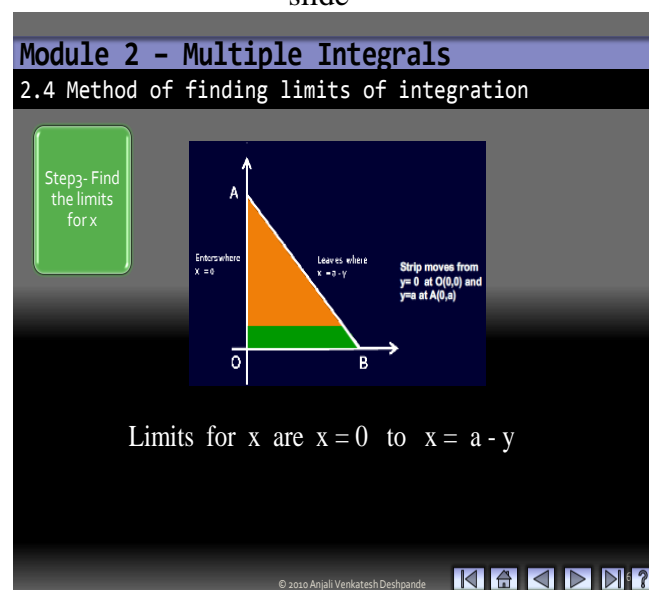
Inclusion of textual information in multimedia is the basic step towards development of multimedia software. Text can be of any type, a word, a single line, or a paragraph. The text used is of different type, size, color and style to suit the requirement of the CAI package. It is critical to make text understandable considering that students may not have a resource to help clarify doubts or difficulties arising from poorly written material. The message should be clearly written with simple words.

2.10 Graphics and colour

The human mind responds well to images, hence a subject is better explained with a pictorial/graphical representation, rather than as a large block of text. This aids in developing a "clean" multimedia screen. A large amount of text makes for a dull presentation. The large choice which is available as regards color palettes, preset fonts, formatting effects and backgrounds can make it a very daunting task to pick colors which will aid the instruction process or affect the learning process

otherwise. There is every possibility that a designer may go overboard with the use of color and graphics. Sometimes decisions like whether to use grayscale scheme instead of colors also had to be taken. Elements of a display which appear in the same colour give the impression of being related in some way. Conversely, elements in different colours are seen as separate. This coding is used deliberately to relate different parts of a display. The use of color in a consistent manner is important. For example throughout the software the headings have been written using the same scheme. Change should be made only if necessary and for a special purpose. At every stage the user's interest was given primary importance. While designing the CAI care was taken to choose color which would be pleasing to the eye and also not divert the attention of the learner from the main instructional material.

Fig.7. Colour Example of one slide



2.11 Animation

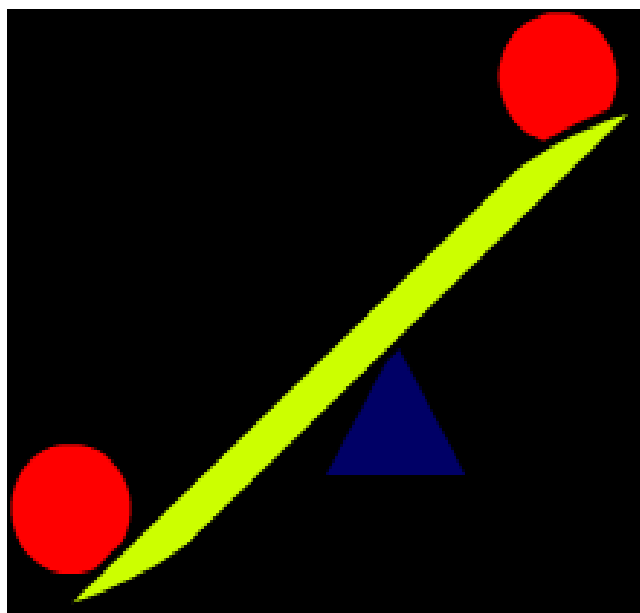
Animation means "to give life to" something. Moving images have an overpowering effect on the human peripheral vision. According to Reeves (1998), animation learning can stimulate more than one sense at a time and that may be more attention-getting and attention-holding.[17] Some fundamentals need to be followed while creating animations. The animation was run using different frame rates and the effect with each was carefully

studied before finalising its use. For some a very slow frame rate like 6 was considered appropriate whilst for others a rapid frame rate like 24 was good for creating the desired effect .So timing is the essence of animation . Animation has the following advantages :

- a) Demonstrate continuity in transitions
- b) Show dimensionality in transitions
- c) Show change over time
- d) Enrich graphical presentations
- e) Visualization of three dimensional structures
- f) Attract attention of the user

Here the author(designer and developer) created animations to demonstrate concepts as well as for problem solving .

Fig.8. Example of an animation



2.12 Timing

Allowing the user to control when changes to the screen display take place, and at what speed, makes a programme more flexible for use with a wide range of learners of different abilities.

2.13 Audio

Audio definitely succeeds in attracting the attention of the audience. Audio can be used to gain attention, give feedback, give directions, personalize computers, make annotations, provide multilingual support, teach how to pronounce words, provide meaning for images or image collections, and accommodate weak readers. In case the meaning is unclear to a learner using visual information only, the audio may clarify it. A sense of realism may also be experienced due to audio. It can be used to direct attention to important points .So a learner may be prompted to look at a certain portion of the screen .However sound effects should be used judiciously as they may distract the learner from the main message. Also continuous presence of sound may cause the learner to ignore the audio . Producing good quality audio can be difficult, moreover like other media most commercial audio, particularly music, is copyright. The learners should have access to appropriate hardware and software . Careful use of audio can greatly increase the ease of use, effectiveness and appeal of many applications. Thompson, Simonson, and Hargrave in Educational Technology, A Review of the Research (AECT) reviewed studies conducted on the effectiveness of audio media on learning when accompanied by other forms of media. Gordon (1998) researched the relevance of learner characteristics and learning styles when planning law school courses. He identified four major learning modalities, kinesthetic, tactual, auditory, and visual. Kinesthetic learners and auditory learners seemed to benefit the most by the integration of audio media into teaching strategies.[23]

2.14 Programming Phase

After the screenlayout is ready the next phase is to get the CAI package running on the .This may be done by the instructional designer or a team of programmers may be assigned the work . This was the phase in which all the pieces of text, graphics, animations, sound and video were integrated to prepare the multimedia .These are the tools that are designed to minimize the actual amount of programming expertise required by a teacher in the

creating of educational software. Two main groups of such authoring tools exist:

- i) authoring languages (AL)
- ii) authoring systems (AS)

Authoring languages can be regarded as a family of specialized higher order application languages, facilitating the production of software. Authoring systems are software packages that guided the researcher through the process eliminating the need to know to programme .

Conclusions

At the undergraduate level Mathematics is usually taught in the traditional way. Today the use of computers in education is widespread and is a fact that we cannot escape from, however it is pertinent to mention here that while technology can be a huge factor in motivating the students and facilitating learning; if not utilized properly they may lead students to an error .

It is expected that engineering education will evolve to make greater use of information and communications technologies, as tools that can help improve teaching and learning.[18]

The author(designer and developer) has experienced that the development of Multimedia package is a sequential programme which needs deep concentration and consistency to give a proper shape to the product. Understanding the needs of the target audience and implementing this need the CAI is a challenging task .The design and development of this particular package has been described here.

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