E-Learning tool for DSP

V. B. Dharmadhikari and D.Y.Loni

Abstract--**Advances in the multimedia technology provide an opportunity to enhance learning an Engineering subject like Digital Signal Processing (DSP). The paper presents a new teaching method that effectively integrates Information Technology into teaching and learning process. It contains three major components: Multimedia demonstrations for visualization of difficult concepts, Mathworks Matlab to smoothly introduce DSP by various examples using its graphical output, and a Question Bank to evaluate the understanding level of students. The method is well suited for teaching the theoretical & mathematical concepts of DSP. The appraisal of this new animated learning tool in the classroom is also included.**

***Index Terms*--Animation, auditory system, engineering education, equations, feedback, multimedia, question bank, simulation software, video, visualization.**

I. INTRODUCTION

TEACHING a large mass is always a very challenging task for Educators. This is due to many difficulties imposed on the teaching-learning process. These difficulties vary from encouraging attendance, delivering well-balanced course contests to keep students' interest on subject, getting students actively participated in the learning process, and motivating students. Learning in a large class is often recognized as less effective than in a small class. With the rapid development in Information Technology, especially the Internet, it is possible to address the above difficulties with the help of various existing technologies. The proper use of Information Technology not only enhances the students learning experience but also maximizes student productivity [1]-[5].

DSP is traditionally a highly mathematical subject. To learn various DSP concepts, large numbers of mathematical equations are introduced to students at the initial stage. However, many students just want a simple introduction to the basic concepts and techniques of DSP. The wide spectrum of students makes it very difficult for Educator to deliver well-balanced course contents to keep the attention and interest of most of students. This complexity is an initiation for the development of this E-learning tool. This tool provides the learners with extra flexibility, better class interaction, attractive teaching material, learning continuity, resource standardization and full time alternative support and hence helps to increase learner engagement.

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The key aim of this tool is to bridge the gap between the theory and mathematics of textbooks and the practical application and implementations of DSP.

II. PURPOSE OF E-LEARNING TOOL FOR DSP.

DSP is a bunch of mathematics, algorithms, and techniques applied to manipulate signals after they have been converted into a digital form. This includes a wide variety of goals, such as: enhancement of visual images, recognition and generation of speech, compression of data for storage and transmission, etc.

Eight good reasons for learning DSP

1. **It's the future!**
   Think how electronics has changed the world in the last 50 years. DSP will have the same role over the next 50 years. Learn it or be left behind!
2. **Software based--**can change behavior by changing software.
3. **Excellent graphics support**
4. **Powerful--** can do more things than you can do using analog hardware
5. **Simple computer programs**
6. **Economical--** similar to microprocessors, you can pack a lot of different functions into one chip
7. **Digital Filters--** simple to implement, incredible performance**!**
8. With the use of DSP Processors, the performance of the existing electronic applications can be enhanced to much greater level.

It is found that the DSP course is not the most attractive ones for the students, especially at the undergraduate level. This is due to the large number of mathematical equations that need in introduction of DSP concepts. However, students are fully aware the importance of DSP. Based on the observation, there are three major difficulties in addition to traditional problems for teaching a large DSP class [1]. They are:

A. Entry Barrier.

DSP is traditionally a highly mathematical subject, and the standard DSP textbooks contain a lot of mathematical exposition. This is necessary for a profound understanding of the subject. To learn various DSP concepts, large numbers of mathematical equations are introduced to students at the initial stage. Students need to put some efforts to appreciate the underlying concept. It is this initial complexity and apparent

abstractness that keeps students away from learning actively. However, many students just want a simple introduction to the basic concepts and techniques of DSP. This is like a challenge posted on an Educator on how to help the students to penetrate the barrier and speedup this process.

B. *Background Divide*

DSP texts start with the assumption that the student is having a deeper background of mathematics: calculus and differential equations, analog circuit theory through linear signals and systems theory, computer architecture & computer programming: basic programming and assembly language. A large class usually consists of students with different levels. The wide spectrum of students makes it very difficult for Educator to deliver well-balanced course contents to keep the attention and interest of most of students.

C. Broken Linkage.

Although many students appear to understand the concepts and associated mathematical equations, their awareness of how and when to use the various techniques is not well developed. There is a broken linkage between gaining knowledge and applying them to solve problems.

Along with this, there are many factors contributing towards the vast diversity of students' learning need in a classroom. Students' level of knowledge at entry to a subject is often the greatest challenge for educators. The other contributing factor is the students' individual learning ability and learning style preferences. Irregular attendance of students can cause diversity in the learning need of students. Their personality, social and family status, attentiveness and attention span can also be contributing factors. Finally students' basic skill proficiency and ability to speak the English language are other contributing factors.

The new teaching method is designed with the following objectives:

- Ability to make material being taught stimulating and interesting.
- To help students to penetrate the entry barrier quickly so that their interest and motivation in learning DSP are well maintained and their thinking ability is stimulated.
- A facility for engaging with students at their level of understanding.
- To deliver well-balanced course contents in a lecture to maximize the gain of learning and to encourage active learning.
- A desire to learn from students and other sources about the effects of teaching and how it might be improved.
- To make learning process enjoyable.

To achieve the above, the first important step is to source technologies that will enhance students understanding and stimulate their interest in the subject. The integration of multimedia technologies along with computer simulation yields the desired goals.

III. DESIGN OF E-LEARNING TOOL.

A multimedia learning object is defined as an animation that includes a combination of text, graphics, sound, and video packaged together. Unlike the standard lecture mode, learning objects allow flexibility and round-the-clock access to the students. The design issues of the tool are discussed below:

A. Tools selected:

This innovative teaching method includes following tools:

1) Incorporating Text

Text isn't necessarily seen as multimedia, but it is an important element in e- learning. In the development of each page of Animated Teaching tool, optimized linguistic and logical parsing and placement of words is done to have the most effect.

2) Incorporating Audio

The power of audio may often be overlooked, but the combination of written and spoken words does have a big impact on recall and retention of students

3) Incorporating Conceptual Visualizing.

Difficult concepts and theories are introduced to students using multimedia visualization before mathematic descriptions are presented. This step helps students to overcome the entry barrier so that they are able to understand the concept quickly. This allows students to have a clear picture of the underlying concept for a mathematic description, and stimulates their curiosity and thinking ability.

4) Incorporating Animation

Animated graphic elements are great to use in training. They are fun to watch, and can get a message across that words or audio (or even video in some instances) cannot. Animation is another element, however, that has to be used appropriately.

B. Mapping the Structure of the Subject:

In the development of tools for the subject, first a full mind map for that subject is drawn. This map is initially prepared by referring to the curriculum, but is further organized and optimized. Fig.1 shows the general shape of a mind map for a subject.

In the center is the title of the subject. Radiating from the center there are sections and for each section a number of topics and for each topic a number of issues. Once the mind map for a subject is completed and all the topics are identified, then the map is re-assessed and re-drawn until logical dependencies and weighted relevance between topics, sections and subjects are optimized. Every topic has a small map of its own.

Normally it is observed that only about 10% of students meet the minimum required level of curriculum knowledge. Therefore, in order to engage the other 90% of students, the educator will have to cover some of the pre-requisites. For example before starting Discrete Fourier Transform concept in

the class, the Educator needs to first cover the basics of Fourier Transform to have a proper tuning of all students.

C. Construction of the Tools:

Once the course content has been completely redesigned, then for each issue of a topic, scripting begins. The script that is produced here plays a crucial role in creating the correct map for the mind of the learner. The accuracy of the created mind map for the learner is as important as the time it takes to create the map. That means that the scripts and the animation created for each script cannot be too long.

After the scripts are carefully and expertly optimized, they were recorded in union with the created animation, generating the video files.

Fig. 1. General Shape and Structure of a Mind Map for a Subject

IV. SELECTED DSP MODULES.

As discussed earlier, in the design of Animated Teaching material for a subject like 'Digital Signal Processing', first a full mind map for that subject is drawn. This map is initially made by referring to the curriculum. The focuses is upon areas that students generally find difficult to grasp, and are key concepts. This E-learning Object developed illustrates the following concepts:

- Convolution.
- The Discrete Fourier Transform (DFT).
- Fast Fourier Transform (FFT) Algorithms for DFT computation.
- Design of Finite Impulse Response (FIR) Digital Filters.
- Design of Infinite Impulse Response (IIR) Digital Filters.

V. METHODOLOGY.

In the development of the tool, three learning styles are utilized. Visual and auditory are the main delivery style of the multimedia animations whereas to verify the kinesthetic style of learning, where learners acquire information by reflecting, experiencing and learning by making mistakes, a pre-composed set of questionnaire is also added. Each module is designed using following tools:

A. Video:

The video is an animated learning material to make learning more entertaining and interactive rather than passive. Imaginative animations and accompanying audio not only adds the extra stimulating flavor to the class, but also assured accurate and complete delivery of the important messages every time, all the time [2]. Sound, music, visuals, movement and talking encourages the user to participate in the learning process. The sound and animation worked together to attract the students' attention to the appropriate points at the appropriate times. Students remain completely focused and attentive throughout the time when the animated videos are being played. In traditional lecturing mode, to assist the flow of thoughts, we often use pointing, circling, arcing etc, but nothing as precisely timed and adequate like what could be achieved with computer animation. Animation of teacher's thoughts helps learners see what it means.

B. Matlab Tool for Verifying DSP Concepts.

The main difficulty in DSP course is the large amount of mathematical models and equations. The repetitive algebraic and the complete understanding of the physical concepts embedded in the equations require the use of a suitable computational tool. The introduction of Matlab in this tool is due to its facility to build up mathematical functions and also due to its powerful graphical user interface in order to display the results. Important concepts of DSP are smoothly introduced by various examples and using graphical output [3], [4]. It is an ideal environment wherein the students design DSP systems, verify results and change parameters, if necessary, to find out the best performance.

To encourage students to do more hands-on, a set of Matlab programs is included in E-learning tool**.** The use of Matlab package is useful to assimilate the DSP concepts, to provide better capability to solve related problems and beyond this create interest of the students in theoretical aspects of DSP and its practical applications.

C. Inclusion of Questionnaire Bank

The Question Bank is enriched with variety of questions like multiple choice, true/false, yes/no, short answer, completion type & numeric response. The students are encouraged to solve the Question Bank at the end of the multimedia presentation. This helps the students to check out the understanding of the concepts that they have just learned. The performance of the students is not used for assessment but it provides the instructor with timely data on where the "sticky" spots are for the learners, which are then addressed in the coming face-to-face session.

All these tools are assimilated together using Macromedia Flash. A sample of Convolution module is included in Fig. 2

VI. IMPLEMENTATION OF TOOL

First, students are prepared for taking up a new concept. Here the educator's interaction with students is aimed at gathering everyone's attention and if appropriate, quickly recalling previously taught relevant objects. Once the educator is convinced that initial layout for the topic is put down, then the tool is played using a projector and simple sound system.

This animated teaching tool puts forward the concept more systematically. The tool also provides the students with extra flexibility, better class interaction, attractive teaching material, learning continuity, resource standardization and full time alternative support and hence helps to increase student engagement. In the meantime the educator observes the students for signs of struggling/understanding and replays and/or explains parts if required.

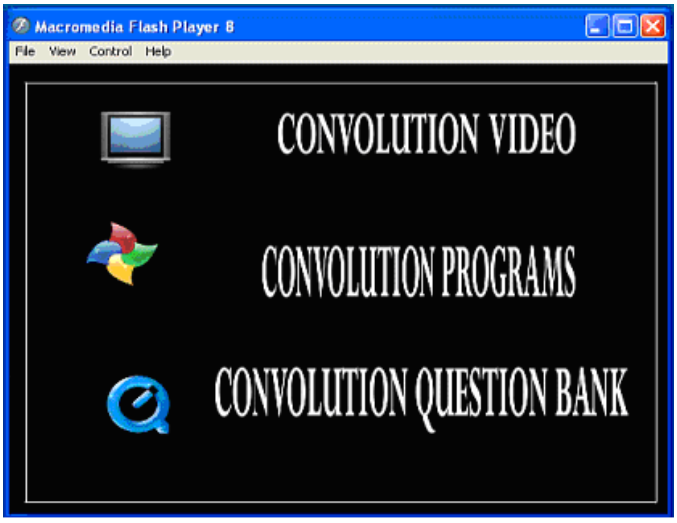

Fig. 2. Sample of Convolution Module

Finally students are encouraged to do a number of online activities at a pace that they are comfortable with allowing everyone to become fully engaged. These activities have an incremental design from simple to complex and relate directly to the topic at hand and may involve previously learnt concepts. In the meantime the educator observes helps and assesses learners while moving around in the class.

VII. EVALUATION OF MODULES.

Once educational tools have been developed further work is then necessary to determine the effectiveness of the tools by evaluating it, to verify whether the aim of facilitating an enhanced learning experience for students and enabling their development of understanding of the subject is achieved.

The role of feedback in any learning environment is clearly important. It provides two main functions; first, it helps educator to know what difficulties students may face in their learning process; second, it allows student to find out their weakness. Only by analyzing the tools in use in a teaching environment can information relating to the educational effects of any educational tool be identified. Only then can decisions be made as to whether the tool development has been successful or whether further development is required.

It was intended that addressing these questions would not only provide information to assist the tool developers and drive forward the development of the tools, but would also provide information of interest to lecturers and tutors relating to how the tools can impart DSP concepts more effectively and can best be deployed to support the teaching of DSP.

VIII. RESULTS

The radical change from traditional teaching approach to an E-learning approach aroused curiosity and excitement among students. Majority of students appreciated the simplicity and the ease of delivered teaching messages, but certainly everyone felt confident with this style of learning a technical subject using the blended tool. In assessing the effectiveness of the innovative teaching method and its supporting tools, we use two measurements, the students' performance and their feedback. Table 1 shows the collective views of students regarding the DSP tool and their experience.

This data was gathered via a questionnaire, which was filled and returned by 59 students out of the total of 72 students. The table contains some general questions the students were asked along with the average of the marks given by the students to each question. Students are asked to rank module between 0 to 10.

TABLE I
RESULTS FROM A QUESTIONNAIRE

Questions	Mean Mark
How effective is teaching DSP using E-learning tool?	9.00
How effective is your learning using an animated tool?	8.72
Does the animation incorporated actually help you to visualize the concepts of DSP?	8.92
Was their a proper flow & continuity of the topic throughout?	8.80
How effective is E-learning tool for revision?	8.97
How memorable do you find the E-learning tool?	8.17
How easy is it to understand DSP using E-learning tool as compared with conventional way of learning?	8.59
How much has the tool contributed towards your learning?	8.31
Do you feel motivated towards learning using such tools?	8.76

As it is shown in Table 1, the first set of five questions aimed to seek the students' response whereas, the second set of four questions aimed to capture their feeling and their experience of using the E-learning tool. On the whole the Qualitative feedback received from the students strongly favors the multimedia elements and cooperative activities performed in the class. In the view of the students, the multimedia content especially the learning objects and Matlab programs greatly enhanced the quality of delivery of the course. The students are inspired by this blended teaching method and have gained an improvement in their learning experience.

The E-learning tool relieves the educator from the task of one-way transmission of chalk and talk teaching, enabling him/her to focus completely on the two-way interaction with

students. This will further improve the efficiency of classroom teaching. While tool is delivering the teaching messages, the educator can concentrate on identifying signs of learning difficulties by observing the learners. This is virtually impossible in traditional classroom teaching since transmission of knowledge absorbs most of the educator's energy.

Students with irregular attendance can be given the chance to keep abreast of class progress. Once a lesson has been delivered in the classroom, then the same source can be used again for reflective learning and revision. This approach provides the best support for those who were absent or require more repetition before they are confident of their learning.

Students with language difficulty and deficiency in basic skills can have more time to reflect back on the lessons afterwards without the need for recording them. Also students with increasingly shorter attention span can benefit from concise teaching messages of E-learning teaching objects.

Hence it displays all the attributes of an effective and workable blended learning solution to address diversity at curriculum level.

The following are some feedback from students.

1. *"Understand the concept better."*
2. *"Creates interest in the subject."*
3. *"Animation assists to visualize the concept. The animations are memorable."*
4. *"It is a permanent source of research material."*

IX. CONCLUSION

A new teaching approach is developed for effective teaching of subject like Digital Signal Processing. The tool incorporates method to address the difficulties faced by students in learning an engineering course. Though it requires expert educators to redesign course contents, a huge literature survey and expertise to develop animated teaching objects which is very time consuming and create a different classroom teaching approach, this often means development of E-learning tool is slow and expensive. But by improving efficiency of classroom teaching and offering a new method of teaching-learning for a mathematical subject like DSP, it reduces the effects of diversity at curriculum level and improves individuals' interest in the subject.

The feedback from the students is very positive and encouraging. This new teaching approach will definitely be enjoyable and productive.

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IX. BIOGRAPHIES

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