

Effective Teaching – Learning Practices Adopted in Signals and Systems (SAS) Course

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Abstract: As the course Signals and Systems (SAS) is loaded with abstracts, concepts, mathematical analysis and applications, students need to remember, analyze, compare, interpret and apply the concepts to solve problems. Students find it difficult to comprehend & understand abstract concepts. The course is pre-requisite for many engineering courses such as Control systems, Analog communication, Digital communication, Digital signal processing, Image processing, Speech processing etc., which the students study later in their higher semesters. It is therefore very essential that students be taught this course in such a way that they learn and retain the content of the course for a longer period. So teaching SAS course effectively for engineering students is a big challenge.

In this paper an analysis of the various levels of difficulties generally students face while undergoing this course is made. A systematic action plan implemented to address each of these difficulties is discussed. Finally analysis of Course Outcomes before and after implementing effective Teaching-Learning Practices is presented.

Keywords: Teaching-Learning, Signals and Systems, Tutorials, Activities, MATLAB.

1. Introduction

This paper makes an attempt to identify the difficulties students normally face while learning the SAS course. These difficulties are then categorized and eventually Teaching-Learning practices are designed to address each them. Course contents include: Classifications of signals, Elementary signals, Operations on signals, LTI systems, Convolution, Difference equations, Fourier representations and applications, Z transforms and applications. The course outcomes are listed in Table: 2.

Course contents, topic level objectives, lecture plan, teaching learning methodology and assessment methodology are designed to meet the program outcomes.

2. Background

Several papers are published on improving teaching learning methodology for effective class room teaching specifically in SAS course. To achieve expected learning outcomes of the signals and system course, University of Texas at El Paso^[1] has implemented the technology-based instruction for two consecutive semesters. It is claimed that students taking the course were able to actively participate in their learning by using four technologies: Connexions, Quad base system, interactive simulations and Openstax Tutor. Students used the modules in Connexions to study at their own place and time. They were able to reinforce their knowledge in specific topics of the course from the homework feedback by using the Quad base system. The paper claims a significant improvement on the learning outcomes when technology-based instruction is used compared to the traditional instruction.

The paper, " Refined 'Chalk-and-Talk' of Lecture Content: Teaching Signals and Systems at the Griffith School of Engineering^[2] " by Stephen So, presents that for courses such as SAS traditional way of teaching through chalk-and-talk i.e., blackboard teaching is more efficient and delivers more dividend than teaching using Power Point Presentations.

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Richard Vaz, Nicholas Arcolano WPI , 2001^[3] discusses importance of combining outcome based learning and assessments. It emphasizes on use of Simulink tools, assignments, projects for the course.

3. Objective

The objective of this paper is to identify the difficulties generally encountered by the students while learning SAS and to use innovative methods to address them.

4. Methodology

Effective teaching of SAS would enable students to (i) learn the basics (ii) analyze the information processing challenges in real-time projects (iii) apply these concepts in other engineering courses as well.

The proposed work is classified as different phases such as (A) Identifying difficulties of students (B) Categorize the difficulties (C) Addressing the difficulties with effective Teaching-Learning Practices.

By analyzing the performances of 170 students in each year during the period 2008-11, in Continuous Internal Evaluation (CIE) and Semester End Examination Evaluation (SEE), the mistakes generally committed by the students in tests/quiz/Assignments/End exams are identified. An attempt is made to consolidate them in Table: 1

Table: 1 Analysis of Mistakes Committed by the Students over a period of 3 years (2008-2011) with a strength of 170 students in each year.

Sl. No	Mistakes committed by the students	% ge of students [#]	Problem category
1	i) While using formulae for computing Energy, Power, Fourier/ Inverse Fourier coefficients	20	Memorizing the Formula Avg: 20%
2	i) While representing signals by mathematical expressions ii) Performing Integration, Differentiation, Geometric series iii) Simplification iv) Performing combined operations : Time shifting, Time scaling, Time folded signals	18 25 20 25	Performing mathematical operations: Problem-solving skills. Avg: 22%
3	i) While Sketching the signals ii) Taking (t - n) range and (τ - k) range in convolution operation.	15 25	Convolution Process Avg:20%
4	i) Confusion with continuous & discrete time representations; periodic & non periodic signals ii) Confusion with Time domain & Frequency domain operations iii) Confusion with Impulse response and Frequency response iv) Justifying stability &	12 15 13	Conceptual Mistakes Avg:16%

	causality of system in terms of Poles & Zeros v) Sketching of spectrum of sampled signal : Aliasing concept	20 20	
5	i) Applying Fourier / Z transform properties to solve problems ii) Applying Z-T/ F-T to find Stability, causality of systems	25 25	Applying the concepts Avg: 25%

[#]There is overlapping of students while committing different category of mistakes

5. Effective Teaching-Learning Practices

Considering the difficulties students generally encounter the following Teaching-Learning Practices are adopted. Ideally the Teaching Learning practices should be designed to nullify the effect of variation in faculty and student intake.

A. Conducting Weekly Tutorial Classes

Students who have secured good grade in Engineering Mathematics which is the pre-requisite for SAS course are identified to assist the faculty in conducting tutorial classes. Tutorial classes for a batch of 15 students involving these bright students of same class are conducted weekly. One-to-one attention is possible as the strength of class is small. Problems can be discussed with students individually. Scope is there to allow the students to solve problems in their own pace. Few students hesitate to express their trivial doubts with faculty which is addressed by involving their own class mates in tutorials. In tutorial classes, each student will solve problems with the help of peer learner and faculty. This practice develops problem-solving skills among the students, encouraging them to learn from each other. Assisting their fellow class mates in turn helps them to get their concepts strengthened.

B. Convolution Animation

Since many students find performing convolution operation difficult, special attention is given to solve convolution problems through animation. This enables students to visualize the entire convolution process. Convolution Animation is developed to illustrate the convolution concepts and is uploaded on the internet which can be downloaded from <http://sites.google.com/site/rsswamy18/signals&systems/convolution>. Convolution operation for continuous time and discrete time signals are demonstrated in this animation which can be easily understood by the students.

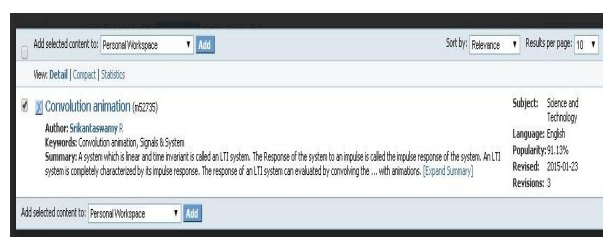


Fig:1. Openstax_cnx display screen shot

The convolution is illustrated here with couple of examples.

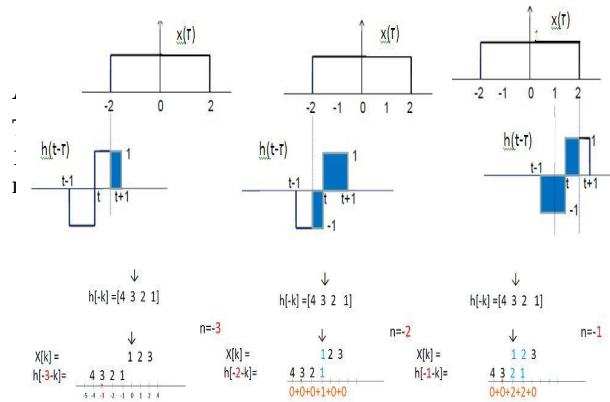


Fig. 2. Convolution examples

C. Activity Based Learning

Technical quiz competitions are organized after covering LTI systems and Fourier representations. "Pick-and-speak or sketch" is organized covering signal operations, system properties, Fourier representation formulae topics. Learner centric teaching is implemented. These activities help students to interact freely with faculty which intern enables them to get their doubts cleared. Concept retention also improves considerably.

D. Conducting Remedial Classes

To boost the morale of slow learners remedial classes are also conducted. Here students will be taught easy ways to memorize formulae. Thought provoking questions will be raised. Students are encouraged to solve a problem using different approaches.

E. Effective Utilization of Mathematical Tool

MATLAB tool is used to demonstrate the concept of representation of real valued and complex valued signals, computing energy, spectrum of signals, poles & zeros plot, sampling theorem, impulse response, and frequency response. Some examples are shown below.

%Real Valued Exponential signal

```
a=0.6;
t=[-5:20];x=(a).^t;
figure(3);
plot(t,x),xlabel('t'),ylabel('y(t)');
title('Exponential Signal');
```

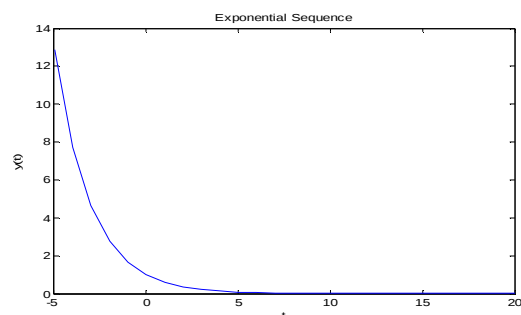


Fig.3 Exponential Signal

%Delayed Unit Step Sequence

```
n1=-20;n2=20;n0=2;
n=n1:n2;
step=[(n-n0)>=0];
figure(4);
stem(n,step),xlabel('n'),ylabel('y(n)');
title('Delayed Unit Step Sequence');
```

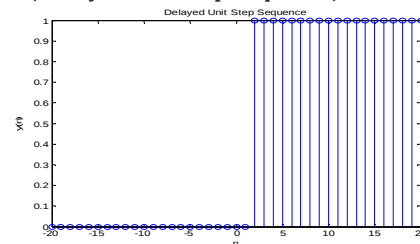


Fig.4 Delayed Unit Step Sequence

% Triangular Wave

```
t=0:0.0001:4/50;
x=sawtooth(2*pi*50*t,0.5);
plot(t,x),xlabel('t'),ylabel('x(t)');
title('Triangular Wave');
```

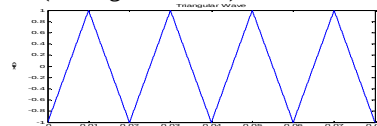


Fig.5 Triangular wave

% Representing Complex Valued Signal

```
n=-10:10
x=exp((-0.1+(j*0.3))*n)
mag=abs(x); phase=angle(x)
y=real(x); z=imag(x)
subplot(221),stem(y),title('real part of signal')
subplot(222),stem(mag),title('Mag of signal of signal')
subplot(223),stem(phase),title('PHASE of signal')
subplot(224),stem(z),title('imag part of signal')
```

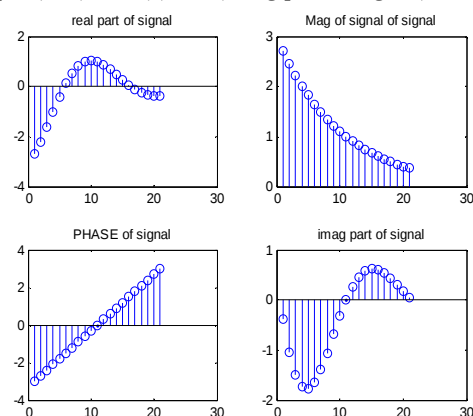


Fig:6 Representation of complex valued signal

% Energy Computation for complex signal

E=sum(abs(x).^2) ; E = 40.1516

% Representing Spectrum of a Composite Signal

%signal representation

```
fm1=50;fm2=100;fm3=250;
fs=1000; t=0.00001:1/fs:10/fm1;
x=sin(2*pi*fm1*t)+ sin(2*pi*fm2*t)
+ sin(2*pi*fm3*t);
N=length(x);
plot(t,x)
xlabel('time in sec')
ylabel('x(t)')
```

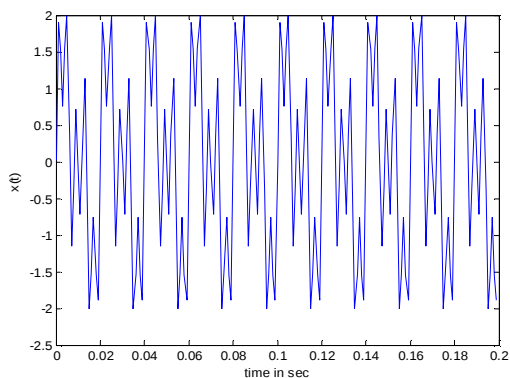


Fig.7 Composite Sinusoidal Signal

% Spectrum of signal

```
x_f=fft(x);
l=0:N-1;
k=(fs/N)*l;
stem(k,abs(x_f))
xlabel('frequency in Hz')
title('Spectrum of Signal')
```

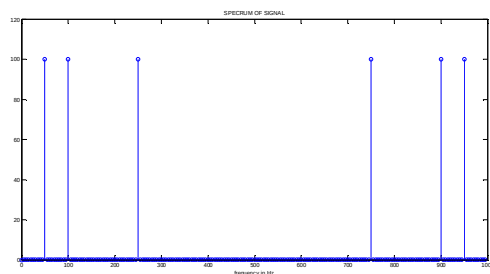


Fig: 8 Spectrum of the Composite Signal

% Poles and Zeros

% System:

$y[n] = x[n] + 0.5y[n-1]$

$a=[1,-0.5]; b=[1];$

$y=zplane(b,a);$

% Concept

$y[n] = x[n] + 0.5y[n-1]$

$H(Z) = \frac{1}{1 - 0.5z^{-1}}$

$h[n] = (0.5)^n u[n]$

Since $h[n]$ is Right handed side & absolutely summable, the system is both Causal & stable Since $H(z)$ has pole inside unit circle, the system is both Causal & Stable

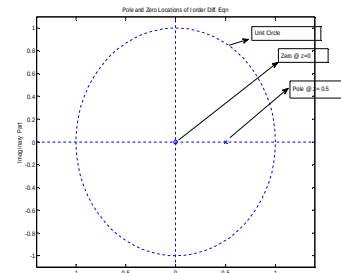


Fig: 9 Poles and Zeros of I order DE

% Impulse response and Frequency response

% of system

$y[n] = x[n] + 0.5y[n-1]$

$a=[1,-0.5]; b=[1];$

$\text{impz}(b,a)$ % Impulse response

$\text{freqz}(b,a)$ % Frequency response

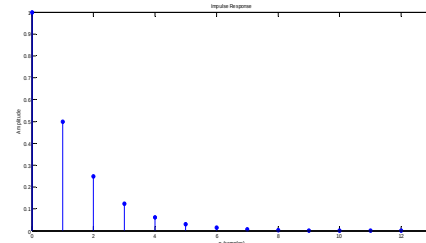


Fig:10 Impulse Response of the I order DE

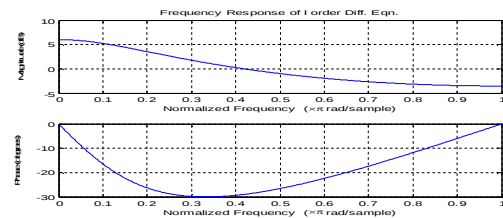


Fig 11 Frequency response of the I order DE

6. Mapping of Teaching-Learning Practices

Fig:12 shows how each of the difficulties of the students is addressed by one or more Teaching-Learning Practices adopted.

Course Outcomes (COs)	Before 2012	2012	2013	2014
CO1: Evaluate different types of signals.	D	C	B	B
CO2: Analyze the properties of system	B	B	A	B
CO3: Compute the response of LTI system.	C	B	B	A
CO4: Analyze the signals in frequency domain.	C	C	B	B
CO5: Illustrate the application of Fourier representation.	C	B	B	B
CO6: Apply Z-transforms for broader characterization of discrete time signals and LTI systems.	B	A	A	A

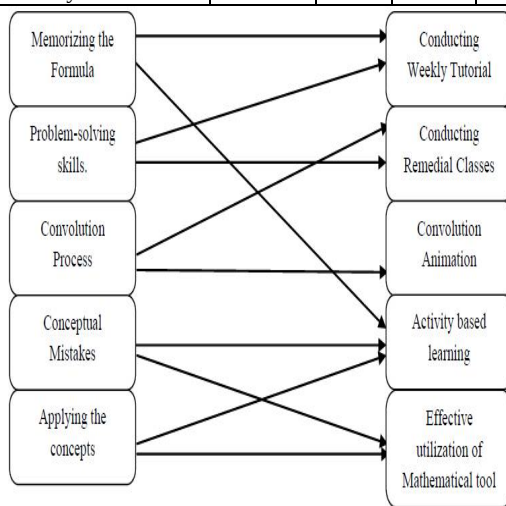


Fig:12 Mapping of students' difficulties and Teaching-Learning Practices

7. Evidence of Success

The result of effective Teaching-Learning practices adopted is presented here. The bar chart in Fig: 13 reflect the outcome of the Teaching-Learning practices under taken during the period 2012-14. It clearly shows that percentage of students committing mistakes in different problem category has been declining since the introduction of effective Teaching Learning practices. It is also encouraging that the #overlapping of number of students committing different category of mistakes is reduced since 2012. This has resulted in improvement of results in SAS course. Data is analysed for the same set of faculty teaching for three years.

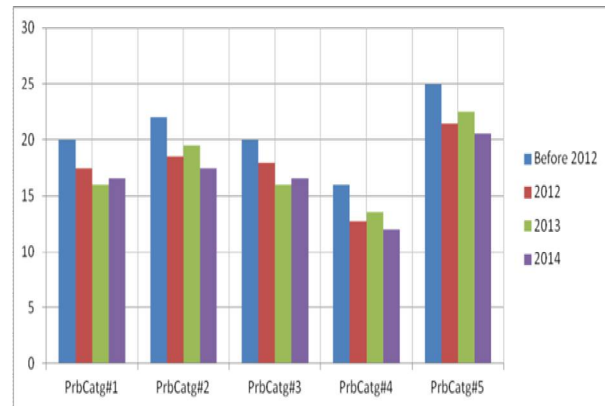


Fig. 13 Result of Teaching Learning practices undertaken from 2012.

Questions from examinations, addressing each Course Outcome (CO) are considered for assessment. Marks obtained by all the students for those questions addressing each CO are averaged. If the percentages of the average marks are less than 45: D, 46 to 60: C, 61 to 75: B, 76 to 90: A, 91 to 100: S grade is marked. This analysis is presented in Table: 2.

Table: 2 Analysis of Course Outcomes before and after Implementing effective Teaching-Learning Practices

8. Conclusion

In this paper, a methodology to identify the common difficulties students face while learning Signals and Systems course is devised. Difficulties are identified and categorized. The average percentage of each problem category is estimated. Considering these issues, innovative Teaching Learning methodologies are designed and adopted to address these difficulties. Finally the result of the innovative Teaching Learning practices adopted is presented. There is always a scope to come up with new innovations to improve teaching and learning process to achieve good results.

Reference:

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