

AC 2008-812: ON-LINE LEARNING TOOL FOR UNDERGRADUATE ELECTRIC MACHINES AND POWER SYSTEMS COURSE

Khalid Al-Olimat, Ohio Northern University

ON-LINE LEARNING TOOL FOR UNDERGRADUATE ELECTRIC MACHINES AND POWER SYSTEMS COURSE

Abstract

This paper explores both the modules of the developed Electric Machines and Power Systems (EMPS) software and the assessment results of an investigation of learners' attitude toward this media based teaching tool. The investigation is based on a survey completed by fifteen students enrolled in Electric Machines and Power Systems course at Ohio Northern University. The students are majoring in Electrical Engineering. The teaching tool is designed to optimize students' performance through an instant observation of and among the parameters of transformers, dc machines, ac machines and transmission line models. The information and data collected from survey and questionnaires were analyzed and used for the evaluation of attitudes toward the use of this media based teaching tool. Students have responded favorably to and expressed their satisfaction with the developed software tool.

Introduction

In recent years and due to the evolving technology and its attendant introduction of new material into the curriculum, most colleges face a demand to optimize their curriculum and increase the content of courses. This challenges educators to determine more efficient ways of designing their courses and presenting the material in order to ensure that students are provided with information to help them pass along the essential knowledge of their field and acquire computer skills to be adequately prepared to function as high quality professionals of the future.

Meeting the instructional needs of students to learn the material is the keystone of every effective program. The tools of educational technology and software hold tremendous potential for improving both teaching and learning processes. Cohen et al¹ performed analysis of 74 studies that compared visual-based instruction with traditional instruction. They found that students learned more from visual-based instruction than from traditional teaching. It is evident from the paper by Powell et al² that computer based instruction may be the key to improving the grade point average of students. Bartsch and Cobern³ found that PowerPoint presentation can be beneficial to students' learning. Papers⁴⁻⁸ reported that those who integrate technology in the learning process believe it will improve learning and better prepare students to effectively participate in the 21st century workplace. Today, educators are concerned with how to use technology to enhance and enrich their learning environments rather than asking whether to use it.

Multimedia which is defined in paper⁹ as "the integration of video, audio, graphics and data within a single computer workstation" and according to Willis¹⁰ multimedia enables the instructor to custom design and individualize instruction and learner to "plan, execute, and manage" his or her learning experience at the rate, place, and time of the learner's choice.

Folkestad and De Miranda¹¹ have used multimedia through screen-capture to teach students how to use CAD software. They reported that students were unsatisfied with this instructional tool due to its fast pace and the need to switch back and forth from the recorded lecture to the CAD software. In paper¹² a new instructional tool was developed and the problems encountered in reference¹¹ were solved by having a variable pace (slow, medium, fast) which allows the students to proceed at their desired pace. In this paper, a different approach is used. The approach is utilizing this developed software which is one that the students can install it on their personal computers and be able to run it as a standalone program that doesn't need the assistance of any other software. This program was developed using C# and Graphical User Interface (GUI) that provides a user friendly platform for entering all of the data necessary to perform the calculations and receive the outcomes of those calculations. As a helpful learning tool, this program instantly shows the effects that changing one input has on every different aspect of the output and also makes it possible for students to check their homework answers.

This paper is organized through sections. The first section describes the course. The second section includes some screenshots of the software. The data collection and assessment method is described in the third section. This is followed by the results of the assessment and finally the conclusion.

The Course

Electric machines play an important role in industry as well as in our day-to-day life. They are used in power plants to generate electrical power and in industry to provide mechanical work. They are an indispensable part of our daily lives. They start our cars and operate many of our household appliances. An average home in the United States uses a dozen or more electric motors. The electric machines and the power systems areas have been and will continue to be amongst the most important fundamental courses of the electrical engineering curriculum.

Recently, I have attended an NSF-sponsored workshop on the teaching of power engineering courses. The workshop has hosted more than 140 power engineering educators. It was mentioned that 75% of the electrical engineering programs across the United States require a combined course in energy conversion (electric machines) and power systems. As a result of the workshop, it has been recommended that every electrical engineering program should have a combined course in electric machines and power systems to optimize the curriculum. The Electrical & Computer Engineering and Computer Science (ECCS) Department at Ohio Northern University has approved the recommendation and combined two courses the ECCS 335 Energy Conversion and the ECCS 336 Power Systems into one course. The combined course is called ECCS 338 Electric Machines and Power Systems. The course covers the topics of both earlier courses. The topics of this new course include the following:

1. Magnetic circuits
2. Direct current motors
3. Three phase circuits
4. Power transformers
5. Synchronous generators and motors

6. Induction motors
7. Per unit and impedance diagrams
8. Transmission line models
9. Load flow analysis
10. Optimal dispatch of generation.

To optimize the time spent in the classroom and based on the above topics, a viable teaching tool on this subject must be designed to enhance the learning process on every possible front. This will help both students as well as the instructor of the course.

Software Modules

This software is one that the students can install it on their personal computers and be able to run it as a standalone program that doesn't need the assistance of any other software. This program utilizes C# and Graphical User Interface (GUI) that provides a user friendly platform for entering all of the data necessary to perform the calculations and instantly receive the outcomes of those calculations. As a helpful learning tool, this program instantly shows the effects that changing one input has on every different aspect of the output and also makes it possible for students to check their homework answers. There are six modules so far that encapsulate most of the calculations necessary in solving problems in the following topics:

1. Power transformer characteristics and performance measures
2. Direct-current motors characteristics and performance measures
3. Synchronous machines characteristics and performance measures
4. Induction machine characteristics and performance measures
5. Three phase circuits
6. Transmission line models.

Some of the modules are shown in the following figures and they will be displayed to the audience using a laptop during the presentation.

a. Power Transformer Characteristics

Example:

A 100-KVA, 400/2000 V single phase transformer has the following parameters:

$$R_p = 0.01\Omega \quad R_s = 0.25\Omega \quad X_p = 0.03\Omega \quad X_s = 0.75\Omega \quad G_c = 2.2mS \quad B_m = 6.7mS$$

Note that G_c and B_m are given in terms of primary reference. The transformer supplies a load of 90 KVA at 2000 V and 0.8 power factor lagging. Calculate the primary voltage and current using the exact equivalent circuit referred to primary side.

After students enter the given values in the problem as shown in the figure, the output which is the solution of this problem is shown in Figure 1.

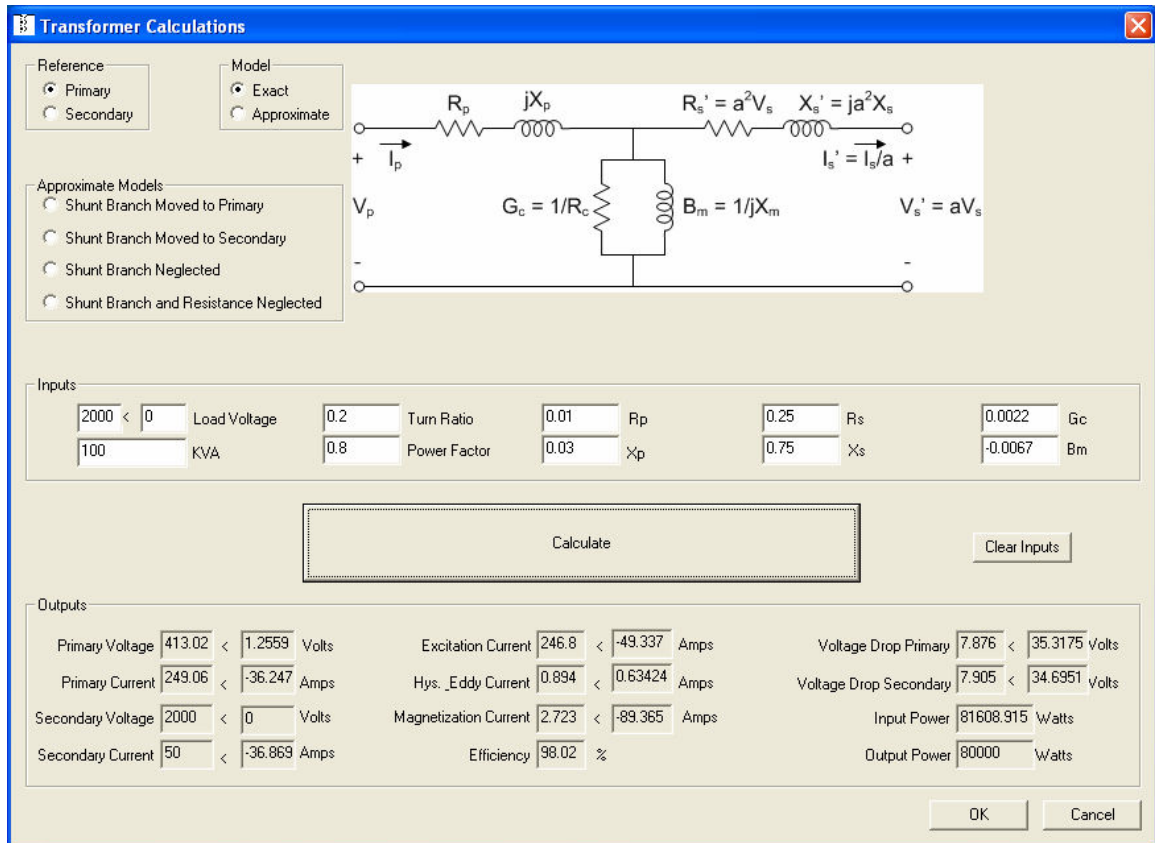


Figure 1_ Output of Transformer Exact Model Referred to Primary

As shown in figure 1, any given transformer can be reflected to the primary side or to the secondary side. Also, the student has the choice of analyzing a given transformer based on the exact model as well as the approximate model. If the approximate model is selected, the student needs to specify one model from the list of the approximate models. The list consists of the following approximate models:

1. Shunt branch moved to primary side.
2. Shunt branch moved to secondary side.
3. Shunt branch neglected
4. Both Shunt branch and resistance neglected.

The parameters of the given transformer in this module must be inserted as an input values. In addition, the load voltage, the turn ratio of the transformer, the rated load in KVA and the load power factor. Problem statements of transformers in most of electric machines textbooks are similar where all the required input values by the above module are stated in the problem statement. This makes the developed modules to work smoothly with most of the available textbooks in the market.

b. Power Transformer Test

Example:

A single phase 2300/230-V 500 KVA transformer is tested and the following data was recorded:

	Open Circuit Test	Short Circuit Test
Voltage (V)	2300	94.5
Current (A)	9.4	217
Power (W)	2250	8220

Find:

1. The equivalent resistance.
2. The equivalent reactance.
3. The magnetization reactance.
4. The core resistance.

After students enter the given values into the specified cells, the output which is the solution of this problem (equivalent parameters) is shown in figure 2.

The screenshot shows a software interface for transformer analysis. It includes two input sections: 'Open-Circuit Test Parameters' and 'Short-Circuit Test Parameters'. The open-circuit test parameters are Voc = 2300 Volts, Ioc = 9.4 Amps, and Poc = 2250 Watts. The short-circuit test parameters are Vsc = 94.5 Volts, Isc = 217 Amps, and Psc = 8220 Watts. A central circuit diagram shows a transformer equivalent circuit with a current source I, a parallel branch with conductance Gc = 1/Rc and magnetizing branch Bm = 1/jXm, and a series branch with equivalent resistance Req and equivalent reactance jXeq. The primary voltage is Vp and the secondary voltage is Vs' = aVs. A 'Calculate' button is present. Below the diagram, the 'Results' section displays: Ye = 0.004086 < -84.02 S = Rc = 2351.11 Ohm · J Xm = 246.016 Ohm and Zse = 0.435483 < 66.36 Ohm = Req = 0.17456 Ohm + J Xeq = 0.39896 Ohm. There are 'Clear Inputs', 'OK', and 'Cancel' buttons.

Figure 2_Transformer Equivalent Parameters

c. Direct Current Motors

Example

A 50-hp, 230-V, 1300-rpm dc shunt motor has an armature resistance of 0.05Ω . At rated speed and output, the armature current is 178.5 A and the field resistance is 115Ω . Calculate:

1. The shunt field current.
2. The counter emf.
3. The power input to the motor.
4. The efficiency of the motor.
5. The developed torque.
6. The output torque.

After students enter the given values, the program will solve and obtain the solution of this problem as shown in figure 3.

The screenshot shows a software window titled "DC Machines". It contains two dropdown menus: "DC Shunt Motor" and "One Operating Condition". Below these are two sections: "Inputs" and "Outputs".

Inputs:

Terminal Voltage	230	Output Power (watts)	37300
Armature Current	178.5	Speed (rpm)	1300
Armature Resistance	0.05	Brush Voltage Drop	0
Shunt Field Resistance	115		

Calculate

Outputs:

Generated Voltage	221.075	Shunt Field Copper Loss	460
Shunt Field Current	2	Brush Loss	0
Line Current	180.5	Rotational Losses	2161.8875
Developed Power	39461.8875	Total Losses	4215
Angular Speed	136.135681655558	Input Power	41515
Developed Torque	289.871744278213	Efficiency	0.89847043237384
Armature Copper Loss	1593.1125	Output Torque	273.991355876663

Clear Fields

Figure 3_ Output of DC Shunt Motor

d. Synchronous Machines Characteristics

Example:

A 20-MVA, three-phase, Y-connected, 13.8-kV, 4-pole synchronous generator operating at full load condition and 0.8 power factor lagging. The synchronous reactance is 8Ω per phase and the armature resistance is 3Ω . Calculate:

1. The speed of the generator.
2. The generated voltage.
3. The voltage regulation.
4. The efficiency of the generator.

After students enter the given values, the solution will be shown as in figure 4. In this module, I still have to fix the problem which is the stator current value. It is shown to be zero while this is not the correct value.

The screenshot shows the 'EE Help Suite' software interface. It has a blue title bar and a menu bar with 'AC Machines' and 'Power Flow'. The 'Synchronous Machines' tab is active, and the 'Induction Motor' sub-tab is selected. The 'Inputs' section contains the following values: Power Rating (20), Vt line-line (13800), Frequency (60), Number of Poles (4), Power Factor (0.8), Armature Resistance (3), Synchronous Reactance (8), and a dropdown menu set to 'Y'. The 'Outputs' section displays: Per Phase Voltage (7967.43 + j0.00), Stator Current (0.00 + j0.00), Generated Voltage (7967.44 + j0.00), Power Angle (4.83091422153056), Voltage Regulation (7.56143783911684), Complex Power (16.00 + j12.00), Real Power (16), Reactive Power (12), Maximum Power (23805018.0000028), Maximum Torque (126289.5428364), Speed (rpm) (1800), Speed (rad/sec) (188.495559215388), and Efficiency (0.99999960617532). At the bottom right, there are 'Calculate' and 'Clear' buttons.

Input	Value
Power Rating	20
Vt line - line	13800
Frequency	60
Number of Poles	4
Power Factor	0.8
Armature Resistance	3
Synchronous Reactance	8
Connection	Y
Power Factor Type	Lagging

Output	Value
Per Phase Voltage	7967.43 + j0.00
Stator Current	0.00 + j0.00
Generated Voltage	7967.44 + j0.00
Power Angle	4.83091422153056
Voltage Regulation	7.56143783911684
Complex Power	16.00 + j12.00
Real Power	16
Reactive Power	12
Maximum Power	23805018.0000028
Maximum Torque	126289.5428364
Speed (rpm)	1800
Speed (rad/sec)	188.495559215388
Efficiency	0.99999960617532

Figure 4_Output of Synchronous Machine

e. Induction Machine Test

Example:

A three-phase, 5-hp, 208-V, four-pole, 60-Hz induction motor is subjected to a no-load test at 60 Hz, a blocked rotor test at 15 Hz, and a DC test. The following data are obtained.

	No-Load	Blocked Rotor	DC
Voltage (V)	208	35	20
Current (A)	4	12	25
Power (W)	250	450	

Determine the parameters of this induction motor and the involved electric quantities.

After students enter the given values, the output which is the solution of this problem will be shown as shown in figure 5.

The screenshot shows the 'EE Help Suite' window with the 'Induction Motor' test configuration. The 'Test' tab is active, showing input fields for 'No Load Test Data', 'Blocked Rotor Test Data', and 'Direct Current Test Data'. The 'Other Data' section includes 'Rotational Losses', 'Freq. Locked Rotor Test', and 'Rated Frequency'. The 'Outputs' section displays calculated values for various parameters.

Parameter	Value
Stator Resistance	0.4
Rotational Losses	230.8
No Load Impedance	30.0222139978605
No Load Resistance	5.20833333333333
No Load Reactance	29.5669849193695
Magnetizing Reactance	26.9207961855837
Blocked Rotor Impedance	1.68393828513641
Blocked Rotor Resistance	1.04166666666667
Blocked Rotor Reactance @ Test Freq.	1.32309436689289
Blocked Rotor Reactance	5.29237746757157
Rotor Resistance	0.641666666666666
Rotor Reactance	2.64618873378578
Stator Reactance	2.64618873378578

Figure 5_ Output of Induction Motor Test

f. Induction Machine Characteristics

Example:

A three-phase, 25-hp, 440-V, 60-Hz, four-pole, induction motor has the following impedances referred to the stator in $\Omega/phase$.

$$R_1 = 0.50 \quad R_2 = 0.35 \quad X_1 = 1.20 \quad X_2 = 1.20 \quad X_m = 25$$

The combined rotational losses amount to 1250 W. For a rotor slip of 2.5% at rated voltage and rated frequency, find all involved electric quantities in this motor.

After students enter the given values, the program will solve and obtain the solution of this problem as shown in figure 6.

The screenshot shows the 'EE Help Suite' window with the 'Induction Motor' tab selected. The 'Inputs' section contains the following values:

Input	Value
Rated Output (HP)	25
Line Voltage	440
Frequency	60
Number of Poles	4
Slip	0.025
Rotational Losses	1250
Stator Resistance	0.5
Stator Reactance	1.2
Rotor Resistance	0.35
Rotor Reactance	1.2
Core Resistance	0
Magnetization Reactance	25

The 'Exact' dropdown menu is set to 'Exact'. The 'Outputs' section shows the following results:

Output	Value
Synchronous Speed	1800
Actual Speed	1755
Rated Output (Watts)	18650
Rotor Impedance	14.00 + j1.20
Input Impedance	10.42 + j7.64
Voltage per Phase	254.03 + j0.00
Stator Current	15.85 + j-11.63
Power Factor	0.80620835295782
Input Power	12081.2525885219
Stator Copper Loss	579.954594396352
Rotor Copper Loss	287.532449853139
Output Power	9963.76554427242
Efficiency	0.82472951138681
Air Gap Power	11501.2979941256
Developed Torque	59.4908739014845
Developed Power	11213.7655442724

Buttons for 'Calculate' and 'Clear' are located at the bottom right of the interface.

Figure 6_Output of Induction Machine

g. Induction Machine General Case

Example:

A 5-hp, 220-V, 4-poles, 50 Hz, Y-connected induction motor has a full-load slip of 4 percent. Find:

1. The synchronous and the actual speed of the motor.
2. The rotor frequency.
3. The slip speed.
4. The output power of the motor in Watts.

After students enter the given values, the program will solve and obtain the solution of this problem as shown in figure 7.

The screenshot shows a software window titled "EE Help Suite" with a menu bar containing "AC Machines" and "Power Flow". Under "AC Machines", there are sub-menus for "Synchronous Machines" and "Induction Motor". The "Induction Motor" sub-menu is active, showing a "General" tab. The "Inputs" section contains four text boxes: "Rated Output (HP)" with value 5, "Number of Poles" with value 4, "Frequency" with value 50, and "Slip" with value .04. The "Outputs" section contains three text boxes: "Synchronous Speed" with value 1500, "Actual Speed" with value 1440, and "Rated Output (Watts)" with value 3730. Additionally, there are two more output boxes: "Slip RPM" with value 60 and "Rotor Frequency" with value 2. At the bottom right, there are two buttons: "Calculate" and "Clear".

Input	Value
Rated Output (HP)	5
Number of Poles	4
Frequency	50
Slip	.04

Output	Value
Synchronous Speed	1500
Actual Speed	1440
Rated Output (Watts)	3730
Slip RPM	60
Rotor Frequency	2

Figure 7_Output of Induction Machine General Case

h. Three Phase Circuits

Example:

A balanced abc-sequence Y-connected source with the phase voltage at the source end of $\tilde{V}_{an} = 120\angle 0^\circ \text{ V}$ is connected to a Δ connected balanced load $15\angle 36.87^\circ \Omega$ per phase through a transmission line of $0.134\angle 63.4^\circ \Omega$. Calculate the electrical quantities involved in this system.

When students enter the given values in the problem into the specified cells and choose the specific connections for the load and for the source as shown and then click “calculate”, the program will output all the required quantities as shown in figure 8.

3-Phase Circuits

Phase Sequence: a-b-c a-c-b

Source Connection: Y Delta

Load Connection: Y Delta

Inputs

Frequency: 60 Hz

Phase Voltage: 120 \angle 0 v

Line Impedance: .134 \angle 63.4 Ohms

Load Impedance: 15 \angle 6.87 Ohms

Desired PF: 1

Calculate

Source Phase Voltages

V_{an} : 120 \angle 0 v

V_{bn} : 120 \angle -120 v

V_{cn} : 120 \angle 120 v

Source Line Voltages

V_{ab} : 207.8 \angle 30 v

V_{bc} : 207.8 \angle -90 v

V_{ca} : 207.8 \angle 150 v

Phase Currents

I_{aA} : 13.5 \angle -7.5 A

I_{bB} : 13.5 \angle -127 A

I_{cC} : 13.5 \angle 112 A

Line Currents

I_{aA} : 23.4 \angle -37.5 A

I_{bB} : 23.4 \angle -157 A

I_{cC} : 23.4 \angle 82.4 A

Voltage Drops

Voltage Drop Across Each Line Impedance: 3.14 \angle 25.8 v

Voltage Drop Across Each Load Impedance: 202.8 \angle 29.3 v

Complex Power

Complex Power of Line Impedances: 220.8 \angle 63.4 VA

98.8 W + j 197.4 VAR

Complex Power of Combined Load: 8238 \angle 36.8 VA

6591 W + j 4943 VAR

System Total Complex Power: 8437 \angle 37.5 VA

6690 W + j 5140 VAR

Power Factor

Power Factor Angle of Load: 36.87 $^\circ$

Power Factor of Load: 0 Leading

Parallel Reactive Element to Correct PF: j 0 Ohms

OK Cancel

Figure 8_Output of a Three phase Y-Delta connection

i. Transmission Lines

Example:

A 60-Hz, three-phase transmission line is 125 miles long. It has a total series impedance of $35 + j40 \Omega$ and a shunt admittance of $930 \times 10^{-6} \angle 90^\circ S$. It delivers 44.4 MVA at 220 kV and 0.9 power factor lagging. Determine

1. The transmission line parameters.
2. The sending end voltage.
3. The sending end current.
4. The sending end power factor.
5. The voltage regulation.
6. The efficiency of the line.

First, students need to specify the model of this transmission line based on the given length. In this case the transmission line has a medium length and the medium model is selected. Second, student need to specify that the given values in the problem correspond to which end. In this case they are given at the receiving end of the line. Then they need to insert the given values into the specified cells and choose the power factor if it is leading or lagging as shown and then click “calculate”, the program will output all the required quantities as shown in figure 9.

The screenshot shows a software window with the following data:

Inputs	
Model	Medium
End	Receiving End
Complex Power	44.4 MVA @ a Power Factor of: 0.9 Lagging
Line to Line Voltage	220000 < 0
Line Impedance	144.3 < 76
Line Admittance	930e-6 < 90

Outputs	
Line Parameters	
A	0.935034 < 0.994743
B	144.3 < 76
C	0.000899 < -89.5193
D	0.934893 < 0.994743
Sending End Voltage	
	130382.0 < 6.593805
Receiving End Voltage	
	220000 < 0
Voltage Regulation	
	9.78120763928149 %
Sending End Current	
	119.4897 < 34.97849
Receiving End Current	
	116.5197 < -25.84193
Efficiency	
	97.1816149529283 %
Sending End Power Factor	
	0.87977561844838
Receiving End Power Factor	
	0.9

Figure 9_A medium length transmission line

Data Collection and Assessment Method

The participants completed a survey and questionnaires based on their attitude toward the use of the developed software tool.

1. *Participants*

The pool included fifteen students enrolled in the course at Ohio Northern University. There were 80% male and 20% female. All participants were junior standing. Students have classified themselves regarding computer knowledge based on a score ranges from 1 to 10. There were 40% considered their level of computer knowledge to be 7, 47% higher than 7 and 13% below 7.

2. *Measures*

The primary assessment goal was to measure the attitude of students toward this teaching tool. In order to perform this assessment, a survey that consists of 11 questions was distributed to students at the end of the quarter. The survey sheet is shown in Table 1.

Students were asked to indicate their level of agreement on each statement of the survey using a five-point Likert scale with higher values indicating greater levels of agreement with the statement. The scale is defined as 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. This methodology is often used to ensure that participants make at least some commitment toward attitude.

3. *Results*

1. *Statistical Results*

The data obtained from the students is shown in Table 2. As shown, the average of student's computer knowledge came out to be 73%.

As a result of the survey, the response average of each question is calculated and is shown in Table 2. The majority of students have indicated that they have enjoyed learning using this instructional tool (80%). (73%) of students supported the idea of media based instructional tool. Majority of students felt comfortable with the instructional tool (67%). Majority of students expressed that they felt relaxed when using this instructional tool (73%). All students believed that it is very important to know how to use variety of software. 40% of the students believed that they have concentrated better using this instructional tool while 60% were neutral. 73% of the students believed the instructional tool has accelerated the learning process and they learned more using this instructional tool compared to textbooks with same content. Majority of students agreed that they have engaged in the learning process (80%). Approximately 93% of students believed that the media based instructional tool has motivated them to work out some more problems related to the material. Statistically, the results show that students are in favor of using such tool to help them in understanding the material of the course. The most important point here is that it motivated them to do more like homework problems and see if they got the answers right.

Table 1_ Survey Sheet

ECCS 338 ELECTRIC MACHINES AND POWER SYSTEMS					
Survey of Students' Attitude toward EMPS Software					
In a 1 to 10 scale, I consider my computer knowledge at					
Please circle one answer for each of the following questions:	SD	D	N	A	SA
1 I enjoy learning using media-based instruction	1	2	3	4	5
2 I believe that the more teachers use media-based instruction, the more I will enjoy learning	1	2	3	4	5
3 I feel uncomfortable learning material using media-based instruction in my own time	1	2	3	4	5
4 I feel nervous when I know that I need to use technology related instructional material	1	2	3	4	5
5 I believe it is important for me to know how to use variety of software	1	2	3	4	5
6 I concentrate better when a media-based instruction is used	1	2	3	4	5
7 Learning the course content is faster using this software compared to traditional method	1	2	3	4	5
8 I can learn more from this software than from traditional textbook with same content	1	2	3	4	5
9 Using this software improved my engagement in the learning process	1	2	3	4	5
10 Using this software motivated me to solve more problems related to the course	1	2	3	4	5

Table 2 Data of Students Response

Student	Sex	Computer Knowledge	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	F	8	5	5	2	1	5	4	4	4	4	5
2	F	9	5	5	1	1	5	4	5	5	5	5
3	F	7	4	4	2	2	5	3	4	4	4	5
4	M	8	4	4	2	2	5	3	4	4	5	5
5	M	8	4	5	1	1	5	4	5	5	5	5
6	M	8	5	4	2	1	5	4	5	5	5	5
7	M	8	5	4	2	2	5	3	4	4	5	5
8	M	8	4	4	3	2	5	3	3	3	3	4
9	M	7	3	3	4	3	5	3	3	3	3	4
10	M	7	4	4	2	1	5	4	5	5	4	5
11	M	7	4	4	2	1	5	3	4	4	5	5
12	M	7	4	4	2	2	5	4	4	4	4	4
13	M	7	3	3	4	3	5	3	3	3	4	4
14	M	6	4	3	3	4	5	3	4	4	5	4
15	M	5	3	1	5	4	5	3	1	1	1	3
Average		7.33	4.1	3.8	2.5	2	5	3.4	3.9	3.9	4.1	4.53

2. Students Comments

At the back of the survey sheet, students were asked to write comments regarding the developed software tool. The comments of students included the following:

- In general, it all depends on how the information is presented. I believe a teacher will be able to teach me better while some stuff would be easier to learn through a media representation.
- I like being able to see visually what is being done rather than reading where you don't see the results as quickly as the media allows.
- This software tool helped clarify a few things, such as the relationships among parameters.
- This software helped me to do more problems. It is advantageous to learn by doing.
- This program would not only save time but also allow for a better understanding of the parameters relationship and it really caught me many times with mistakes when I solved my homework problems. I checked my solution and found the mistakes.

Based on the statistical data and the comments obtained from students, the developed software tool is proven to be an effective learning tool that has worked for majority of students. Students were satisfied with the instruction, and the access to the tool.

Conclusion

The software tool was designed to help students in solving problems related to electric machines and power systems. The information and data collected from the surveys were analyzed and used for the assessment and evaluation. Students have responded favorably to and expressed their satisfaction in the developed tool. I believe that the media based instructional tool offers some advantages such as it is a completely learner-paced, it can be followed easily, it does not require a great deal of time or effort and the learner does not have to be at a specific time and place to use it. In the course, Electric Machines and Power Systems, it is no longer necessary to devote additional classroom or laboratory time to provide and solve examples; students can do those on their own time.

Finally, since the role of instruction is not to distribute facts but to grant students with ways to assemble knowledge, educators must find favored strategies that build students' confidence and enhanced course relevance. This can be achieved through the continual investigation of appropriate ways to introduce new technologies into the classroom.

Bibliography

- [1] P. Cohen, B. Ebeling & J. Kulik, "A meta-analysis of outcomes studies of visual-based instruction," *Educational Communications and Technology Journal*, 29, pp 26-36, 1981.
- [2] J. V. Powell, V. G. Aeby Jr. & T. Carpenter-Aeby, "A comparison of student outcomes with and without teacher facilitated computer-based instruction," *Computers & Education*, 40, pp183-191, 2003.
- [3] R. A. Bartsch & K. M. Cobern, "Effectiveness of PowerPoint presentations in lectures," *Computer & Education*, 41, pp 77-86, 2003.
- [4] S. M. Butzin, "Using instructional technology in transformed learning environments: An evaluation of project child," *Journal of Research in Computing Education*, 33(4), pp 367-384, 2000.
- [5] M. H. Hopson, R. L. Simms & G. A. Knezek, "Using a technologically enriched environment to improve higher-order thinking skills," *Journal of Research on Technology in Education*, 34(2), pp 109-119, 2002.
- [6] S. T. Marina, "Facing the challenges, getting the right way with distance learning," *Ed at a Distance*, 15(30), pp 1-8, 2001.
- [7] R. A. Reiser, "A history of instructional design and technology: Part1: A history of instructional media," *Educational Technology Research and Development*, 49(1), pp 53-64, 2001.
- [8] K. Njagi, R. Smith & C. Isbell, "Assessing Students' Attitude Toward Web-based Learning Resources," <http://naweb.unb.ca/proceedings/2003/PosterNjagiIsbell.html>, 2003.
- [9] A. W. Bates, R. Harrington, D. Gilmore & C van Soest, "Compressed video and video-conferencing in open and distance learning: A guide to current developments," *The Open Learning Agency*, Burnaby, B.C., pp 6, 1992.

- [10] B. Willis, Distance Education Strategies And Tools, Educational Technology Publications, Inc., pp 169, 1994.
- [11] J. E. Folkestad & M. A. De Miranda, "Impact of Screen-Capture Based Instruction on Student Comprehension of Computer Aided Design (CAD) Software Principles," Journal of Industrial Technology, 18(1), pp 1-5, Novemebr 2001 to January 2002.
- [12] Khalid Al-Olimat and Feng Jao, "An Investigation of the Attitude of Learners toward Media Based Instructions of PSPICE in Electric Circuits Analysis," Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, Salt Lake City, UT, June 2004.
- [13] S. J. Chapman, Electric Machinery and Power System Fundamentals, McGraw Hill, 2002.
- [14] Z. A. Yamayee and J. L. Bala, Electromechanical Energy Devices and Power Systems, Wiley, 1994.
- [15] Hadi Saadat, Power System Analysis, 2nd edition, McGraw Hill, 2002.
- [16] A. E. Fitzgerald, C. Kingsley Jr. and S. D. Umans, Electric Machinery, 6th edition, McGraw Hill, 2003.

Author Biography

Dr. Khalid S. Al-Olimat is an associate professor in the Department of Electrical & Computer Engineering and Computer Science at Ohio Northern University. He obtained his BS in Electrical Engineering from Far Eastern University in 1990, his MS in Manufacturing Engineering from Bradley University in 1994 and his PhD in Electrical Engineering from the University of Toledo in 1999. Dr. Al-Olimat has many publications in the area of adaptive control, fuzzy control and machine drives. His areas of interest are power engineering, adaptive, fuzzy and intelligent control. He is a member of ASEE and IEEE where he is the past chair of IEEE-Lima section. Dr. Al-Olimat is a registered professional engineer in the State of Michigan.