An Optimized Approach for Teaching the Interdisciplinary Course Electrical Engineering for Non Majors[1]

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Abstract

This paper introduces plans for an optimized curriculum and teaching approach for the interdisciplinary service course *Introduction to Electrical Engineering for all non-EE majors* at Michigan Technological University. The curriculum optimizes the current 3-credit service course by addressing: (1) the general needs of all majors through in-class lectures and lab experiments, and (2) special needs of all majors by designing a web-based teaching and lab system. In order to specify the general *and* special needs of non-EE majors and form an overall curriculum for them, a survey was designed and distributed to universities and industry. Faculty members, students and industrial personnel responded to the survey. This work presents an analysis of the survey and describes a preliminary overall curriculum for this course.

1. Introduction

It is generally recognized in the academic environment that an introductory course in Electrical Engineering (EE) should be offered to the non-electrical engineering (non-EE) students. As a result, almost all engineering institutions offer at least one "service course" to non-EE majors through the EE department. Traditionally, the content of this EE service course is a cut-and-paste combination of some of the content of courses offered to EE students. In addition, the traditional approach covers some limited topics in EE in detail, but does not cover the broad range of technologies in the field of electrical engineering. This practice is not consistent with growing interdisciplinary technologies and it does not adequately fulfill students' future needs.

A number of universities recognized the problem and tried to find solutions usually just for one Engineering area (e.g., Mechanical Engineering) by including an additional course for non-EE majors [1], [2]. This is not an optimized approach because this additional course: (a) meets the needs of only one area of engineering, (b) needs more university resources to offer the course, and (c) costs students their time and funding. In other words, it increases the number of required courses rather than optimizing the current course. This experience formed the basis for a preliminary study conducted at Michigan Tech University and presented in ASEE 2004 [3].

In our previous paper [3], we discussed the preliminary work for evaluating the teaching approach for the interdisciplinary course "Introduction to Electrical Engineering (EE) for non-EE majors". We surveyed professors, graduate and undergraduate students of the Department of Mechanical Engineering-Engineering Mechanics (ME-EM) in Michigan Tech University. The

[1] This work is supported by NSF Award EEC-0415962.

results of that preliminary study confirmed that there were problems associated with the traditional curriculum and teaching strategies for this course.

This paper introduces an optimized curriculum and teaching approach for designing a 3-credit service course for all non-EE majors. The optimized curriculum is formed by a merger of many curriculum subspaces, which are the unique curricula for each non-EE area. Each curriculum sub-space is designed independently for one non-EE engineering field and includes the required topics and their associated depth of coverage. The intersection of curriculum subspaces forms the core of the final curriculum that will be taught in the lecture portion of the class. The areas that are unique to each non-EE field forms the web-based curriculum. The laboratory will also be designed accordingly: some in-class lab experiments will be designed to address the needs of all non-EE majors, and some in-class as well as web-based lab experiments, will be designed to address the special needs of each non-EE field.

We started by developing a survey to investigate the new curriculum and initiate the process of generating the curriculum subspaces. The survey was developed by the contribution of faculty members from different non-EE engineering disciplines of Michigan Tech. Non-EE faculty members collaborated with EE faculty members to identify the topics that might be suitable for their engineering field. The survey also searches for new fields and topics that might be suitable for non-EE students. The survey was placed on-line, and its URL was submitted to many universities in the US and filled by students and faculty members across the country. This survey was distributed to students (graduate and undergraduate) and to faculty of all non-EE majors at Michigan Tech as well. The survey outcome determines the final curriculum by identifying topics and their depth of coverage for all non-EE fields. This work introduces the details of curriculum development, analyzes the outcomes of the survey, and describes an overall curriculum for this course.

This work is organized as follows: Section 2 explains the details of our solution to optimize the curriculum of the course Introduction to Electrical Engineering for non-majors. Section 3 explains the process of forming the survey and its structure. Section 4 details the survey analysis and outcomes and proposes the curriculum sub-space as well as the final curriculum. Section 5 concludes the paper.

2. Optimized Curriculum

In general, three options are possible for delivery of the EE course to non majors (see Figure 1). Option 1 is delivery via the traditional lecture and lab scheme for all non-EE students. This is what we have been doing for some time, and it is not the preferred option for reasons discussed in Section 1. Option 2 is to create the best curriculum possible for each non-EE student and offer a unique course for each of them. Although Option 2 provides each non-EE major student with the best approach to learning; it requires a larger number of instructors and more space to provide all of these classes. Moreover, for some non-EE majors, the course content could extend beyond the time frame of one semester. This means that more than 3 credits might be required for some majors. This imposes a high cost to the universities as well as to students, and it prolongs their duration of study. For these reasons option 2 is not acceptable.

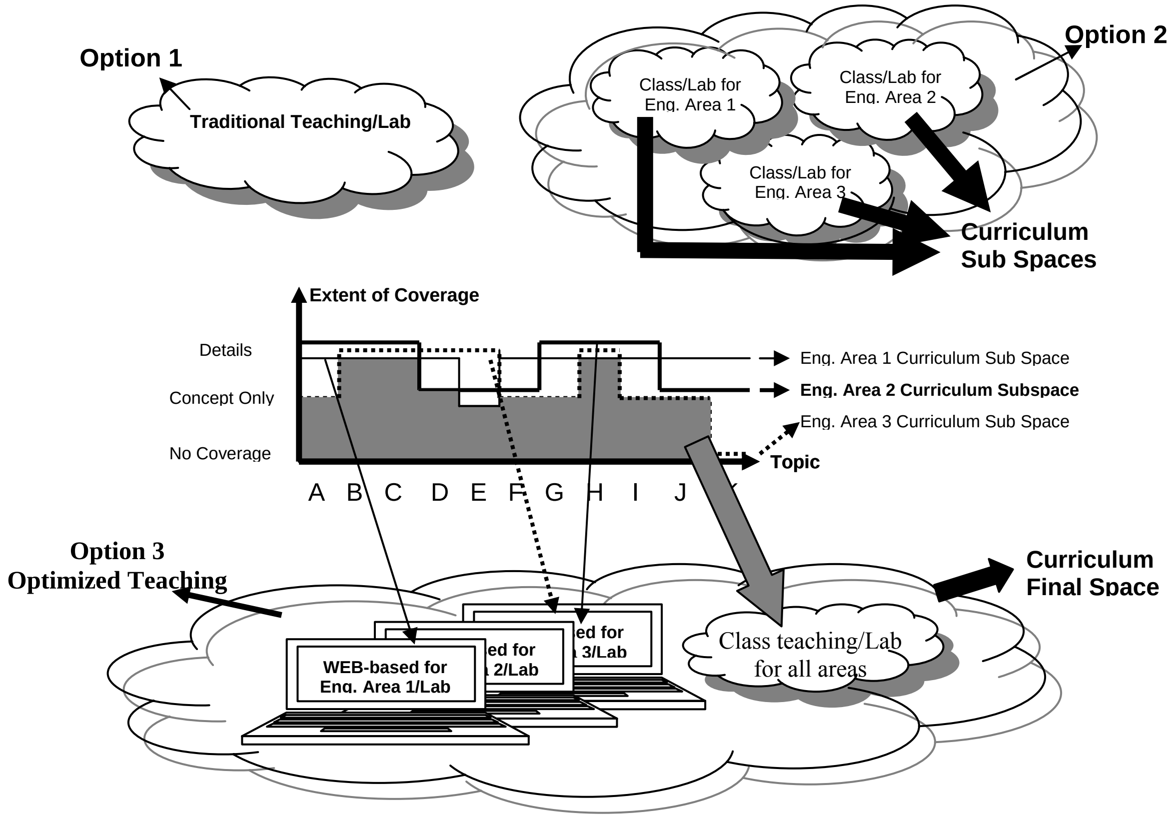

Figure 1 Options of teaching, Curriculum Sub-Spaces and Curriculum Final Space.

The best option (*option 3* in Figure 1) is to create a *curriculum final space* for all of non-EE majors. The curriculum final space is crafted by *curriculum sub-spaces*. We call the optimum curriculum for each non-EE major, the curriculum sub-space. This is a two dimensional space formed by the topics and their depth of coverage (e.g., detail or concepts) the curriculum sub-spaces for each area are shown in the bar graph in Figure 1. The horizontal axis in this graph represents the topics that should be covered for each non-EE major area and the vertical axis represents the depth of coverage of each topic.

The curriculum final space is represented in Figure 1 and includes two main parts: (1) one which is common to all of curriculum sub-spaces (shaded region in the diagram of Figure 1). This part will be covered in the lecture portion of the class for all non-EE majors simultaneously; and (2) the part which is not common to the subspaces. This part will be covered using different Web-based systems created for different non-EE majors (areas) and their associated Laboratory experiments.

Web based education is a delivery strategy that maximizes the efficiency and effectiveness of time spent in the classroom where basic instruction, practice materials, and formative assessment are delivered. The use of this tool to augment the traditional lecture format rather than replace it will allow presentations in the classroom or lecture hall to focus on the interdisciplinary nature of engineering practice. Concentration on the effective learning domain [4] in the classroom has the potential to enable faculty to frame basic electrical engineering principles in the context of other engineering disciplines through the use of examples from research and industry.

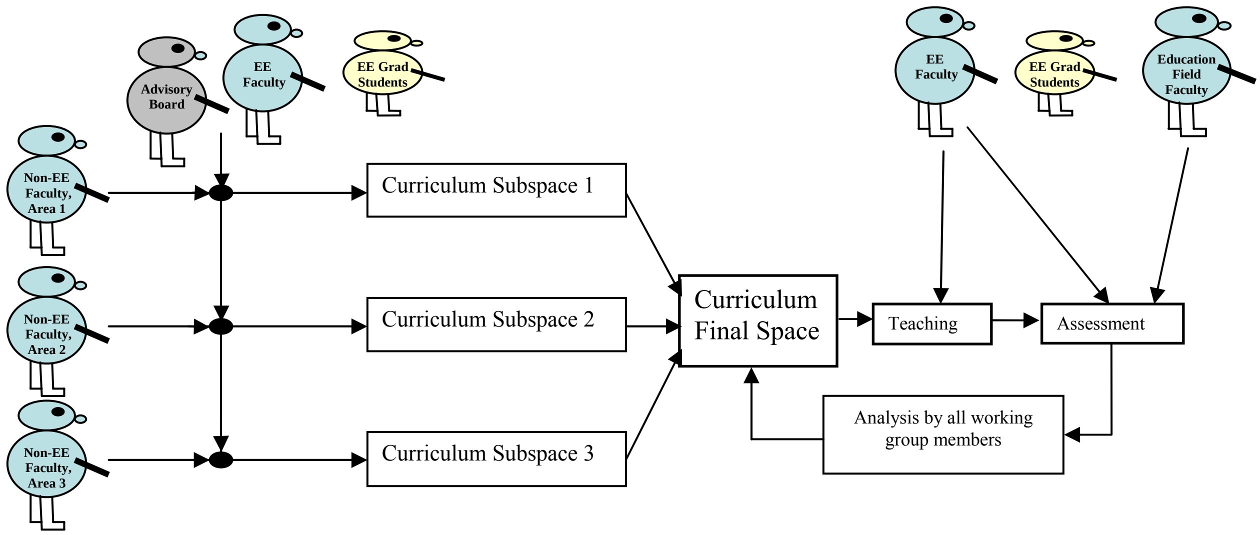

Figure 2 The process of creation of the Curriculum Final Space.

Furthermore, by firmly making the connection between disciplines, students may be more strongly motivated to pursue basic skills and knowledge through the web based strategy. By translating the specific topics defined by the optimized curriculum space into reusable online learning objects [5] it will be possible to tailor individual learning experiences for each non-EE major with minimum effort and expense.

The process of developing the curriculum final space is illustrated in Figure 2. Each independent curriculum subspace for each non-EE area will be designed through the collaboration of faculty members of that non-EE field and EE faculty members. Then the curriculum sub-spaces will be merged to create the curriculum final space. The final new curriculum will be taught for three semesters at Michigan Technological University. This new curriculum will be taught in parallel to the traditional curriculum. Students will be assessed many times during each round of teaching. The assessment materials will be developed and analyzed by the contribution of a faculty member inform the Department of Education. Other faculty members will also contribute in the process as approrpiate. The new curriculum will be revised based on the assessment outcomes. We feel after three times of teaching we should approach to our goal of an optimized curriculum.

3. A Survey for Curriculum Development

Choosing the optimum curricular topics for each non-EE major and forming the curriculum sub-spaces are the most challenging objectives of our work. In order to form a curriculum that best serves a wide spectrum of non-EE majors and equips them with the required knowledge necessary for their future career, we needed to gather enough information from all non-EE communities, including undergraduate and graduate students, members of faculty and industry. To do that, we needed to create a survey that covered all possible required topics in EE for all non-EE fields.

Hence, we formed a group consisting of faculty members from all engineering areas (EE and non-EE) at Michigan Tech. The group also consisted of faculty from the Education Department and some EE graduate students. We conducted regular weekly meetings out of which we identified the main topics and sub-topics in Electrical Engineering to be potentially required for non-EE majors as summarized in Table 1.

Table 1 The topics presented in the survey.

Area	Category	Subcategory	Topic
Safety	Safety Topics		Explosive Environments
			Electric Shock Hazards
			Environmental RF Hazards
			Safety Implications of the National Electric Code (NEC)
Analog Systems	Basics	Elements and Sources	Voltage sources
			Current sources
			Dependent sources
			Resistors
			Capacitors
			Inductors/Transformers
		Circuit Analysis	DC
			DC Transients
			AC Transients
			AC Steady State
			Node Voltage Analysis
			Thevenin and Norton Equivalents
			AC Power
	Advanced	Advanced Analog Systems	Illumination
			Impedance Matching
			Amplifiers
			Grounding techniques
		3-Phase Power and Distribution	Delta
			Y-Delta
		Discrete Electronic Devices	Diodes
			BJT Transistors (Bipolar Junction Transistor)
			FET Transistors (Field Effect Transistor)
		Analog Devices	Op Amps (Operational Amplifiers)
			Voltage regulators
			DC – DC converters
			Voltage to Frequency converters
			Phase Locked Loops
			Interface Devices
			Analog Multiplexers
		Frequency Analysis	Fourier series and Transform
			Laplace Transform
	Energy Conversion	AC Motors	Induction Motors
			Synchronous Motors
		Other energy conversion topics	DC Motors
			Motor-Generators
			Power Transmission systems
			Photo-Voltaic systems
			Electro-Chemical systems
			Electro-Thermal systems
Digital Systems	Basics		Binary Number System
			Digital Logic
			Logic Devices (AND, OR, INVERTER)
			Combinatorial Logic (Memory-less logic systems)
			Synchronous Logic (Systems with memory)
	Advanced	Advanced Digital Systems	A/D and D/A conversion (Analog to Digital & Digital to Analog)
			Embedded microprocessors
			Digital signal Processing
			Automated Test Equipment
		Computer Based Instrumentation Systems	Data Acquisition
			Interfaces
			GPIB (General Purpose Interface Bus)
			TCP/IP (Transmission Control Protocol/Internet Protocol)
Sensors	Various Sensors		Pressure
			Acoustic
			Acceleration
			Strain/Load Cells
			Linear Variable Displacement Transformers (LVDT)
	Temperature Sensors		Thermistors
			Thermocouples
			Resistive Temperature Detector (RTD)
Hardware Tools	Oscilloscopes		
	Multimeters		
	Function Generators		
	DC /AC power supplies		
	Spectrum Analyzers		
Software Tools	Matlab		
	Simulink		
	Mathematica		
	Orcad		
	P-Spice		
	Labview		
Special Topics	Control and Electromagnetic Topics		Electromagnetic fields
			Microwave systems
			Micro-electromechanical systems (MEMS)
			MEMS Manufacturing
			Industrial Control systems
			Electromagnetic Compatibility (EMC)
			Electromagnetic Interference (EMI)
	Communications Systems		Point-to-Point Terrestrial
			Satellite
			Wireless
	Antennas		Fixed
			Conformal
			Phased Array
			Synthetic Aperture
	Remote Sensors		MRI (Magnetic Resonance Imaging)
			CAT (Computer Assisted Tomography)
			Ultrasound
			Other Interferometric Sensors
			Radar
			UWB (Ultra-Wide Band)
			Optical Remote Sensors

After identification of potential topics, a survey was designed to elicit feedback from our constituencies regarding the importance of these topics for the various engineering disciplines. The survey consisted of two main parts. In the first part, we asked general questions such as gender, primary academic training, current activity, and status. In the second part of the survey, we queried the level of importance of each item in Table 1 for people in their specialty area. The importance level was numbered from 1 to 4, which represents the required depth of instruction for topics as discussed in the bar diagram of Figure 1. Respondents could also signify "no opinion" regarding any topic listed in Table 1. In addition, we asked whether there were other important sub-topics under each main topic that should be considered for a specific field of study.

We prepared an on-line system for the survey, and we submitted its URL to many universities and engineering departments in the US. The results of the survey were analyzed in order to generate the curriculum sub-spaces for each non-EE field. We then found the cross section of the curriculum sub-spaces in order to find the core curriculum final space.

4. Survey Results: Curriculum Subspaces and Final Spaces

The questionnaire was used to collect data on 9 respondent background variables, and on 99 topics. The respondents were asked to rate the relevance of each topic on a scale of 1 to 4 with 1 being 'irrelevant' and 4 'relevant.' Respondents had the option to choose 'No opinion' as a response for each of the topics. The results are presented according to the professional field of respondent. The five fields surveyed were Civil/Environmental, Chemical/Petroleum, Biomedical, Mechanical/Industrial/Manufacturing, and Materials Engineering. At the time that this paper was completed, preliminary results were available yet responses were still coming in. Final results will be presented at the ASEE Annual Conference in June.

A total of 291 responses were received by the time the data presented in this paper was analyzed. Table 2 indicates the distribution of the respondents by field. The numbers of respondents from Biomedical and Materials were 11 and 5 respectively. These numbers are too small for meaningful statistical analysis and these results are not included in the data analysis. We are currently seeking additional respondents from these fields. Table 3 gives the status of the respondents. The data indicates that the majority of respondents (38.8%) were faculty, drawn from Michigan Technological University and other universities. The respondents also included a significant number of undergraduate and graduate students. Of concern is that fact that only 6.9% of the respondents were from industry. We are also actively seeking input from this constituency at this time.

In analyzing the survey data, the responses were rated a four point scale ranging from 1 = topic not relevant to 4 = relevant and the mean rating of each topic by discipline was computed. A response of 'no opinion' was excluded from the computation of the mean. Mean ratings were calculated for three aggregated fields of (1) Mechanical/Industrial/Manufacturing, (2) Civil/Environmental, and (3) Chemical/Petroleum. The recommendation for each topic was based on the criteria indicated in Table 4, and the further analysis provided by the non-EE faculty.

Table 2: Professional field of respondents (N = 290, 1 missing)

Professional field of respondents	**Number**	**Percentage**
Civil/Environmental	100	34.5
Chemical/Petroleum	54	18.6
Biomedical	11	3.8
Mechanical/Industrial/Manufacturing	109	37.6
Materials	5	1.7
Other	11	3.8
TOTAL	290	100

Table 3: Status of respondents (N = 290)

Status	**Number**	**Percentage**
Undergraduate Student	87	30.0
Graduate Student	57	19.6
Faculty Academic	113	38.8
Industrial Employee	20	6.9
Government Employee	2	0.7
Consulting/Self Employed	12	4.1
TOTAL	291	100

Table 4: Recommendation criteria for surveyed topics

Response	**Recommendation**
$1 \leq$ Mean Rating < 2.5	Topic should not be taught
$2.5 \leq$ Mean Rating < 3	Topic should be taught as concept only
$3 \leq$ Mean Rating ≤ 4	Topic should be taught in detail

Table 5 describes the overall recommendations for the teaching approach for each of the topics surveyed. The optimized curriculum is formed by a merger of several curriculum subspaces. Each curriculum subspace includes the required topics and their associated depth of coverage. The analysis focuses on 3 aggregated fields: Civil/Environmental, Chemical/Petroleum and Mechanical/Industrial/Manufacturing. Analysis for additional fields will be conducted when enough data is available.

Table 5: Overall Recommendations for each of the Topics

TOPIC	**FIELD**			**RECOMMENDATION**	
	Mech./industrial	Civil/Environmental	Chem./Petroleum	Classroom	Web Based
Safety					
Explosive Environments	No coverage	Concept only	Detail	No coverage	Civil (Con), Chem (Detail)
Electric Shock Hazards	Concept only	Concept only	Detail	Concept only	Chemical (Detail)
Environmental RF-Hazards	No coverage	Concept only	Detail	No coverage	Civil (Concept) & Chem (Detail)
Safety Implications of NEC	No coverage	Concept only	Concept only	No coverage	Civil & Chem (Concept)
Elements and sources					
Voltage sources	Detail	Detail	Detail	Detail	None
Current sources	Detail	Detail	Detail	Detail	None
Dependant sources	Concept only	Concept only	Concept only	Concept only	None
Resistors	Detail	Detail	Detail	Detail	None
Capacitors	Detail	Detail	Detail	Detail	None
Inductors/Transformers	Detail	Detail	Detail	Detail	None
Circuit Analysis					
DC	Detail	Detail	Detail	Detail	None
DC Transients	Detail	Concept only	Concept only	Concept only	Mech (Detail)
AC Transients	Detail	Concept only	Concept only	Concept only	Mech (Detail)
AC Steady State	Detail	Detail	Detail	Detail	None
Node Voltage Analysis	Detail	Concept only	Concept only	Concept only	Mech (Detail)
Thevenin Norton Equivalents	Concept only	Concept only	Concept only	Concept only	None
AC Power	Detail	Concept only	Detail	Concept only	Mech & Chem (Detail)
3-phase power and distrib.					
Delta	No coverage	Concept only	Concept only	No coverage	Civil & Chem (Concept)

Y-Delta	No coverage	Concept only	Concept only	No coverage	Civil & Chem (Concept)
Other advanced topics					
schematics	Detail	Concept only	No coverage	No coverage	Mech (Detail), Civil (Conc)
Illumination	No coverage	Concept only	No coverage	No coverage	Civil (Concept)
Impedance Matching	Concept only	No Coverage	No coverage	No coverage	Mech (Concept)
Amplifiers	Detail	No Coverage	Concept only	No coverage	Mech (Detail), Chem (Con)
Grounding techniques	Detail	Concept only	Detail	Concept only	Mech and Chem (Detail)
Discrete Electronic Devices					
Diodes	Concept only	No Coverage	No coverage	No coverage	Mech (Concept)
Bipolar Junction Transistor	No coverage	No Coverage	No coverage	No coverage	None
Field Effect Transistor	No coverage	No coverage	No coverage	No coverage	None
Analog Devices					
Operational Amplifiers	Detail	No Coverage	No coverage	No coverage	Mech (Detail)
Voltage regulators	Concept only	Concept only	Concept only	Concept only	None
DC-DC converters	Concept only	Concept only	No coverage	No coverage	Mech and Civil (Concept)
Volt to Frequency converters	Concept only	No coverage	No coverage	No coverage	Mech (Concept)
Interface devices	No coverage	No coverage	No coverage	No coverage	None
Phase Locked Loops	No coverage	No coverage	No coverage	No coverage	None
Analog Multiplexers	No coverage	No coverage	No coverage	No coverage	None
Frequency Analysis					
Fourier series and Transform	Concept only	Concept only	Concept only	Concept only	None
Laplace Transform	Concept only	Concept only	Detail	Concept only	Chem (Detail)
Energy conversion					
Induction motors	Concept only	Concept only	Concept only	Concept only	None
Synchronous Motors	Concept only	Concept only	Concept only	Concept only	None
DC Motors	Detail	Concept only	Concept only	Concept only	Mech (Detail)
Motor Generators	Concept only	Concept only	Concept only	Concept only	None
Power Transmission Systems	Concept only	Concept only	Detail	Concept only	Chem (Detail)
Photo voltaic systems	No coverage	Concept only	Concept only	No coverage	Civil & Chem (Concept)
Electro-chemical systems	No coverage	Concept only	Concept only	No coverage	Civil & Chem (Concept)
Electro-Thermal systems	No coverage	No coverage	Concept only	No coverage	Chem (Concept)
Digital systems					
Binary Number System	No coverage	Concept only	Concept only	No coverage	Civil & Chem (Concept)
Digital Logic	Concept only	Concept only	Concept only	Concept only	None
Logic Devices	Concept only	Concept only	No coverage	No coverage	Mech & Civil (Concept)
Combinatorial Logic	No coverage	No coverage	No coverage	No coverage	None
Synchronous logic	No coverage	No coverage	No coverage	No coverage	None
Analog to Dig&Dig to Analog	Concept only	Concept only	Concept only	Concept only	None
Embedded microprocessors	No coverage	No coverage	Concept only	No coverage	Chem (Concept)
Digital Signal Processing	Concept only	Concept only	Concept only	Concept only	None
Computer Based inst. Sys.					
Data Acquisition	Detail	Detail	Detail	Detail	None
Interfaces	Concept only	Concept only	Detail	Concept only	Mech & Civil (Detail)
General Purpose Interface Bus	No coverage	Concept only	No coverage	No coverage	Civil (Concept)
Trans control pro/Internet pro	No coverage	Concept only	Detail	No coverage	Civil (conc), Chem (Detail)
Automated Test Equipment	Concept only	Concept only	Concept only	Concept only	None
Sensors					
Pressure	Detail	Detail	Detail	Detail	None
Thermistors	Detail	Detail	Detail	Detail	None
Thermocouples	Detail	Detail	Detail	Detail	None
Resistive Temp Detectors	Detail	Concept only	Detail	Concept only	Mech & Chem (Detail)
Acoustic	Detail	Concept only	No coverage	No coverage	Mech (Detail), Civil (Conc)
Acceleration	Detail	Concept only	Concept only	Concept only	Mech (Detail)
Strain/Load Cells	Detail	Detail	Detail	Detail	None
Linear variable displacement Transformers	Detail	Detail	No coverage	No coverage	Mech and Civil (Detail)
Hardware tools					
Oscilloscopes	Detail	Concept only	No coverage	No coverage	Mech (Detail), Civil (Con.)
Multimeters	Detail	Detail	Detail	Detail	None
Functions Generators	Detail	Concept only	No coverage	No coverage	Mech (Detail), Civil (Con.)
DC/AC Power Supplies	Detail	Concept only	Detail	Concept only	Mech & Chem (Detail)
Network Analyzer	Concept only	Concept only	Concept only	Concept only	None
Software tools					
Matlab	Detail	Concept only	Detail	Concept only	Mech & Chem (Detail)
Simulink	Detail	No coverage	Concept only	No coverage	Mech (Detail), Chem (Con)
Mathematica	No coverage	Concept only	No coverage	No coverage	Civil (Concept)
Orcad	No coverage	No coverage	No coverage	No coverage	None
P-spice	No coverage	No coverage	No coverage	No coverage	None
Labview	Concept only	Concept only	Detail	Concept only	Chem (Detail)
Communication Systems					
Point to Point Terrestrial	No coverage	Concept only	No coverage	No coverage	Civil (Concept)
Satellite	No coverage	Concept only	No coverage	No coverage	Civil (Concept)
Wireless	No coverage	Concept only	No coverage	No coverage	Civil (Concept)
Antennas					
Fixed	No coverage	No coverage	No coverage	No coverage	None
Conformal	No coverage	No coverage	No coverage	No coverage	None
Phased Array	No coverage	No coverage	No coverage	No coverage	None

Synthetic Aperture	No coverage	No coverage	No coverage	No coverage	None
Remote Sensors					
Magnetic Resonance Imaging	No coverage	No coverage	No coverage	No coverage	None
Comp Assisted Tomography	No coverage	No coverage	No coverage	No coverage	None
Ultrasound	No coverage	No coverage	No coverage	No coverage	None
Radar	No coverage	No coverage	No coverage	No coverage	None
Ultra Wide Band	No coverage	No coverage	No coverage	No coverage	None
Interferometric sensors	No coverage	No coverage	No coverage	No coverage	None
Optical	No coverage	No coverage	No coverage	No coverage	None
Topics					
Electromagnetic fields	Concept only	Concept only	Concept only	Concept only	None
Microwave	No coverage	No coverage	No coverage	No coverage	None
Electromagnetic Compatibility	No coverage	No coverage	No coverage	No coverage	None
Industrial Control Systems	Concept only	No coverage	Detail	No coverage	Mech (Con), Chem (Detail)
MEMS manufacturing	Concept only	No coverage	Concept only	No coverage	Mech and Chem (Concept)
Micro-electromech systems	No coverage	No coverage	No coverage	No coverage	None
Electromagnetic Interference	No coverage	No coverage	Concept only	No coverage	Chem (Concept)
Robotics	Detail	No coverage	No coverage	No Coverage	Mech (Detail)

The intersection of curriculum subspaces forms a core for the curriculum that is taught in the lecture portion of the future class. The areas that are unique to each non-EE field will form the web-based curriculum that is custom designed for specific fields. The combination of a common curriculum with elective online web-based course materials makes it possible to provide a service course that uniquely meets the needs of each of the fields of specialization, taking into account the range of topics and the depth of coverage.

Based on the summary data presented in Table 5, the list of topics common to all fields that should be taught to all students was extracted. Some of these topics should be taught in detail and some others only as concepts. A set of 17 topics indicated in Table 6(a) will be taught to all students in detail and the topics indicated Table 6(b) will be taught at concept level only. These topics will form the core of the course for non-EE majors and will partially meet the general needs of all majors through in-class lectures and lab experiments. All the topics presented in Table 6(a) and most of the topics presented in Table 6(b) will be taught in the classroom. Based on the class schedule and priorities determined by the means presented in Table 5 additional will be covered via a Web-based system.

Table 6(a): Topics to be taught in detail for all

1. Voltage sources	8. Data Acquisition
2. Current sources	9. Pressure
3. Resistors	10. Thermistors
4. Capacitors	11. Thermocouples
5. Inductors/Transformers	12. Strain/Load Cells
6. DC Analysis	13. Multimeters
7. AC Steady State	

Table 6(b) Topic to be taught at concept level for all in the classroom

1. Electric Shock Hazards	15. Motor Generators
2. Dependant sources	16. Power Transmission Systems
3. DC Transients	17. Digital Logic
4. AC Transients	18. Analog to Digital and Digital to Analog
5. Node Voltage Analysis	19. Embedded microprocessors
6. Thevenin Norton Equivalents	20. Digital Signal Processing
7. AC Power	21. Interfaces
8. Grounding techniques	22. Automated Test Equipment
9. Voltage regulators	23. Acceleration (sensors)
10. Fourier series and Transform	24. DC/AC Power Supplies
11. Laplace Transform	25. Network Analyzer
12. Induction motors	26. Matlab
13. Synchronous Motors	27. Labview
14. DC Motors	28. Electromagnetic fields

The final set of topics that is not common between all disciplines will be taught through the use of web-based modules. The topics, which are listed in the last column of Table 5, are the topics that uniquely meet the needs of specific fields. The use of web tools makes it possible to meet the needs of each of the fields that is served by the course in Electrical Engineering. Appropriate labs will be designed for each of the topics offered through the web. Table 7(a) indicates the web-based topics that will be designed for students from the Civil/Environmental field. Three topics will be developed at the concept level and another six topics in detail. Table 7 (b) indicates the web-based topics that will be designed for students from the Mechanical/Industrial/Manufacturing field. Nine topics will be developed at the concept level and another 14 in detail. Finally, table 7 (c) indicates the web-based topics that will be designed for students from the Chemical/Petroleum field. Three topics will be developed at the concept level and another two in detail.

Table 7(a) Web-based topics Civil/Environmental

TOPIC AND DEPTH	
Concept only	**Detail**
Explosive Environments	Interfaces
Environmental RF-Hazards	LVDT
Safety Implications of NEC	
Delta	
Y-Delta	
schematics	
Illumination	
DC-DC converters	
Photo voltaic systems	
Electro-chemical systems	
Binary Number System	
Logic Devices	
General Purpose Interface Bus	
Trans control pro/Internet pro	
Acoustic	
Oscilloscopes	
Functions Generators	
Mathematica	
Point to Point Terrestrial	
Satellite	
Wireless	

Table 7(b): Web-based topics— Mechanical/Industrial/Manufacturing

TOPIC AND DEPTH	
Concept only	**Detail**
Impedance Matching	DC Transients
Diodes	AC Transients
DC-DC converters	Node Voltage Analysis
Volt to Frequency converters	AC Power
Logic Devices	schematics
Industrial Control Systems	Amplifiers
MEMS manufacturing	Grounding techniques
	Operational Amplifiers
	DC Motors
	Interfaces
	Resistive Temp Detectors
	Acoustic
	Acceleration
	LVDT
	Oscilloscopes
	Functions Generators
	DC/AC Power Supplies
	Matlab
	Simulink
	Robotics

Table 7(c): Web-based topics— Chemical/Petroleum.

TOPIC AND DEPTH	
Concept only	**Detail**
Safety Implications of NEC	Explosive Environments
Delta	Electric Shock Hazards
Y-Delta	Environmental RF-Hazards
Amplifiers	AC Power
Photo voltaic systems	Grounding techniques
Electro-chemical systems	Laplace Transform
Electro-Thermal systems	Power Transmission Systems
Binary Number System	Trans control pro/Internet pro
Embedded microprocessors	Resistive Temp Detectors
Simulink	DC/AC Power Supplies
MEMS manufacturing	Matlab
Electromagnetic Interference	Labview
	Industrial Control Systems

5. Conclusions

We have proposed an optimized curriculum for the course introduction to *Electrical Engineering for non-EE majors*. The curriculum proposal is based on survey data collected from faculty, students and industrial employees in the US. The findings will be refined and expanded to include other engineering fields as more data becomes available. The proposed curriculum was generated through a merger of independent curriculum sub-spaces created for each non-EE field. The proposed curriculum includes two main parts, one part which will be taught via in-class lectures and the other that will be taught via a web-based system. The proposed in-class curriculum is the inter-section of the curriculum sub-spaces. The proposed web-based curriculum consists of the parts that are not common between curriculum sub-spaces. In the next phase of the study, we will develop the curriculum based on the results reported in this paper and evaluate it by teaching it in three consecutive semesters.

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Acknowledgement

The authors would like to thank the support provided by the following for the development and the distribution of the survey: Dr. William Bulleit (Dept. of Civil and Environmental Engineering), Dr. Harold Evensen (Dept. of Mechanical Engineering), Dr. Tony Rogers (Dept. of Chemical Engineering), Dr. David Nelson (Dept. of Biomedical Engineering), Mr. Glen Archer and Mr. Jafar Pourrostam (Dept. of Electrical Engineering) at Michigan Tech University.

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