Multimedia and Web Techniques for Teaching Circuits I

Charles Slivinsky
University of Missouri-Columbia

Abstract

A variety of computer and Web-based techniques are being employed for instruction in the sophomore-level electrical circuits course at the University of Missouri-Columbia. For the classroom lectures, presentation software is used; the slides produced are based on an archive of several years’ lecture notes and make effective use of graphics design techniques and simple animations; students use their paper copies to take notes during class. For homework, exercises based on a widely used set of computer-generated problems are employed. For electronic conferencing, both e-mail and a computer conferencing system are utilized. A photo roster is also prepared and distributed to students.

For delivery of grades, locally developed software is employed to send individual e-mail messages to students to provide them with the scores mirroring the scores that the teacher has recorded for them in the gradebook. For individual self-study, a set of multimedia tutorials is under development to use to review for exams; these tutorials play back on PCs and incorporate digital video along with text, graphics, and animation techniques. Additional work is being done to develop Web-based Java software for acquiring and processing student assessments of the classroom teaching materials and presentations on a lecture-by-lecture basis.

I. Introduction

The author began studying multimedia systems techniques several years ago to support the first electrical circuits course in electrical engineering. The next eight sections below discuss the status and plans for the suite of techniques that have been or are being developed. The final section gives the lessons learned to-date and the conclusions. The remainder of this section describes the circuits course.

Enginr 124 is a three-credit, three-lecture-per-week course on circuit analysis that covers traditional material and uses a standard text. The course description is shown in Table 1. This single course serves both EE majors and other engineering undergraduates.

II. Presentation Slides for Classroom Lectures

PowerPoint slides custom-prepared by the instructor are used in delivering the course lectures. The slides are created specifically to support the lectures, going beyond merely providing an outline of the particular lecture topic or reproducing text and figures directly from the course.
textbook. Each set provides a high level of detail keyed to the instructor’s specific classroom explanations of the topics for that class session. For clarity only a limited amount of detail can be included on each slide, and sequences of step-by-step circuit diagrams may be drawn and frequently repeated from slide-to-slide. Thus, a large number of slides, with groups of them having information in common, are needed. For a given lecture there may be 20-25 slides.

**Enginr 124 Circuit Theory I**

Catalog Data: DC circuit analysis, inductors and capacitors, first-order response, AC circuit analysis, AC power, three-phase circuits, transformers. Prerequisites: Physics II and Differential & Integral Calculus.

<table>
<thead>
<tr>
<th>Topics</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Course overview, computer aids</td>
<td>1 class</td>
</tr>
<tr>
<td>2.</td>
<td>Charge, current, voltage, power, energy</td>
<td>3 classes</td>
</tr>
<tr>
<td>3.</td>
<td>Sources, Ohm’s Law, KCL, KVL</td>
<td>3 classes</td>
</tr>
<tr>
<td>4.</td>
<td>Series, parallel, voltage &amp; current division</td>
<td>2 classes</td>
</tr>
<tr>
<td>5.</td>
<td>Nodal &amp; mesh analysis</td>
<td>5 classes</td>
</tr>
<tr>
<td>6.</td>
<td>Network theorems &amp; maximum power</td>
<td>3 classes</td>
</tr>
<tr>
<td>7.</td>
<td>Capacitors &amp; inductors</td>
<td>4 classes</td>
</tr>
<tr>
<td>8.</td>
<td>RC &amp; RL circuit responses</td>
<td>4 classes</td>
</tr>
<tr>
<td>9.</td>
<td>AC steady-state, complex numbers, phasors</td>
<td>2 classes</td>
</tr>
<tr>
<td>10.</td>
<td>Phasors solution of AC circuits</td>
<td>4 classes</td>
</tr>
<tr>
<td>11.</td>
<td>AC power</td>
<td>3 classes</td>
</tr>
<tr>
<td>12.</td>
<td>Three-phase circuits</td>
<td>3 classes</td>
</tr>
<tr>
<td>13.</td>
<td>Mutual inductance &amp; transformers</td>
<td>3 classes</td>
</tr>
</tbody>
</table>

| Total  | 40 classes |

Table 1. Course Description of Enginr 124 Circuit Theory I

The master copies used to make the double-sided photocopies given to students can be printed within PowerPoint in two ways that have proven to be satisfactory. The PowerPoint print option “Handouts: two per page” along with the “Landscape” orientation can be employed to produce master copies, or the PowerPoint print option “Slides” and the copy machine’s image-combination capability can be used to produce master copies containing four slides on each master. The slides can also be made accessible via the course Web page.

The slides make effective use of simple graphics and animation effects not easily achieved with conventional presentations using the chalkboard or ordinary transparencies for the overhead projector. For example, for text, equations, and drawings of circuits, use is made of color highlighting, variable line thicknesses, and variations in font sizes and styles. In addition, the simple animation techniques available in PowerPoint are employed where appropriate. Figure 1
below shows the use of some of these features as well as the amount of information typically put
on a single slide. (This particular slide has no animation.) The slides are prepared using the built-
in drawing, font, and animation capabilities of PowerPoint. The software package MathType, a
mathematical equation editor for Windows that integrates seamlessly into PowerPoint, is
employed for writing the more complicated equations.

III. CircuitTutor Homework

For self-study, students in the course utilize CircuitTutor, a set of HyperCard stacks and
ToolBook modules developed by Burks Oakley at the University of Illinois at Urbana-
Champaign. The interactive tutorials utilized are ones that roughly correspond to the topics
listed the course description given in Table 1 above.

The expanded version of CircuitTutor also has homework problems and quizzes with circuit-
element values automatically chosen at random internally from a prepared list. At the beginning of
the semester we give students a set of handouts that contain printed versions of the
CircuitTutor homework. The same selection of circuit parameters per problem is utilized for all
students, in contrast to the randomly generated sets of parameters available when the
CircuitTutor homework is utilized in an on-line mode. Students grade each other’s homework using a portion of one class session each week.

IV. Conferencing Software

The course presently uses both e-mail and the conferencing system FirstClass, a commercial system that enables its clients to exchange messages and electronic documents on a private server. Authorized clients can use Macintosh and Windows client programs, and communication is over the Internet. Students can post messages, and faculty and teaching assistants or even other students can then read the messages and reply with messages that address the students’ concerns and provide specific assistance. There are also real-time “chat” modes that permit those persons logged on at a given time to interact while on-line. Chat sessions can be saved for all clients to look at and perhaps benefit from.

FirstClass was brought to the College of Engineering for the express purpose of utilizing it in Enginr 124. It works best in the course when there are “listeners” (teaching assistants and faculty) who provide a guaranteed response to students’ posted questions during prescribed hours of the day. During recent semesters we have not been able to provide listeners and have used FirstClass only sparingly in the circuits course.

Other courses in the college, however, are making extensive use of FirstClass. For example, a course on Java programming requires that students write applets and prepare PowerPoint presentations of homework problems each week. These assignments are submitted and graded using FirstClass without any hard copy being generated. Our distance-learning courses also use FirstClass as a primary means of interaction.

V. Photo Roster

At the beginning of the semester the teacher uses a digital camera and Photoshop to take a digital photo of each student and makes up a photo roster. Students then get a copy of the single-page complete roster showing small-sized color photos and names. This roster serves as an aid in helping students become acquainted with each other and in working together on the course. A part of a recent photo-roster is shown (with students’ permissions) in Fig. 2.

VI. Electronic Delivery of Grades (EDOG)

Electronic Delivery of Grades (EDOG) was developed at the University of Missouri-Columbia and is available, with permission, for public use by other institutions (http://www.missouri.edu/edog/index.cgi). The EDOG Web application lets an instructor maintain a gradebook as a spreadsheet or database, and then use that data to conveniently and appropriately e-mail to each student that student's homework scores, quiz scores, exam scores, grade estimates, and personalized messages. The software requires the teacher to provide the
links to Student ID numbers and data to be transmitted. These links are the column numbers and file name of the spreadsheet that the teacher is using to keep the student scores and statistics for the course. An example of an e-mail message sent to students by the teacher using EDOG is given in Figure 3(a). Figure 3(b) shows the student’s response to that particular message.

VII. Multimedia Problem-Solving Tutorials

A set of multimedia solved-problem presentations is being developed for playback by individual students to augment the classroom instruction. The presentations make use of full-motion digital video (basically a “talking head” of the teacher) to explain the solutions of representative circuit-analysis problems. The first such presentation developed is intended for use as a review for the first hour exam. It contains the solution of seven circuits problems taken from exams given previously in the course.

During playback the general appearance of the screen seen by the user is shown in Figure 4. The Video Window contains the talking head—the digital video narration of the problem solution. The playback of the digital video is synchronized with the information in the Graphics and Animation Window. This latter window contains the text, circuit diagrams, and animation for the problem statement and solution. The information that appears in this window is synchronized so that the representation of the problem solution unfolds in the Graphics and Animation Window in synchronism with the playback of the digital video.
ID number: 1234566
Name: Doe, John
First name: John
Last name: Doe
Class: ENGR
Year: JR
Set 1: 1-9; P1.3-3, 5; P1.5-4; P1.6-6, 17: 33 of 35
Set 2: all but #4; P3.3-1, 2; P3.4-2; P3.7-3: 28 of 32
Set 3: 1, 3 4; 3.5-1, 4; 3.7-17, 18: 0
HW Total (84 possible so far): 61
HW points (22 possible so far): 16.05263158
Quiz1: 8.5
Exam1: 72
Exam1 grade: C
Total Points 142 possible so far): 88
Total (%): 57.43143069
Course Grade so far: C
Rank (out of 40): 19
Comments: Missing HW Set 3
Please inform me of corrections.
Charles Slivinsky

(a) One Of The E-Mail Messages Sent By The Teacher Using EDOG

Professor Slivinsky,
Written below there is no record of me handing in HW#3.
But I turned it into class this morning.
John Doe

(b) E-Mail Response Sent By The Student Receiving The E-Mail Message

Figure 3 Example E-Mail Message Sent By EDOG And Sample Student Response.

The Graphics and Animation Window also contains navigation buttons to allow the user to pause, stop, and replay the presentation; in addition, there are buttons in this window to activate popups that provide supplementary and tutorial information within the window upon request by the user (by clicking on buttons). The third window, the Reference Window, is used for an abbreviated representation of the problem statement and for reference material, such as the
relevant circuit theory relationships, that the user may find helpful in working though or understanding the problem solutions.

![Video Window](Graphics and Animation Window)

**Figure 4. Display Format for the Multimedia Presentations**

The three-window multimedia presentation itself is a Macromedia Director “movie.” As the starting point in making the digital video to be used in the Video Window for one of the multimedia presentations, the university’s Academic Support Center films a narration, by the teacher, of the circuit theory problem statements and problem solutions. This narration is placed on cassette tape and then digitized and edited by the teacher or a student assistant using Adobe Premier (running on a PC) to produce a digitized version of the original video. Start, Pause, and Stop markers are inserted in the edited digital video to permit its playback to be controlled within the Director movie and synchronized with the information that appears in the Animation Window. The movie also synchronizes the appearance of the information displayed in the Reference Window.

The Director movie itself is put together using the Macromedia Director authoring software and programming in Macromedia’s proprietary programming language Lingo (http://www.macromedia.com). A discounted version of this commercial software, for academic use only, is available from Macromedia.

The Director movie can use the full range of PC-based multimedia—text, color, graphics, audio, video, animation, interactivity, and Web connectivity. Once produced, the Director movie can be converted into a self-contained, stand-alone “projector” that may be freely distributed. The projector is an executable file can run under Windows without the need to have Director software or any other supplementary software installed before playback.

The Director projectors for the circuits course are being stored on CD-ROM. The storage required without compression exceeds 100 MB. Making the multimedia presentation with a Video Window with still shots in place of the digital video while retaining the digital audio can significantly reduce the size of the projector. Students play back the self-contained Director projectors on their own Windows-based computers or at campus computing sites.
The original Director movie file can also be “shocked,” that is, lossily compressed and put in a
form that can played directly by either of the Web browsers Netscape Navigator or Microsoft
Explorer. After the Director movie file is shocked it is placed on a Web page, where it now
becomes available to any user who can access that Web page. The user must first install a
browser plug-in (free from Macromedia and downloadable from its Web site) before the user’s
browser can play the shocked Director movie. There is no charge to the user in this process, but
neither the shocked file nor the projector file is capable of being edited. The Director movie in its
original form can, of course, be edited, but only by using the software purchased from
Macromedia.

VIII. Asynchronous Assessment

A wide variety of assessment techniques and instruments are used in college teaching. Typically, the assessment instrument has a set of questions concerned both with an overall evaluation of the course and with the performance of the teacher. While these assessments are valuable for a variety of purposes, they usually do not explicitly ask for detailed feedback on the effectiveness of the specific approaches, explanations, examples, teaching materials, etc., that the teacher uses in a particular class. Without this latter kind of feedback the teacher may not know with any degree of validity what works for students and what does not work in learning the course material presented during a particular class session. In order to provide this feedback there must be a clear and direct naming of and focus on the specific activities and materials that are used during a given class. Traditional assessments do not have this capability.

A system for anonymous assessment by students is being developed for use in the circuits
course. Students anonymously submit their detailed assessments using the course Web page,
topic-by-topic as the course proceeds. The assessment instrument elicits detailed feedback from
students regarding specific class sessions. The focus is on the effectiveness of each individual
class session as perceived by students at the time that they are actively engaged in learning the
material. The assessments are of necessity highly customized and change with each class session.
The teacher receives the anonymous assessments and a statistical summary and then posts responses.

Figure 5 shows an example questionnaire from the first version of the assessment system. HTML
and custom-prepared graphics are used to prepare the questionnaire for each individual class.
Microsoft Access is used to process the assessment data the students provide. This system was
found to demand considerable effort from the teacher in preparing a unique questionnaire for
each class session. It is no longer actively being developed, but has served as a transition to the
current system.

The current version of the assessment system under development uses Java programming and
the same PowerPoint slides that were prepared for the classroom. The goal is to provide self-
contained software with its own database capabilities and features that make it simpler and much
less work for the teacher to compose questionnaires. A provision will be incorporated to edit out
any information provided by the senders that could possibly identify the senders or that is clearly
not useful in developing a helpful relationship between the teacher and the students.
Class Session 19, Course Element 3.

The example circuit was used to show how to find $v_C(0^+)$ and $\frac{dv_C(0^+)}{dt}$.

1. I understood the explanation of how to find $v_C(0^-)$:
   Not at all __  Somewhat __  Mostly __  Completely __
   Comment: ______________________________________________

2. I understood why $v_C(0^+) = v_C(0^-)$:
   Not at all __  Somewhat __  Mostly __  Completely __
   Comment: ______________________________________________

3. I understood how to calculate $i(0^+)$:
   Not at all __  Somewhat __  Mostly __  Completely __
   Comment: ______________________________________________

4. I understood how to calculate $\frac{dv(0^+)}{dt}$:
   Not at all __  Somewhat __  Mostly __  Completely __
   Comment: ______________________________________________

5. This course element should be retained.
   No __  Probably __  Yes __
   It could be improved by ______________________________________

---

Figure 5. Example Questionnaire From The First Version Of The Assessment System

The timing of the administration of the questionnaire is worth investigating further. Students allocate the time they spend on a course in conjunction to the course’s specific deadlines and graded assignments, and in conjunction with the quizzes and exams. Thus, students may be in the best position to evaluate the instruction just after completing an assignment or immediately following a scheduled exam rather than immediately after leaving the classroom. Also, the type of information being sought may be best obtained through an interview process rather than by the use of a computer-based questionnaire.
IX. Lessons Learned and Conclusions

Preparation time for a teacher working without technical support for creating materials can be ten times greater than that needed for conventional teaching. This is particularly true if the teacher makes the effort to use the formatting and animation capabilities of PowerPoint and creates a presentation specifically tailored to the particular classroom presentation. The teacher’s experience, creativity, and archive of examples and problems are valuable in devising presentations using multimedia. Unfortunately, the notes, drawings, artwork, and other materials in that archive generally are not in a form suitable for direct incorporation into multimedia presentations; furthermore, those starting-point materials were typically not developed with the intent of using the features of the presentation tools.

A thorough assessment of the value of the use of the techniques developed has yet to be undertaken to obtain actual data about student performance and evidence on the effect of the approaches on student learning. During the current offering of the course an assessment by students of the techniques currently being used is being carried out. A study on the effects on student learning is planned for future offerings. This study will include comparisons of exam grades, course grades, number of dropouts, etc. Having multiple sections of the circuits course (all of which are not using the PowerPoint slides and the other techniques developed) and having common hour exams and a common final exam facilitate the study. The student assessments conducted previously indicate that students prefer more difficult examples to be presented in the classroom sessions, instead of more straightforward examples that until recently were being used. Students also indicate a strong preference for applications-oriented examples and ones that relate more directly to the assigned homework problems and the exams.

We have gained valuable experience in developing a variety of techniques to support our introductory circuits course. Moreover, the equipment and the experience acquired provided a basis for additional applications of asynchronous learning and the expansion of computer conferencing throughout the college. In general, the students who are still becoming accustomed to the fast pace of engineering instruction or who are not as adequately prepared as desirable seem to benefit most from using the materials created. The techniques being developed have the potential to encourage all students to become reflective learners and to build trust with the teacher.

Bibliography
5. *FirstClass* is a commercial package published by SoftArc Inc. 100 Allstate Parkway, Markham, Ontario, Canada. Their Home Page is at [http://198.133.3711/](http://198.133.3711/)


CHARLES SLIVINSKY

Charles Slivinsky is a Professor of Electrical Engineering at the University of Missouri-Columbia, where he has taught since 1968. He has worked for several companies and government laboratories and is a former department chair. He is involved in both engineering and computer science accreditation activities. Dr. Slivinsky received his B.S.E. in Electrical Engineering from Princeton University in 1963 and the MSEE and Ph.D. from the University of Arizona in 1966 and 1969, respectively.