A hands-on laboratory-driven Electrical Engineering 2-year curriculum for distance
and at-home learning

PR116B000142

YEAR 1 REPORT

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I. Introduction

This document is part of the Comprehensive Program Annual Performance Report for FIPSE Grant PR116B000142.

II. Project status

1. Progress in accomplishing objectives

The status will be reported with respect to the proposed objectives. For each objective, we re-state the original objective statement, specify the current status, and describe progress in more details.

1.1 Objective 1

Statement. Develop a laboratory-driven curriculum for four-year universities and community colleges (CCs) to include hands-on hardware-based laboratory experience. This curriculum may be delivered on-site (e.g. at a four-year university) or synchronously on-line (e.g. at a community college by a local instructor, using on-line materials).

Status: on schedule.

Report. The curriculum materials have been prepared for 2 courses (EE 233 and EE 215) and progress has been made in converting a student handbook for the third course (EE 235) to html format. Five motivating experiments have been built and verified:

- Roll your own electronic lock
- The pocket metronome
- Audio filter design for better frequency selection
- Design of a simple vector network analyzer, and
- Design of a simple multi-purpose oscillator.

These experiments are suitable for the four courses covered by this proposal. The documentation of these experiments is in progress. We discovered that the method to motivate students based on these experiments required significant interaction between the instructor and the students in a classroom setting, and adapting these experiments to a distance-learning format requires more sophisticated web-based interactive tools. This topic will be reported in depth in Objective 2 below.

The materials available for EE 233 include a Faculty Handbook and a Student Handbook, written based on the topics covered so that the handbooks are usable by other institutions. The first version of both handbooks is posted on the project web site. They are being used in our on-campus classes (by different instructors) and assessment is being conducted to study their usefulness. The handbooks have also been sent to the University of Alaska Fairbanks for possible use in their equivalent courses.

The materials for EE 215 were created in Spring 2001 while the course was taught on-campus and are being adapted for distance learning. These materials include the regular experiments but have not included the motivating experiments yet.

The student handbook for EE 235 is being converted to html format, including both the “passive” web pages and also
“interactive animated” web pages. Professor Riskin is also revising a textbook (previously co-authored by Philips and Parr) for this course and the materials developed in our work are being incorporated into this text.

A new instructional designer, Dr. Robert Lee, was hired in March 2001 by our distance-learning unit (EDGE) to work on several projects, including this project. Dr. Lee came from the Seattle Community College District, where he had abundant experience in course web site design, teaching both in the classroom and online, and working with faculty to put their courses on the web. He has taught geography at several local community colleges over the past ten years, has been an editor with Houghton Mifflin, and has had his own educational consulting business. He earned his doctorate in education and geography from the University of Iowa and held a post-doctoral fellowship at Harvard University. The development of two courses (EE 233 and 235) has accelerated considerably since Dr. Lee’s arrival. Professors Soma and Riskin have met weekly with Dr. Lee to discuss course design and production issues. Students have been brought into the team for production assistance and to bring a different perspective to the process. The students have been especially helpful in converting text, equations, and graphics from many sources into html formats.

1.2 Objective 2

Statement. Adapt and enhance this laboratory-driven curriculum to target students in geographically remote communities without convenient physical access to nearby post-secondary educational institutions. This curriculum is delivered asynchronously on-line. Hereafter, we will refer to these students as “at-home” students since they literally have to do all their course work at home. The constraint in this instance is the lack of any laboratory facility at all in the students’ homes.

Status: on schedule.

Report. A major component to make at-home hands-on experiments possible is the laboratory instrumentation kit, which will be referred to as the Pandora box. A first version of the Pandora box, using a mix of electronic controls and mechanical controls, has been built and includes the power supplies and the waveform generator. The oscilloscope was built but not incorporated into the first box due to delays in manufacturing. The Pandora box was tested by two student groups: one individual student and a team of 3 students, using experiments in EE 371 (one of the 4 courses in this proposal). The assessment was conducted by our evaluator and the full evaluation report is included in this progress report. We note that the students were extremely enthusiastic about using this instrumentation tool kit (all four students offered to help with its development) and all the problems discovered in preliminary testing were due to the mechanical controls, which will be eliminated in the next design. We rushed the assessment of the first box in spring 2001 to ensure of early students’ feedback before proceeding too far with the manufacturing of the final box.

The final integration of all the instrumentation into the box is proceeding. Due to safety considerations, we have decided to use an external simple power converter (e.g. those used for portable home electronics) to provide the power supplies. To incorporate a power supply into the Pandora box with direct connections to the wall 3-phase power outlets would require Underwriter Laboratories approval and compliance with various safety laws governing electronic products. Moreover, the transformer-based internal power supply is large and heavy, making the box too large to fit into a student’s backpack and too heavy to be conveniently portable. The cost of an external power converter is low (we are evaluating 4 units costing between $15 to $30 each) and we will include voltage regulators in the Pandora box to ensure reasonably clean power for students’ experiments. The other instrumentation (waveform generator and 2-channel oscilloscope) is being incorporated, with complete electronic controls from the host PC.

The communication between the host PC and the Pandora box relies on the USB bus. We use the USB microcontroller marketed by Cypress Semiconductors (the most popular USB controller) and have developed software to communicate between the host and the device. Since the USB bus is relatively new, most development tools are rather cryptic and it has taken us some time to understand how to work with this bus protocol. The user interface is being written in cooperation with Cypress and we have also contacted National Instruments (the marketer of LabView) to see if we can use their user interface. The key consideration is to keep the cost down for students, targeting the total price of the Pandora box at $200. Some manufacturers are not willing to meet this price point yet so the negotiations are still in progress.

We have started a plan to manufacture about 100 units for trials in distance-learning courses beginning Winter 2002. Our in-house capability is only up to 10 units or so, and we are working with Cypress and other companies to establish this prototype manufacturing arrangements.

Some video production for use in the distance-learning format has been scheduled for later this summer. Because of
the time and expense required for this activity, it is usually best to schedule it late in the course development process. Premature taping can lead to expensive re-shooting and editing if significant changes to the course design need to be made. Also, any video associated with the Pandora box will need to wait until the box design is closer to final manufacturing. Too many discrepancies between the hardware shown on the video and the actual kit would detract from student learning.

With respect to pedagogy, we discovered in developing materials for the motivating experiments that passive web pages defeat the “motivating” purpose. In class, we describe the desired goals in building a project (e.g. a modem, a metronome, etc.) and assign students the work to find an initial circuit, to evaluate trade-offs, to compare different methods to process a signal, etc. This process of understanding a design and trade-off evaluation is the springboard for the lectures and the theory. Incorporating a motivating experiment into a course takes several weeks of interactions between the instructor and the students, and between the student teams. Passive web pages are not suitable for this purpose, especially in the context of distance learning; thus we have started to design interactive animated web pages (using Macromedia Flash as the key tool) to teach motivating experiments as well as to provide practice opportunities for students at home. Interactive web pages also help illustrate theory (e.g. convolution) and visualize circuit performance. We are re-orienting the development of curriculum materials toward interaction as much as possible.

1.3 Objective 3

Statement. Establish a laboratory-driven curriculum development methodology, common to two-year and four-year institutions, to provide hands-on laboratory experience at a reasonable cost.

Status: under consideration.

Report. The development of this methodology must take into account various factors: the characteristics of “motivating” experiments, where to find materials for these experiments, and how to incorporate them into existing courses. Last but not least is to convince the instructors to teach experiments as a way to lead into the lectures, a process drastically different from accepted teaching practices. We are compiling a collection of motivating experiments and have begun the process of documenting teaching methods to incorporate them. Progress has been slow on this objective since during the first year of this project, we have focused more on objectives 1 and 2 as described above.

2. Significant changes for the coming year

We do not foresee any significant changes in the coming year with regard to the overall project objectives. The offering of distance learning courses depends on the manufacturing of the Pandora box with sufficient volume to accommodate students, and could be delayed one quarter if we need more time to find a suitable industrial partner. Some activities, such as video production, may take place on a different schedule than originally planned. By the end of next year, we expect to complete all video production originally described in the proposal.

3. Impact on teaching and learning in our institution

The immediate impact of the project is with respect to the courses we are working on. Materials from this project are being provided to instructors of EE 233 and EE 235, which is better in terms of quality and quantity than previously available. Our department is considering a curriculum revision, and the chair of the Undergraduate Curriculum Committee (Professor Richard Christie) has been a regular attendee of our monthly meetings. He has contributed significantly to this project (especially in providing materials for EE 215) and we expect that our development becomes an integral part of the new curriculum. Because several different faculty members teach these courses, we believe that the use of the grant-funded course materials will improve the consistency and quality of the courses. By selecting the materials they find most useful, faculty will have an expanded toolbox and will spend less time creating materials whose equivalents have already been developed. We also believe that community college students who take the courses will be better prepared to transfer into the UW. Again, the consistency between different versions of the course will ensure that students have comparable preparation as they enter into more advanced courses.

4. Impact on other institutions

This project is in its first year, so it is too early to see any impact on other institutions. We did send the faculty handbook and student handbook for EE 233 to the University of Alaska, Fairbanks (UAF, a partner in this project) for
evaluation. UAF is a semester school, thus the materials we provide do not cover their entire corresponding course. We design these handbooks based on topics, not on a specific textbook or a weekly schedule, thus they can be adapted for different courses and different quarter / semester structures. Assessment is being conducted with UAF to evaluate the usefulness of these materials to their faculty and students.

5. Evaluation progress

5.1 Method

The first year of the Pandora Project has focused on curriculum development and the production of the lab kit. Monthly meetings of the project team track progress and provide a venue for communicating developments and clarifying strategies. The meeting record is posted on the project web site.

5.2 Findings

5.2.1 Pandora box (laboratory instrumentation tool kit)

A major effort for the project has been the Pandora box development. Early in the year, a preliminary version of the box was revealed at a monthly meeting. The box had wires springing out from all sides and was immediately named "Pandora" for its resemblance to the mythical Pandora's box. Technical experts have since improved the box, which was assessed in its redesigned version for its usability.

Four student volunteers from the spring quarter EE 371 class tested the Pandora box by conducting experiments they had previously done in their class. The first test was performed by an individual student and took an hour; the second test was conducted by a team of three students and lasted about two hours. Assessment questions were designed by the OEA with input and modification by Mani Soma to make them appropriate for EE 371 students.

This version of the box has mechanical controls to set signal parameters (amplitude, frequency, offset, signal type, duty cycle). The final design will be completely controllable from a PC, without any mechanical devices. The students were given the Pandora web site to read about the project and a one-page user's guide. The students were observed during their experiments using the lab kit and were asked to complete the assessment questionnaire.

The individual student was very careful in using the box and discovered very few problems using it. The three students on the team manipulated the mechanical controls simultaneously, which is not the proper use, but most students seem to do this in the lab with regular equipment, and discovered several problems with the mechanical controls. Students' responses during the test were enthusiastic, revealing that the lab kit was much easier to use than current instrumentation in the lab. Students' written responses to questions suggested some problems, but overall highly positive outcomes. Especially significant are student responses concerning how their use of the lab kit would enhance their education:

Having a consistent measurement device would be great. It is a pain to switch from one device to another in the current labs.

I would be able to implement my own ideas and be able to test them.

Practical experience with signal operators and discrete components is valuable.

I could experiment with other things besides class projects at my convenience.

It is worthy to note that all of the students eagerly volunteered to test the next model. From the evaluation of this part of the project, several actions will be taken:

The electronic version will eliminate all mechanical controls and their associated problems.

The timing control is critical and will be revised to avoid problems in operation of the lab kit.

The student feedback about the user interface design is extremely valuable and is being incorporated.

Triggering the oscilloscope needs to be designed carefully since it still poses problems for students in
The complete questionnaire and assessment data are posted on our project web site.

5.2.2 Curriculum Development

The pilot of the first course, EE215, will be offered winter quarter 2002. UW EDGE is developing the online version of the course using materials supplied by Engineering faculty. The current EE courses are mapped to the ABET learning outcomes and include learning objectives. The online curriculum designer hopes to develop one lesson in online format, then review it with Mani Soma or Eve Riskin. Some problems have emerged when converting formulas to web formats; parts of the formulas seem to disappear or appear in different formats. The need to scan or hand-enter formulas has been discussed. One point of discussion has been the development of the interactive component of the online course. Instead of designing a course using SQ4R (survey, question, read, recite, rite, review), designing a course with an interactive component, where students interact with the web as an aid to their understanding, seems to require not only different ways of thinking about teaching and learning, but also a web interface system. Recently, several UW undergraduate students have been hired to help design the web interface for the interactive part of the class.

An unforeseen outcome of the project is that members of the project team are connecting with other people who also have innovative ideas. Some faculty and staff have attended UW Catalyst workshops to learn about E-Post webforum, and WebQ (online interactive instructional aids) and have initiated conversations with Catalyst personnel about their new Virtual Cases, a method to facilitate online problem-based learning. Faculty have also met with a person who is developing a speech recognition program that the Pandora project might use to help summarize lecture information.

The first draft of handbooks for faculty and students has been developed for EE 233. An instructor at the Alaska site and one on the UW campus are piloting the materials in their summer courses. Every two weeks this summer, the project evaluator is meeting with the UW instructor to obtain formative feedback on the materials. Initial reports from the UW instructor suggest that the handbooks are well written, lucid, and well laid out. Email communication with the Alaska instructor has been initiated to gather additional information. A possible site visit to Alaska by the online curriculum designer may also take place.

Pandora Project leaders seem to have a clear picture of their vision for the project. Questions have been raised about the viability of the project timeline. At this point it is hard to know if the timeline is too optimistic. One thing is for sure: EE 215 will be advertised this fall for its initial offering winter 2002. Pandora's Hope, the one good thing among many evils her box had contained, remains strong for project participants.

6. Sustainability over long term

The courses we develop are an integral part of our core sophomore/junior curriculum. Even if there is a curriculum revision with different course structures, our materials are topic-oriented, thus they can be re-used as modules in the new curriculum. For example, the materials on the Laplace transform will certainly be used, no matter how courses are re-formatted. These materials can be incorporated into a new course as self-contained modules. This topic-based framework also facilitates the use of these modules at other institutions.

The availability of the Pandora instrumentation tool box, based on initial students’ assessment in Spring 2001, will be a major contributor to the hands-on experience of our undergraduate students, and we expect it to be useful at other institutions as well as for at-home students.

The clearest indication of the sustainability of our project, at least at our institution, is the preliminary approval of a 3-year grant from the University Tools for Transformation program to continue this curriculum development methodology for 3 senior courses in Electrical Engineering. We expect this 3-year grant to begin in September 2001. The total budget, not including overhead, is $500K, and after including $400K matching funds from our distance-learning unit, will total to $900K.

The "at-home" version of the courses will be offered to the general public as a certificate program through UW Extension Distance Learning beginning in early 2002. The program, entitled "Fundamentals of Electrical Engineering" is being advertised in Extension's autumn quarter catalog, and brochures are now being developed. We are planning for an initial group of 20-25 online students. Students who complete the certificate program will be able to use the credits they earn toward their BSEE degree. The distance learning courses are expected to be self-sustaining
after completion of the grant period.

Licensing discussions are also in the early stages with the state's community colleges. UW Educational Outreach is in negotiation with one institution to establish a new licensing model. In addition to allowing the licensee to offer certain UW-developed courses on its campus, this model will enable the partner institution to sub-license those courses to other community colleges in the state. When the model is more complete, we will investigate the possibility of using it to disseminate the grant-funded courses.

7. Products and resources from our project thus far

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<tr>
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<tbody>
<tr>
<td>___ journal articles</td>
<td>XX printed course materials and modules (EE215, 233, 235)</td>
</tr>
<tr>
<td>___ books</td>
<td>XX web course materials and modules (EE 215, 233, 235)</td>
</tr>
<tr>
<td>XX textbooks (EE 235)</td>
<td>XX other project materials on the Internet (EE 215, 233, 235)</td>
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<tr>
<td>XX guides/handbooks (EE 233)</td>
<td>XX evaluation reports</td>
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<tr>
<td>___ video or audio disks</td>
<td>___ conference proceedings</td>
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<td>___ CD-ROMS</td>
<td>___ policy documents</td>
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<tr>
<td>___ software programs</td>
<td>XX other (explain) interactive animated web pages (EE 235)</td>
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<td>___ syllabi</td>
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A presentation proposal entitled "The Use of Software/Hardware Kits in Technology Distance Education" has been submitted to the 7th Sloan-C International Conference on Online Learning, to take place in November 2001. The presentation will highlight three examples of using software/hardware kits in on-line learning: the lab kit from this project, a development kit used in the "Certificate Program in Embedded Systems" through UW Extension, and a development kit used in a digital signal processing course at Georgia Institute of Technology. We will be notified by July 25 if this proposal has been accepted.

8. Special recognition from our institution

The Department of Electrical Engineering 2001 Annual Research Review (EE Kaleidoscope 2001) includes a two-page full-color description of our project. The report is sent to all Engineering Deans, and high-level managers in industry and government agencies. The report can be viewed on-line at www.ee.washington.edu/welcome/eek.pdf, and our project is on pages 6 and 7.

The University Tools for Transformation program also recognizes our effort and has tentatively approved an extension of this project to cover a 3-course senior sequence in EE, with a budget totaling $900K (no overhead) for the next 3 years. More information on this pending grant is in the sustainability section above.
### III. Budget Information

1. Chart

<table>
<thead>
<tr>
<th>BUDGET STATUS REPORT</th>
<th>Current Budget 10/01/00 - 09/30/01</th>
<th>Expenditures 10/01/01 - 06/15/01</th>
<th>Obligations &amp; Projected Expenditures 06/15/01 - 09/30/01</th>
<th>Estimated Unobliged Balance 09/30/01</th>
<th>Unobliged Carryover from Previous Budget Period(s)</th>
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<tbody>
<tr>
<td>A. Direct Costs</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1. Salaries</td>
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<td>2. Benefits</td>
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<td>3. Travel</td>
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<td>4. Materials</td>
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<td>5. Consultants</td>
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<td>B. Indirect Costs</td>
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<td>5,473</td>
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<td>TOTAL</td>
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<td>73,887</td>
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</tbody>
</table>

2. Narrative

We underspent the budget in this first-year period for these reasons:

2.1 Salaries / benefits:

a. We decided to employ all undergraduate students to work on this project: designing and building the Pandora box, developing web pages, designing and building motivating experiments, etc. The undergraduate students are paid by the hour (approximately $10 / hour) and several actually prefer to get independent study credits rather than money. Thus while we employ more than 12 undergraduate students, the cost is less than the budgeted cost for one graduate student, and there is no tuition fee charged to the grant. We plan to continue working with undergraduate students, but we also will hire one graduate student to integrate and help manufacture the Pandora box for the second year. The cost for
students will increase and absorb the remaining amount from the first year.
b. Professor Eve Riskin decided not to use her course release during the first year, but will do so for the second year.

2.2 Travel
During the first year of the project, we have not generated sufficient materials for conference presentations so no conference travel is charged to the budget. The planned travel to Alaska to visit our partner in Fairbanks is postponed until UAF has more time to evaluate our materials. With our current progress, we expect to travel much more extensively next year to disseminate our results.

2.3 Consultants
Two of our community college partners have actively participated in the project but have been rather slow in billing us for their cost. We have contacted their fiscal units and ask for more timely billing.

2.4 Indirect cost
The underspent amount is a consequence of the above factors.

3. Carryover request
We respectfully request a carryover to the second year since the start-up period of any project is rather slow. We are proceeding at full speed at this time and expect to use the resources as originally proposed.