THE IMPACT OF BENCHMARKING PEER INSTITUTIONS IN CURRICULAR REFORM

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Abstract

Benchmarking peer institutions should be viewed as an essential element in curricular reform, i.e., continuous quality improvement (CQI) in both the undergraduate and graduate curriculum. The process of benchmarking can also be viewed as an opportunity to establish a network of individuals who share common interests and potentially a common vision regarding educational reform. This paper describes the outcomes of a survey of 36 institutions regarding the content of their electrical engineering service courses. The primary objective of this survey was to assess how national and regional universities used these courses to achieve their respective undergraduate engineering educational program objectives. We describe how we used these data to develop local reform strategies for service courses. We also describe the implications of these results for identifying the opportunities for reform and the challenges to institutionalizing curricular changes.

I. Introduction

Engineering Service Courses

An engineering service course may be defined as a required or elective course taken by engineering students outside their principal field of study—e.g., an environmental engineering or computer engineering course taken by students majoring in mechanical engineering. While preparing for an EC2000 accreditation site visit to Michigan State University (MSU), several members of the College of Engineering faculty came to recognize that engineering service courses were often overlooked—or even discounted—in their potential educational value. Reviews of the undergraduate engineering programs revealed that by and large MSU’s engineering faculty viewed engineering service courses primarily as a longstanding engineering curricular mandate from ABET. This Engineering Topics curricular-content requirement is concisely stated as follows in a recent addition of ABET’s Criteria for Accrediting Programs in Engineering in the United States:

“In order to promote breadth, the curriculum must include at least one engineering course outside the major disciplinary area.”

Several faculty members began to look beyond this cryptic requirement to add breadth to engineering programs and asked the following important question:
“How might MSU transform its engineering service courses to better achieve the program outcomes mandated in EC2000’s Criterion 3?”

One outcome of this review was to take a critical look at the various engineering service courses at MSU and seek ways to improve them. This paper focuses on one of these courses, ECE 345—Introduction to Electronic Instrumentation Systems. This course is offered by the Department of Electrical and Computer Engineering (ECE) and is required by students in four engineering majors. Five other programs designate it as an elective course. Electrical engineering and computer engineering majors are not allowed to receive credit for taking this course, instead taking a more in depth sequence of courses. Students are introduced to electrical and electronic components, circuits and instruments. The circuit laws are applied to dc, ac, and transient circuit applications. Students are also introduced to digital logic fundamentals and gain experience in designing, building and testing simple logic circuits. A three-hour/week laboratory provides active learning experiences for the students.

**Initial Process for Assessing the Course Learning Objectives**

ECE 345 did not have a good reputation. Students who took the course and the faculty members who taught it shared this opinion. Students had difficulty learning the material and seeing how it could be applied within their major fields of study. Faculty members teaching the course felt that too many topics were covered at a superficial level. Feedback from one student captures the general sense of both the students and faculty:

“This class was really presented at a pace which made retention of the material challenging. It seemed as though the class started and was over before you knew it. And when it was over, it was one of those classes where you really didn’t know what you had learned.”

Our initial approach to improve ECE 345 was to sue feedback from students and faculty members as follows:

1. Develop a draft set of course learning objectives and course topics based on the existing course model and content.
2. Share these documents with department chairs throughout the College of Engineering, and with chairpersons of the various departmental and college curriculum committees.
3. Develop a comprehensive plan to revise the existing course. This plan included the following components:
   a. update the course learning objectives;
   b. modify and expand the course topics;
   c. change the course prerequisites;
   d. increase the number of course credits from three to four by adding one additional lecture period per week.
4. Take this revised proposal to the Electrical and Computer Engineering (ECE) Department’s Undergraduate Curriculum Committee for review and action. After lengthy discussions on this course-change proposal, the committee decided to defer taking action on the merits of the proposal until each affected department expressed their opinion on the proposal.
5. Take the course-change plan to each department in the College of Engineering and solicit feedback. A brief summary of this feedback follows:
   a. Departments were not willing to endorse adding a credit to the course.
   b. Departments did offer suggestions for adding course material or adding emphasis to specific topics covered in the course.
   c. Most departments could not draw a strong connection between having ECE 345 as a requirement (or an option) for their respective majors and the educational program objectives of their own undergraduate academic programs.
   d. Most departments expressed the opinion that ECE should have the faculty expertise to determine the course learning objectives and course content.

6. The ECE Department reviewed this feedback and indefinitely deferred action on revising ECE 345. The individual faculty member, who assumed responsibility for the course, began to make incremental changes in the lecture and laboratory material with an eye toward improving student learning outcomes and toward linking course material with more advanced courses in various majors.

Almost two years has passed since this review and revision process began. An important question arose during this process: “How do other institutions deal with similar engineering service courses.” This question led us to benchmark other institutions. This benchmarking process and its results are the focus of the remainder of this paper.

II. Benchmarking

Strategic Planning

George Keller was the first to call for the use of strategic planning as a common practice in college and university administration. Since that time, many authors and practitioners have echoed his call for tying resource allocation more directly both to institutional and programmatic needs, and to performance. Many state policy-makers now argue for the use of performance measures, in particular student learning outcomes and faculty teaching and research productivity, to judge the quality of academic programs.

Initially academic program reviews initiated as part of a strategic plan focused on comparing program objectives (e.g., a target retention rate for new students) to performance (e.g., the actual retention rate). This internal comparison left unanswered the question of whether or not the stated objectives were reasonable or even attainable in the first place. As a consequence, many academic institutions expanded their reviews of academic programs to include results from peer institutions or programs.

Most accreditation procedures include some type of comparative analysis or benchmarking. In examining fiscal stability, for example, regional accreditation agencies commonly compare revenues and expenditures for one institution with norms derived from similar institutions. State governing boards sometimes set ranges for faculty salaries in public institutions by comparing salary data from selected peer institutions. The National Science Foundation, the U.S. Department of Education, and the Kellogg Foundation among others publicize exemplary...
academic programs and their achievements both to encourage other institutions to adopt successful practices and to serve as benchmarks for measuring program performance.

In the context of reforming engineering service courses, benchmarking served to identify norms and standards by which the College of Engineering at MSU could judge both current the current status of its service courses and whether the changes over time met or exceeded norms for peer institutions. These benchmarks could focus on demographics; for example, establishing the average number of credits for an Electrical Engineering service course among peer institutions. Or they could focus on instructional practices, such as the extent that hands-on design is used in comparable programs. In both cases, these benchmarks served as comparative data for MSU to determine where it currently ranked and to judge improvements over time.

Ten years of experience with reforming undergraduate engineering education also has shown the importance of benchmarking as a potential lever in the change process. The ECSEL coalition demonstrated that academic leaders could motivate their own faculty members to change by showing that their faculty peers in partner institutions were changing. This finding is consistent with the literature on systemic reform, which argues that the reform process is dependent on more than internal dynamics. Instead, an array of external, institutional, departmental, and individual factors are crucial.

**Prestige and Status: Role Models for Innovation in Undergraduate Education**

Academic institutions, their programs, their faculty and administrators typically aspire to join the ranks of those perceived as holding higher status. These higher status institutions, usually major research universities (e.g., Harvard University, the University of California at Berkeley) are seen as setting the standards by which others should be aspire. Fulton and Trow identified the appeal of status as the reason for mimicry, where institutions (or programs) of perceived lower prestige try to behave like their higher status compatriots. Their hypothesis has been proven. Research productivity is the strongest predictor of faculty salaries (and in many cases promotion and tenure) regardless of type of institution or academic discipline. That is, research productivity today is as highly valued in masters-level institutions as it is in research universities. The high value placed on research and scholarly activity means that most Colleges of Engineering attempting educational reform will look to their perceived peers or superiors in level of prestige to provide benchmarks for goals, objectives, and even improvement strategies.

Yet major research universities may not set the standards nor provide the best examples of successful reform for engineering service courses. The very reason for high status—research productivity—often comes at the expense of instruction, especially undergraduate education. As our research in this paper shows, less prestigious institutions with greater emphasis on undergraduate education better integrate curricula and incorporate innovations in service courses. As we discussed previously, these institutions focus on undergraduate teaching and learning, have more integrated curricula (in part because of having fewer courses and specialties), and exhibit more interdisciplinary courses in part because they have fewer faculty members who must teach courses outside their disciplines. As we discuss below, our findings strongly suggest that these more teaching-oriented institutions, regardless of their national stature, may serve as
better benchmarks for undergraduate reform in engineering education than major research-oriented universities.

**Building a Network for Reform**

The traditional view of benchmarking in academe is to identify standards for comparison. These standards may serve as the basis for program review or accreditation, norms for setting salaries and workloads, or goals. However, none of these purposes is particularly suited to disseminating innovations. Instead of seeing benchmarking solely as setting standards and norms, we propose to use it to promote dissemination. From this perspective, benchmarking serves to help us identify partnerships with like-minded individuals, that is, individuals and institutions interested in engineering service course reform. Benchmarking can become the first step in forming a network for reform. This network serves to promote dissemination actively by providing existing test beds of innovation that other institutions can view and study. Most importantly, it encourages a more active view of dissemination, one where those who already have tried and succeeded help others by providing crucial information and by actively assisting in implementation.

**III. Benchmarking Methodology for ECE 345**

**The Electrical Engineering Service Course Survey Instrument**

We began by developing a survey that captured the type of information we wanted to obtain from other institutions regarding electrical engineering service courses. A copy of this survey is contained in Appendix I of this paper. The survey was kept brief to encourage high response rates. The survey had two components—questions regarding the “instructional model” and “supplemental questions.” The six questions regarding the instructional model captured the core of the discussion at MSU regarding the engineering service course ECE 345: Electronic Instrumentation and Systems:

1) Is the course specifically intended for non-EE majors?
2) Do freshmen, sophomores, juniors, or seniors typically take this course?
3) What is the number of lecture hours/week?
4) Is there a laboratory component? If so, how many hours/week?
5) Is the laboratory a separate course or an integral part of the lecture course?
6) Is the laboratory component required?

The four supplemental questions asked respondents to identify textbooks and laboratory exercises used in the course. We were also interested in determining how lessons learned in this service course were applied in follow-up courses; e.g., courses involving the major engineering design experience.

**Sample Population and Responses**

The Carnegie Foundation for the Advancement of Teaching defines a National University as one that offers the Ph.D. degree and a Regional University as one that offers the B.S. or M.S. degree.
as the highest degree. We selected a mix of National and Regional Universities, as identified by *US News and World Report*\(^2^4\). Our survey results are comprised of the following mix of institutions:

1) 36 institutions were surveyed, of which (See Appendix II):
   a. 26 offer a Ph.D. as the highest degree (National University)
   b. 10 offer a B.S. or M.S. as the highest degree (Regional University)

2) 26 institutional responses were received, of which:
   a. 20 offer a Ph.D. as the highest degree (National University)
   b. 6 offer a B.S. or M.S. as the highest degree (Regional University)

Hence, we received responses from 72% of the institutions contacted. This included 77% of the National Universities and 60% of the Regional Universities. The relatively high response rates can be attributed to several factors. First, before sending out the surveys we contacted each institution and received the name of the person responsible for the course(s) of interest. Second, we sent e-mail messages to these individuals indicating that the survey was on its way through the U.S. mail. We then followed up with a second e-mail message in which the survey was actually attached as an electronic document. Finally, we indicated in our cover letter that we would share with each participating institution the results of our benchmarking survey.

IV. Survey Results

*Instructional Model*

1) With respect to whether or not there was a specific electrical engineering course for non-majors, 19 of the 26 respondents indicated that a separate course(s) existed for non-majors.

2) These courses were typically targeted for juniors. However, a few respondents indicated that the courses were part of a freshman engineering experience. A couple indicated that seniors typically took the courses.

3) Although most courses had three-lectures/week, this number varied from 2.5 (quarter system converted to semester system equivalent) to six-lectures/week (covering two semesters of course work).

4) A total of 19 of the 26 respondents indicated that a laboratory experience was included in the course. Although laboratory periods were typically three-hours/week, they varied from one hour to four-hours/week.

5) Almost all respondents indicated that the laboratory was an integral part of the course, not offered as a separate course. One respondent indicated that the lecture and laboratory portions of the course were integrated into a “studio style course.” This course met two-hours/day, three-days/week, with every lecture having a laboratory exercise integrated into it. Lectures typically lasted one-half hour/meeting with the remainder of the time spent in the laboratory portion of the course.

6) All of the institutions that offered the laboratory required it as an integral part of the overall student learning experience.
Supplemental Questions

1) Appendix III summarizes the textbooks used at the various institutions surveyed. We note that these textbooks comprise two groups—texts normally used by electrical engineering majors in a electric-circuits course and texts that provide a survey of EE topics typically needed by non-EE majors.

2) Nine respondents indicated that their EE service course(s) is required for advanced courses in non-EE areas of study.

3) The same nine respondents also reported that material covered in their EE service course(s) is used in follow-up courses.

V. Lessons Learned

We are currently in the process of sharing what we have learned about the reform of EE service courses with various faculty, student, alumni and administrative groups within the MSU College of Engineering. From these discussions, we will identify a strategy for moving forward with plans to better link ECE 345 to follow-on courses within the majors, including the major engineering design experience.

We embarked on the benchmarking project to assist the engineering faculty at MSU change courses and curricula. Change is the heart and sole of continuous quality improvement. Our goal in benchmarking was to show how other institutions dealt with engineering service course issues and how engineering service courses might be integrated into the student’s overall undergraduate student learning experience. Principal lessons learned include the following.

Spontaneous versus Planned Innovation

Perhaps the greatest lesson learned dealt with the basic differences that appear to exist between National Universities (those which offer the Ph.D. degree) and Regional Universities (those which offer the B.S. or M.S. as the highest degree). Regional Universities tended to link engineering service courses to advanced courses, while National Universities did not. This is a very interesting finding; i.e., the Regional Universities surveyed appear to plan strategically for curricular innovations while National Universities generally did not. National Universities tended to progress with course and curriculum reform as “spontaneous innovation” on the part of an individual faculty member of small group of faculty members. While we believe that spontaneous innovation is an important element in course and curricular reform, these innovations cannot be sustained in the long term unless their intrinsic value is properly documented. Once the value of this spontaneous innovation is recognized outside the faculty initially responsible for the innovation, then it needs to be recast as an integral component of the academic unit’s plans for course and curricular innovation and reform. Otherwise, the spontaneous innovation will very likely be short lived because it didn’t become part of the academic unit’s culture.

Benchmarking National versus Regional Universities
One traditional view related to benchmarking best practices is that National Universities would benchmark National Universities and Regional Universities would benchmark Regional Universities. The lesson learned with respect to “spontaneous versus planned innovation” suggests that National Universities should consider also benchmarking Regional Universities when seeking out best practices in undergraduate curricular reform. Although the focus of the benchmarking exercise reported in this paper focused on best practices in the delivery of engineering service courses, we believe that Regional Universities also offer other important examples of best practices in engineering education. These would include the major engineering design experience, outcomes assessment, and the active involvement of constituents in the establishment and review of educational program objectives, as defined in EC2000. 

Isolating Engineering Service Courses from Courses Taken by Majors in the Field

MSU historically has offered a special EE course for non-EE majors. The wisdom of this approach was born out by the survey results indicating that 19 of the 26 respondents offered a separate course. If enrollments in this service course were low compared with separate EE courses offered for the major, then the wisdom of offering a separate course would need to be re-evaluated. The separate EE service course enables the non-EE student to acquire a survey-level introduction to several major EE topics normally covered in more depth in multiple courses within the EE-majors course of study.

Balancing Course Content with the Course Instructional Model

One major complaint about the existing course at MSU is that there is an attempt to cover too much material. After surveying faculty in other engineering departments at MSU, we concluded that the current course content was adequate. However, several departments recommended adding a few topics or devoting more time to existing topics. We concluded that ECE 345 would work best by increasing the number of lecture credits from two-lectures/week to three-lectures/week. The faculty in other engineering departments did not favor this change in course credit. The benchmarking process reinforced the finding that the course credits were too low for the scope and depth of material covered. We are now in the process of sharing this with the faculty in other engineering departments. It appears evident that either the course credits must be increased or the scope and depth of topics covered in the course must be reduced.

Integrating Lectures with Laboratories

We had considered separating the two-credit lecture from the one-credit laboratory. We were then prepared to raise the lecture credits to three and offer the laboratory as a one-credit option. This approach would have kept the total number of credits to three to satisfy some of the constituents. Benchmarking other institutions led us to re-evaluate this recommendation since all institutions that offered a laboratory had it as a required component of the overall course learning experience. Moreover, in separate assessment activities that took place within the course at MSU we learned that students believed that they learned more from the laboratory experience than they did in the lecture. On reflection, this finding makes sense since students gain hands-on experience in the laboratory while the lecture focus is on listening, reading, and problem solving.
VI. Acknowledgements

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Bibliography


**Biography**

P. DAVID FISHER
David Fisher is a Professor of Electrical and Computer Engineering at Michigan State University. He serves at Project Director and Principal Investigator for the GE Fund-sponsored project: “Reforming the Early Undergraduate Learning Experience.” Dr. Fisher is a registered Professional Engineer in the State of Michigan and is an ABET-IEEE Program Evaluator for EC2000 computer engineering and electrical engineering programs.

JAMES S. FAIRWEATHER
James Fairweather is a Professor of Higher Education and Deputy Director of the Center for the Study of Advanced Learning Systems at Michigan State University. He authored *Faculty Work and Public Trust*, a book aimed at increasing the value placed on teaching and public service at American colleges and universities. He was the original evaluator for the ECSEL coalition.

ERIC A. WARMBIER
Eric Warmbier is a M.S. student in Electrical Engineering at Michigan State University. He received his B.S. in electrical engineering from Michigan State University in 1999. Mr. Warmbier currently holds both teaching and research assistant appointments, and is involved in the teaching of an engineering service course—ECE 345: Electronic Instrumentation Systems.
APPENDIX I: ELECTRICAL ENGINEERING SERVICE COURSE SURVEY

This survey is being conducted by Dr. P. David Fisher (fisher@egr.msu.edu) and the Department of Electrical and Computer Engineering at Michigan State University and is part of an engineering research project funded by the GE Fund. The goal of this survey is to obtain information regarding electrical engineering service courses at other institutions, and it will be used to help reform the electrical engineering service course (ECE 345) at MSU. A summary of the results of this and other related surveys will be shared with all respondents. Your help and time is greatly appreciated. For your information, copies of the syllabus and lecture-laboratory schedules for the EE service course (ECE 345) offered at MSU are attached. Additional information about this course can be found at http://www.egr.msu.edu/classes/ece345. Thank you for your participation.

Instructional Model

<table>
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<th>Instructional Model</th>
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<tr>
<td>Is this course specifically intended for non-EE majors?</td>
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<tr>
<td>Is this course typically taken by?</td>
</tr>
<tr>
<td>Number of lecture hours/week ____</td>
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<tr>
<td>Is there a laboratory component?</td>
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<tr>
<td>Is the lab a separate course or part of the lecture course?</td>
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<td>Is the lab component required?</td>
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Supplemental Questions

May we obtain a copy of the course and lab syllabus? | Yes  No |
If so, please send it with this completed survey in the enclosed self-addressed stamped envelope. If this is not possible, how might we obtain a copy?

What textbook is used for the lecture portion of the course?

Author: ________________________  Title:________________________________________

If a laboratory component exists, how might we obtain a copy of the laboratory manual?

Is this course required for any follow-up courses in any of the non-EE majors? | Yes  No |
If so, which ones?

Is any material from this course used in any follow-up course for non-EE majors? | Yes  No |
If yes, what are the topics?
Appendix II: Institutions Surveyed

Institutions with highest degree of Ph.D. (referred to by the Carnegie Foundation as a National University)

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### Appendix II Continued: Institutions Surveyed

**Institutions with highest degree of B.S. or M.S. (referred to by the Carnegie Foundation as a Regional University)**

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## Appendix III: Required Textbooks/Notes

<table>
<thead>
<tr>
<th>Textbook</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith and Dorf. <em>Circuits, Devices and Systems.</em> 5th Edn, Wiley.</td>
<td>2</td>
</tr>
<tr>
<td>Department made note pack</td>
<td>1</td>
</tr>
<tr>
<td>Irwin and Kerns. <em>Introduction to Electrical Engineering.</em> Prentice-Hall</td>
<td>1</td>
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<tr>
<td>No Text, articles read from <em>The Science of Radio</em> by P.J. Nathan</td>
<td>1</td>
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<tr>
<td>No textbook, but Radio Shack mini-notebooks used and class notes from University of Alberta</td>
<td>1</td>
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