Teaching future professors how to teach


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Abstract This paper describes a course designed to provide hands-on teaching experience to future professors and to incorporate techniques for more effective teaching. A team of Ph.D. candidates, under the direction of a senior faculty member, prepared a new course from beginning to end and then offered it to a class of graduate students. The course was developed using the unit map concept so that the presentations by the five student-instructors complemented and built upon one another. Immediately after each class, feedback was given to the student-instructors by the faculty advisor and the other student-instructors. Review of video tapes of the lecture reinforced this feedback. At the completion of the course, both students and student-instructors were surveyed as to the effectiveness of the course and the student-instructors. This teaching experience and the feedback obtained from the surveys will be invaluable to the student-instructors in their future development.

Keywords Teaching; course development; graduate education; environmental education; effective teaching; unit map; biofilms; student-instructors

Introduction

Quality teaching skills have always been a requirement for university faculty to become tenured or to be promoted, but this demand has increased significantly in recent years as universities are continually questioned about the quality of their academic offerings. Unfortunately, most new assistant professors have had very little preparation for the classroom environment.

The Environmental Engineering program at the University of Cincinnati (UC) is one of the largest in the country. Upon graduation, many of our Ph.D. recipients pursue academic careers at universities around the world. As at many universities, they are well trained to independently carry out fundamental and applied research, but their training in how to teach is often weak. They often lack the necessary preparation to take on the teaching responsibilities required of a university faculty. During a graduate seminar course, several students pointed out that there was little opportunity for students seeking academic careers to obtain in-class teaching experience. All courses in the Environmental Engineering program at UC, as at many other universities, are taught by full-time faculty. Students generally have few opportunities to gain in-class teaching experience, as all our Ph.D. students are funded as research assistants. To fill the gap in their training, the faculty agreed that we needed to develop ways for Ph.D. candidates to develop their teaching skills.

One of the senior graduate students, Tong Yu, approached Professor Paul Bishop about the need to produce a forum for Ph.D. candidates to develop their teaching skills. Discussions began about what the most effective approach would be. Two other Ph.D. candidates, Margaret Kupferle and Deborah Moll, soon joined the discussions. Suggestions were received from Professors Scott Summers and Pratim Biswas concerning approaches used at other universities.

There are many ways to prepare students to teach, including taking education courses, assisting with the preparation and presentation of an actual course under the direction of the faculty member responsible for that course, participating in an effective teaching program,
etc. Several of the students in the discussion group had completed a Teaching Effectiveness Improvement Program offered by the College of Engineering (Houshmand et al., 1996; Papadakis et al., 1993). This is an excellent 40-hour program designed to improve the teaching skills of our established faculty. The students who had the opportunity to take the course were very enthusiastic about it, but found its application limited because they were not teaching a course in which they could try out the concepts they had learned.

To remedy this lack of opportunity, the students and faculty interested in this issue proposed creating a new graduate-level course in the students’ area of expertise. Rather than just substituting for an absent faculty member and presenting material developed by that faculty member in one or two sessions of an existing course, the students would be responsible for outlining the structure of the new course, developing individual session plans and handouts, and presenting the course. There are two other advantages of this approach. (1) Students registering for the experimental course know beforehand that it is being taught by supervised student-instructors, rather than by a professor who is often absent and uses students to fill in. (2) From the student-instructor’s viewpoint, the problem of being a substitute teacher coming in the middle of an existing course for one or two lectures, often without a complete grasp of what has been taught previously or of the overall course objectives, would be circumvented. Developing and teaching a new course would allow the student-teaches to experience the whole process of teaching, from planning the course so that it makes a coherent whole to preparing and presenting individual lectures.

Course preparation
The choice of a topic for the new specialized course was based on meeting the following criteria: it was within the expertise of the student-teachers, it would be of broad interest to other graduate students in the program, and it would supplement current courses in the environmental engineering curriculum. The topic of “environmental biofilms” was selected as meeting these criteria by the students and faculty advisor involved. Biofilms are commonly used in a wide variety of environmental engineering disciplines. Biofilm reactors are used to biologically treat municipal wastewaters and hazardous wastes; biofilters are used to remove odors and volatile organic carbon compounds from air streams; biological activated carbon and biofilters are used to remove organic compounds and disinfection by-product precursors in drinking water treatment; and biofilms are of importance in soil bioremediation, engineered wetland systems and water distribution systems. Each of the three initial participants was conducting his/her dissertation research in this area, as were many other students within the program. Biofilms are covered in a limited fashion in other courses, but none provides an in-depth coverage of the topic that would be of use to students conducting research in this area.

Two additional student-instructors were added to complement the original three in order to provide more students with teaching experience and to limit the course preparation to a manageable two 90-minute lectures. Following a survey of the doctoral students to find others experienced in biofilm systems and with the motivation to gain teaching experience, Margarete Koechling and Cristina Alonso were added to the teaching team. Each person brought a different specialty to the group, and they represented three different research programs. Mr Yu specializes in biofilm mass transport, degradation kinetics and micro-scale biofilm measurements; Ms Kupferle in biofilm growth, hydrodynamics and metal chelation; Ms Moll in biofilm community structure and succession; Ms Koechling in drinking water biofiltration; and Ms Alonso in biofilm modelling.

During frequent discussions between the student-instructor team and the course faculty advisor (Prof. Bishop) in the autumn quarter, the course structure was planned. In order to be meaningful for both the student-instructors and the students taking the course, it was decided that the course would be offered for credit as a one-hour credit-hour course meeting once per
week for 90 minutes throughout the spring quarter. The course would be offered on a pass/fail basis with the grade based primarily on attendance and classroom participation. The course would be designed for masters and doctoral students in the Environmental Engineering and Sciences program, but would also be open to others interested in biofilm research from such programs as Biological Sciences and Environmental Health.

Course preparation began in earnest during the winter quarter. Student-instructors met with Professor Bishop on a weekly basis to finalize the course syllabus and to discuss the contents of individual lectures. The “unit” map concept, used in the Teaching Effectiveness Training Program, was used to structure the course and to establish relationships between the lectures (Fowler and Markle, 1992). Interrelating the various concepts and functional relationships to be taught in a course is often a difficult task. This is particularly true when there are multiple instructors involved. Connections may not be made between what was learned yesterday and what will be learned tomorrow. Construction of a unit map helps to ensure these connections. A unit map presents in a graphical way the contents and functional relationships that make up the content that is to be learned. The unit map developed for this course is shown in Figure 1.

Using the “unit map” as a guide, topics were selected for each of the 10 lectures. The student-instructors then began outlining the content of each of the lectures. During the weekly meetings, they described what they would be discussing and what prerequisite material they would be building on from previous lectures. The earlier lecture contents were then modified to ensure that all necessary material had been presented at the right time. With five people presenting lectures at different times, coordinating the individual lecture contents was a complex task, often requiring additional lecture content modifications. The unit map was very beneficial in organizing the content of the course so that proper connections and interrelationships between various units in the course were made.

The course was designed to present a cohesive progression from an overview of biofilm systems and a review of microbiological terminology to a comparison of engineered biofilm systems to natural biofilm systems, substratum-microorganism and bulk fluid-microorganism interactions, biofilm community succession, microbial growth and substrate degradation kinetics, and biofilm modelling. The course concluded with a panel discussion on new biofilm concepts and treatment techniques. Table 1 shows the outline of the course.

Course presentation
The course was offered during the spring quarter. Eighteen students officially enrolled in the course, more than had been anticipated, and several others sat in on the course without enrolling. Typically, the attendance was between 20 and 25 students. Occasionally, environmental engineering faculty and faculty from the biological sciences department also attended. Students were both masters and doctoral candidates, and came from the research groups of seven different professors in two departments.

Student-instructors did all of the lecturing, with the faculty advisor remaining in the background. Student-instructors prepared visual aids for their lectures and distributed copies of these to the students during the lectures. Reference lists were also distributed for each lecture. Nearly all lectures were video taped for later analysis. Immediately following each 90 minute lecture, the presenter met with the faculty advisor and the other student-instructors who critiqued the content and delivery of the lecture. This gave the lecturer immediate feedback on his/her presentation. The video tape was given to the student-instructor for his/her own review later. The lecturers could then take both the verbal feedback and information obtained from reviewing the tape of their first lecture, and use this to improve their next lecture. In general, each lecturer’s second lecture was much improved over the first, showing the value of this critiquing procedure.

At the conclusion of the course, a teaching effectiveness questionnaire was distributed to all attendees. In addition, a separate questionnaire was given to each student-instructor to
ascertain whether they felt the experience was worthwhile. The results of those surveys are presented next.

**Course evaluation**

We wanted to know how effective this experimental course format was, both from the standpoint of the students enrolled in the course and from the student-instructors who taught the course. Since the goals of course were both to impart knowledge to the graduate students registered for the course and to give our future teachers experience in teaching, both responses were essential. Two questionnaires were developed, one for the enrolled students and one for the student-instructors. The student evaluation form consisted of two parts: the first part contained questions concerning the overall course format while the second part was used to evaluate the performance of the individual instructors. Eighteen
students completed the questionnaire. Of these, fifteen said that their research was related to biofilms. Eleven reported that the course significantly enhanced their understanding of biofilm systems, while six reported that their understanding was moderately enhanced; only one student reported that it did not enhance understanding. Seven students reported that the course definitely brought them up-to-date on recent developments in the field of biofilms, while eleven said that it did to a certain degree. Sixteen of the eighteen stated that the course was a good supplement to the current graduate curriculum, and all said (fourteen enthusiastically) that they would recommend the course be offered again to new graduate students. Overall, the reception of the course from a technical standpoint was excellent. Having a course presented by senior Ph.D. candidates was very well received.

When asked to describe what they liked best about the course, the participants gave a variety of responses. The predominant ones were that they liked the enthusiasm of the student-instructors, the casual atmosphere, the interactive nature of the course brought on by the student-instructors continually asking questions of the audience, and the fact that the students were getting experience teaching a course. They also liked the way the course supplemented the existing curriculum by introducing up-to-date specialized material at an advanced level. There were few dislikes expressed about the course. Surprisingly, the main one was the lack of exams or homework. A few students felt they would have gotten more out of the course if they had the pressure of performing on an exam. The student-instructors may have been over-enthusiastic by handing out the class notes at the start of class rather than at the end. Some students felt that having the lecture material in front of them containing the answers to questions posed by the student-instructors often stifled discussion. Two students found that the depth of the lectures was sometimes inconsistent or that the transitions between lecturers could be smoother, which is not surprising, given that there were five lecturers with five different styles.

Of particular interest was the students’ reception of the format of the course, using students to do the teaching. The response was overwhelmingly positive. When asked for suggestions for similar student-taught courses in the future, several new topics were suggested and a few students expressed interest in participating as a student-instructor.

Table 2 presents a summary of the students’ evaluations of the individual student-instructors. Comments on how each individual student-instructor could improve his/her teaching and communication skills were also made, but are not reproduced here. It is quickly apparent that the student-instructors were well received. Nearly everyone rated them enthusiastic about the student they were teaching. Seventy-nine percent of the ratings on lecture organization stated that the student-instructors were well organized; the remainder were rated adequate. Essentially all of the students rated the student-instructors very knowledgeable in the areas they taught. Responses to the question concerning the student-instructors’ encouragement of questions and participation by the class were mixed, with some instructors faring very well and others less so. This is an area that needs more emphasis. Three of the student-instructors had English as their second language, but most of them still received high marks for their comprehensibility.

The student-instructors were also surveyed at the completion of the course to ascertain whether they had gotten what they expected out of the course. All involved felt that it was a very good experience and that it gave them a taste of what teaching is all about. It took them through the steps of preparing for a course, organizing the lectures and following through with them. They also felt that working together as a team of five to achieve a common goal was a good experience. They agreed with the student feedback that one of the problems with the course was the lack of homework or exams. The student-instructors missed the opportunity to get experience in exam and homework preparation. They also felt it would have been better if a textbook had been assigned.

When asked “What did you learn from teaching this course, both in teaching and in the subject area?”, they all responded that learning how to put a course together into a coherent
package, especially using the unit map approach, was very useful. They all remarked that the preparation of a course requires much more time and effort than they anticipated. They also stated that they learned the importance of time management while lecturing, and the importance of well developed visual aids. They all stressed the importance of learning how to question the class and how to get the class to participate more. They all felt that they understood the material better themselves after having taught it.

The final question to the student-instructors was “If you were given an opportunity to teach this course again, what would you do differently to improve your teaching?” Several said that they would spend more time preparing the lectures. Some felt that their lectures were more like a seminar than a classroom presentation. They would try to cover less material and explain it more fully. Several mentioned that they would try to do more to increase student participation in the classes, and that they would improve their visual aids. Finally, several stated that they would add homework or other out-of-class assignments.

Conclusions
The team of Ph.D. candidates involved in this course under the direction of a senior faculty member learned the intricacies of course development and received hands-on teaching experience. Along with this, they learned to employ techniques for more effective teaching. By preparing a new course from beginning to end, and then offering it to a class of graduate students, they learned much more than they could have by just appearing as a “guest lecturer” in someone else’s already developed class. Essentially all feedback, both from students and student-instructors, was very positive. It would be advantageous to the department and to the Ph.D. students to offer this course on a regular basis, using a different topic each year. The impact should be better prepared Ph.D. graduates who know what is involved in course development and teaching, and who will have an advantage during the first gruelling year of their new careers as professors.

References

Table 2 Student-instructor evaluation results

<table>
<thead>
<tr>
<th>Questions</th>
<th>Instructor 1</th>
<th>Instructor 2</th>
<th>Instructor 3</th>
<th>Instructor 4</th>
<th>Instructor 5</th>
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</thead>
<tbody>
<tr>
<td>1. Are the student-instructors (A) very, (B) moderately, or (C) not enthusiastic about the subject?</td>
<td>A – 17</td>
<td>A – 5</td>
<td>A – 14</td>
<td>A – 11</td>
<td>A – 14</td>
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<td></td>
<td>B – 1</td>
<td>B – 12</td>
<td>B – 2</td>
<td>B – 3</td>
<td>B – 2</td>
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<td>2. Are the lectures (A) well, (B) adequately, or (C) poorly organized?</td>
<td>A – 12</td>
<td>A – 9</td>
<td>A – 13</td>
<td>A – 9</td>
<td>A – 12</td>
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<td>B – 4</td>
<td>B – 6</td>
<td>B – 1</td>
<td>B – 3</td>
<td>B – 3</td>
</tr>
<tr>
<td>3. Are the student-instructors (A) very, (B) moderately, or (C) inadequately knowledgeable in the area he/she taught?</td>
<td>A – 15</td>
<td>A – 7</td>
<td>A – 14</td>
<td>A – 12</td>
<td>A – 14</td>
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<td></td>
<td>B – 2</td>
<td>B – 8</td>
<td>B – 1</td>
<td>B – 1</td>
<td>B – 2</td>
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<td>4. Did the student-instructors (A) frequently, (B) occasionally, or (C) rarely encourage questions and participation in class?</td>
<td>A – 15</td>
<td>A – 10</td>
<td>A – 11</td>
<td>A – 4</td>
<td>A – 6</td>
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<td>B – 2</td>
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<td>B – 7</td>
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<td>5. Is the student-instructors’ English (A) always, (B) usually, or (C) often not comprehensible?</td>
<td>A – 14</td>
<td>A – 11</td>
<td>A – 13</td>
<td>A – 6</td>
<td>A – 6</td>
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<td>6. How can each individual student-instructor improve his/her teaching and communication skills?</td>
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