Advanced Soil Physics Class Develops Research and Publication Skills[1]

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Abstract

Graduate-level classes are more focused, but do not always provide students with an opportunity to develop cognitive and publication skills. Therefore, the aim of this class is to let students take ownership of and responsibility for their proposed research work, complete all specified tasks by the deadlines they set, and, by the end of semester, be able to produce a report at a level of quality appropriate for presenting their work at national conferences. Overall, 50% of the students missed one deadline for completing a specified task, but fewer students missed two or three deadlines. Overall, 50% of the students presented their research work as posters and 90% presented their work as oral presentations. When master's/ PhD students were compared, the majority of the papers came from PhD students. Overall, a majority of students rated the class as superior when compared to any other class, and the class developed responsibility and the cognitive and research skills of the graduate students.

Introduction

The basic purpose of introductory classes (e.g., introductory soils) is to provide students with a broad knowledge of various disciplines to help them make informed and intelligent decisions about their future career goals. Subsequent higher-level classes strengthen their understanding of these fundamental concepts through lectures and laboratory work (e.g., some of the classes from a soils curriculum are soil physics, soil chemistry, soil morphology, and soil microbiology). Let us not forget here that, education is an opportunity, and different students avail this opportunity at different levels or scales. As an example, a student majoring in soil science receives from required courses a reasonably good insight into various soil properties and processes and their interactions. The student is also adequately introduced to laboratory and field methods of soil analysis, although hands-on experience with using various instruments is usually limited (Sammis and Mexal, 1996). Together, these theory and laboratory classes train students satisfactorily in fundamental principles, but probably not so satisfactorily in the application of these concepts to solve real world problems. Other aspects usually missed in these classes deal with training students in concepts related to scientific research, especially developing a testable hypothesis and subsequently conducting a field or laboratory based research to prove or disprove the hypothesis. There is a need to develop and execute teaching strategies for undergraduate and graduate students that are oriented toward conducting scientific research (Allard and Barman, 1994).

Teaching strategies with a research orientation can include theoretical and hands-on experience with various tools and instrumentation (Sammis et al., 2003), and can be achieved by asking students to identify and use already completed research (may be already published work) to develop an individual project. Alternately, students can work as a team and develop an interdisciplinary project. Interdisciplinary or team projects are important because there is an increasing emphasis on interdisciplinary and multi-institutional types of research (Mervis, 2002; National Research Council, 2004; Lawrence and Després, 2004). These strategies can also be combined so that a student starts at an individual level and goes on to form an interdisciplinary research project, and can improve a student's skill and leadership at an individual level as well as a team level. At both of these levels, students' cognitive and communication skills should be evaluated, and efforts should be made to improve these skills for them to be successful teachers or researchers. Accordingly, a flow chart of systems, with processes and feedback loops, can be introduced in graduate-level classes incorporating cognitive skills (Lyle and Williams, 2001), and these classes could also be goal-oriented (Ram, 1999). Students must be encouraged to use search engines to improve their understanding of their information need (Rowlands and Nicholas, 2008) to meet their goals,

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critically evaluate the gathered information, and use it appropriately for the proposal development. In the feedback loop, a student submits an original proposal for instructor feedback, incorporates constructive instructor feedback, and adds additional relevant information. The revised document is resubmitted to the instructor and the feedback loop continues.

The objectives of this research from the advanced soil physics class were to help students learn some basic tools related to water and solute transport through the vadose zone, and to develop their cognitive and communication skills. By the end of the semester, students were expected to complete the goals they had set and defined. The importance of presenting the research in conferences and publishing in peer reviewed journals was shared repeatedly with students. Students were continuously encouraged to present their research at national or international conferences, symposia, or meetings, and to submit manuscripts for publication in peer reviewed journals. In order to achieve these objectives, the student's major advisor was also involved or kept informed throughout the semester where applicable.

Methods and Materials

The advanced soil physics class is a graduate-level class in the Department of Plant and Environmental Sciences at New Mexico State University (Las Cruces, NM), and is usually taught once a year during the spring semester. Students enrolled in this class are usually perusing a Masters/PhD degree.

The students included in this research had a diverse background and were from various departments and colleges, including civil engineering, agronomy, soil science, environmental science, and range science. Although students' quantitative skills, such as computer, physics, math, and statistics skills, varied depending upon their undergraduate major, all of the students enrolled in advanced soil physics had successfully completed the prerequisite of the environmental soil physics class. Most students (~90%) had never written, submitted, or published a manuscript in a peer reviewed journal.

At the beginning of the class, students were given the expectations for passing the class. Students were always given a choice to take the class as a project/goal-oriented class or as a regular homework assignment/quiz/exam class. So far, students have chosen the option of a project/goal-oriented class. At the beginning of the class, each student was asked to develop a proposal that was related to one or more aspects of water dynamics (infiltration, retention, transport, movement, or loss). Students were asked to write and submit an initial draft of the proposal to the instructor by a given date (usually set by the instructor in consultation with the students). The draft of the proposal had to include a tentative title and a brief summary (at least two pages, single-spaced with 12-point font). The summary had to contain an introduction, hypothesis or hypotheses, clearly spelled out objectives, and a timeline for accomplishing different tasks (e.g., literature review, data collection, and analysis, etc.). All course materials, individual proposals, proposed deadlines, tasks performed, and work done by each student were posted each semester on the Blackboard learning system of New Mexico State University (http://learn.nmsu.edu) and were accessible to each student during the semester. An example of the tasks and deadlines proposed by students is presented in Table 1.

Table 1. Tasks and Deadlines Example Proposed by Students.

No.	Topics of Research	Date to submit
1	Draft Proposal Submission	End of Jan.
2	Final Proposal Submission	1st week of Feb.
3	Proposal Presentation	1st week of Feb.*
4	Review of Literature	End of Feb.
5	Field/Lab/Data Collection	March to mid-April
6	Update Presentation	3rd week of March*
7	Analysis/Modeling	End of April
8	Final Report Submission	May 5-8th
9	Final Poster Submission	May 5-8th
10	Final Presentation in Class	May 5-8th*

**Indicates that the deadline was set by the instructor.*

Usually, all the topics in this table were included each semester, but sometimes students had more specific deadlines for different types of data collection, analysis, and modeling.

Study period 2006, 2008-2010 at New Mexico State University, Las Cruces, NM.

The main philosophy behind asking students to provide oral presentations stems from the notion that, a student is a learner, and when his/her status changes from a student to a teacher (presenter) (he/she) becomes a better learner. During the semester, each student was required to make three presentations: proposal and timeline presentation (by the third week of the class), progress presentation (middle of the semester), and final presentation (oral and poster, exam week) (Leigel and Thomson, 1989). PowerPoint slides were required for making the presentation. All three presentations were time-limited (i.e., first presentation was limited to 10 minutes, second to 15, and final to 20). About 10 minutes were usually allowed for questions and answers. Students were also encouraged to ask questions and provide suggestions and help during field or laboratory work. Students were allowed to make major changes to their objectives and methodology until the date of the progress presentation (around the middle of the semester). Students were also allowed to delay their proposed deadlines for any

given task before that deadline expired by sending an email to the instructor with a request and justification for extension. When a student failed to inform the instructor before a deadline expired, points were lost (up to 50% of the assigned points for the task) for missing that deadline.

Students were graded on clarity, quality, the degree of accomplishment of stated goals and deadlines, and timeliness of the presentation. Points were given for student participation for asking questions at the end of a presentation and for assisting classmates in any way. However, assistance had to be documented by the student who benefited from it. If a student had significantly contributed to another student's project work, he or she was either included as a coauthor on the presentation/paper or the contribution was otherwise acknowledged. However, how to acknowledge a student's contribution during a presentation was entirely decided by the students involved. Similarly, a student could decide whether to include the instructor as a coauthor if applicable.

Some of the attributes used for the analysis of data for this study were number of deadlines missed, oral presentations and posters presented in national/international seminars/symposia, and manuscripts submitted to or published in a peer reviewed journal. The instructor, college, or the major advisor paid for all the students' expenses, including registration fees and travel expenses for attending a national conference. Data analysis in this paper was carried out in two ways, first by semester and then by degree (Masters versus PhD). A double tailed simple t-test at 95% confidence level was performed to identify the significant interactions among years and by degree (Table 2). The data did show numerical differences among some of the attributes; however, no significant interactions were noted, likely due to the low sample size.

Results and Discussion

The number of students missing only one, two, or three deadlines per semester is presented in Table 3. About 42% of the students (out of 26 students) missed one deadline, 31% missed two, and 23% missed three. Deadlines were missed at various points in the semester, not necessarily chronologically. Also, missing a deadline actually meant that, due to certain circumstances; the deadline was moved back, although not more than one and a half weeks for most students. There were only two students during the entire duration of this study that moved deadlines back as much as a month. In one student's case it was because the drilling company was not able to drill the test pit on time. The other student reported logistic issues such as permission to access the site as the main reason for delay. Only that particular deadline was moved without moving any others, so there were no chain reactions from moving one deadline back. If the work was completed and submitted before the deadline, it was not considered missing a deadline, although no extra credit was provided for early submission.

The semester-wise number of posters presented, talks given, and manuscripts planned, submitted, and eventually published are given in Table 4. The posters and presentations were regularly made at two national/international conferences: the Annual Water Research Symposium organized by the New Mexico Water Resources Research Institute each August at Socorro, New Mexico, and the joint annual meeting of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America each October or November. Presentations were also made at other regional meetings. The number of presentations as posters was smallest for spring 2006, but that was adequately compensated by high numbers of oral presentations. The number of oral presentations consistently exceeded the number of poster presentations, except in 2010. In general for all four years, 42% of students presented their work as a poster and 81% presented as an oral presentation. The sum of these two is greater than 100% because there were some students who presented their research as a poster in one conference and as an oral presentation at the other, although there were some who did not present at all in a national conference. Some students also added new materials or additional work done after the end of the semester to their posters and/or oral presentations.

Each year, some of the students planned to continue to update their report and complete a manuscript. About 45% of the students planned to write a manuscript for possible publication, but only 27% of the students actually submitted it for publication. Again, more information or data were included in the final version of some of the published manuscripts. Comparing the publication percentage reported in this study with the publication percentage from other similar

Table 2. Total Number of Students, Number of Students Pursuing a Master's or PhD Degree, and Number of Students Who Set Deadlines.

Semester	Total Students	Masters Degree	PhD Degree	Students Setting Deadlines
Spring 2006	5	1	4	5
Spring 2008	10	6	4	10
Spring 2009	6	4	2	6
Spring 2010	5	1	4	5
Total	26	12	14	26

Study period 2006, 2008-2010 at New Mexico State University, Las Cruces, NM

Table 3. Number of Students Who Missed One, Two, or Three Deadlines.

Semester	One	Two	Three
Spring 2006	3	2	0
Spring 2008	3	2	4
Spring 2009	1	3	1
Spring 2010	4	1	0
Total	11	8	5

Study period 2006, 2008-2010 at New Mexico State University, Las Cruces, NM, USA

Table 4. Number of Posters, Oral Presentations Made in Conferences, Manuscripts Planned for Possible Submission, and Manuscripts actually Submitted or Published per Semester.

Semester	Poster	Oral Presentation	Manuscript Planned	Manuscript Submitted/Published
Spring 2006	1	6	3	3
Spring 2008	5	9	4	1
Spring 2009	3	5	2	1
Spring 2010	4	1	2	2
Total	13	21	11	7

classes will be useful to ascertain the success of this class. Comparisons can also be made across various departments (e.g., soil, genetics, engineering, language and arts, etc.) offering classes with similar objectives. However, to the best of our knowledge, no data are available for such comparisons.

During the four years, there were a total of 12 students pursuing a master's degree and 14 pursuing a PhD degree. The master's degree students were at different stages of completion, whereas most PhD students were in the second semester of their studies. More than 95% of students had previously attended the soil physics class taught by the same instructor.

The number of deadlines missed, oral presentations or poster presentations made, and papers planned, submitted, or published are presented in the Figure 1 (by student degree). In general, student numbers were similar for both degrees. About one out of four master's degree students missed one deadline, whereas three out of five PhD students missed a deadline. The number of students missing two deadlines was similar, with about 33% and 29% of master's and PhD students missing two deadlines, respectively. However, a much higher number of master's degree students (33% versus 14%) missed three deadlines compared to PhD students.

Oral presentations made at a conference were similar for both degrees. However, more posters were presented by PhD students (86% of posters) than master's degree students (75% of posters). More PhD students planned to write a research publication (50% for PhD versus 33% for master's), and five out of seven published papers were written by PhD students. Some possible explanations could be that the PhD students were self-motivated or were expected (by their major professor/doctoral committee) to publish at least one paper prior to the dissertation defense.

The comparison of by degree data did not show any statistically significant differences. Although a higher number of PhD students missed one deadline, they still produced a greater number of posters, oral presentations, and publications compared to the master's degree students. Except for spring 2008, the class size was usually five or six enrolled students and usually one audit student (audit students were not included in the data for this study). A class size of six is considered ideal because as the number of students increases, more time is required for making presentations and for one-on-one time with the instructor, and there are more scheduling conflicts. The class also had to cover various topics and concepts related to advanced soil physics, such as representative elementary volume (or mass) (Lal and Shukla, 2004); number of samples (Nielsen and Wendroth, 2003); and models such as GS+ (Gamma Design Software, Plainwell, MI), rootzone water quality model (Ahuja et al., 2000), and hydrus-1D and hydrus-2D (Šimůnek et al., 2008). Therefore,

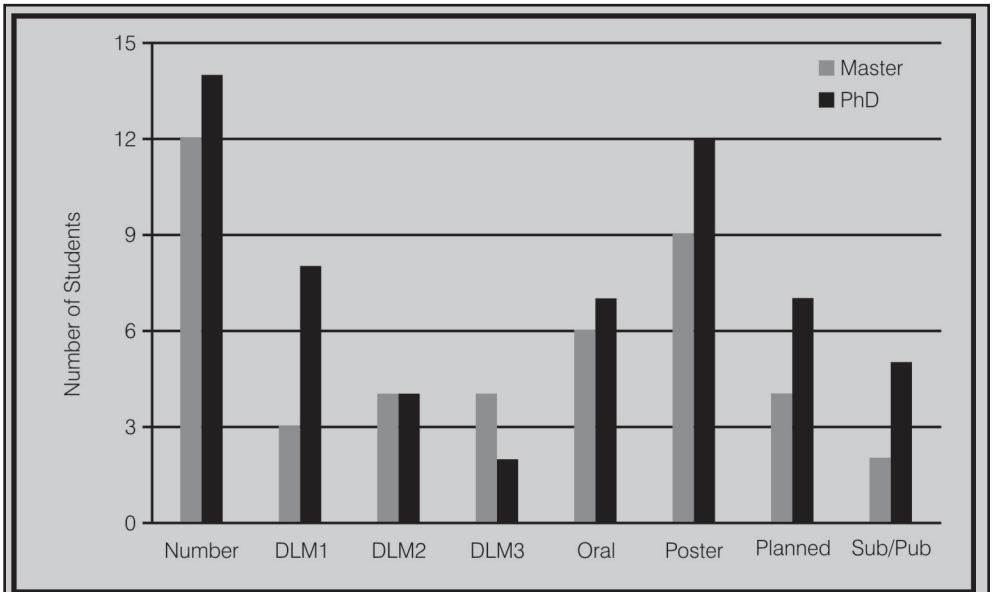

Figure 1. The number of students enrolled in the class at New Mexico State University over four years (2006, 2008, 2009 and 2010), deadlines missed, and presentations/publications by degree sought. "DLM" indicates deadlines missed, "Oral" indicates oral presentations made, "Poster" indicates poster presentations made, "Planned" indicates paper planned, "Sub" indicates paper submitted, and "Pub" indicates paper published.

a class size of five or six students was found to be optimal. During 2008, when 10 students enrolled in the class, there were four students who missed three deadlines.

The instructor distributed research papers related to the topics covered in the class. Students were also required to get electronic or hard copies, using the Internet or the library, of at least 10 additional research papers directly related to their work. Locating scholarly resources using search engines likely improved students' understanding of their information need (Rowland and Nicholas, 2008). Students were asked to write a summary as part of the review and literature section of their papers. Reading published literature trained students on how to write a research paper. The students were asked to revise their proposal and look at their timelines or deadlines carefully before finally submitting them. They were also asked to keep adding other sections, such as methods and materials, results, and discussion, to the initial proposal. Revisiting the proposal multiple times forced students to reevaluate their thought processes, and this, in our opinion, improved their cognitive and schema skills.

Students had the responsibility to meet their own set deadlines and this created a feeling of ownership and added responsibility compared to traditional teaching methods in which instructor sets the deadline. Students are not usually accustomed to set their own deadlines and take full responsibility for the timely delivery of their work in traditional teaching methods. As a result, the instructor consistently reminds students of the deadlines by which they must submit a homework assignment or take a test. Since each student has a different date of completion and submission of his/her own set task, this was a new concept for most of them that is clearly evident from the maximum number of students missing one deadline. Among the students who missed at least one deadline, the most frequently missed deadline was the first. However, as the semester progressed, most students missed deadlines due to a genuine problem. Some of the reasons students reported for delays were a failed experiment, delays in obtaining permission to conduct an experiment, inclement weather, sickness, midterm or other exams, and scheduling conflict between the student, instructor, and student's major advisor. Poor planning on the part of students was one of the factors for scheduling conflicts. One of the major disadvantages of missing a deadline was cramming the remaining tasks into a tighter schedule.

Team spirit was clearly evident in the class. Most students did not hesitate to ask questions and/or clarification from their classmates. The questions were always serious, and at no point did the instructor feel an unhealthy competition among students. Some students also acknowledged the help of fellow students to accomplish a given task. Each year, there was at least one student who was not totally in favor of giving oral presentations. However, only one student in those four years (2006, 2008-2010) missed his or her final presentation on the scheduled date.

The grades in the class ranged from A+ to incomplete. Most students liked the format of the class in general and the presentations in particular. The instructor received favorable student evaluations, and a majority of the students ranked the class as better than other classes they had attended. This type of class generally works well when the class size is low. Sometimes a low class size (of six or seven) may not be considered optimal according to traditional college/university guidelines. The student numbers in these classes could be increased provided students have already taken a similar (not so rigorous) class, which could be a project-oriented general education class. Overall, these classes demonstrated that students can be motivated to develop research and publication skills while taking ownership and responsibility of their work.

Summary

The purpose of the advanced soil physics class was to help students develop research and publication skills and improve their cognitive, communication, and planning skills while simultaneously making them take ownership of and responsibility for their work. The average class size was about six, which was also the optimal size for the class. Overall, 50 to 90% of students presented their work as posters or oral presentations in national or international conferences. About 45% of students planned to write a publication; however, 26% actually submitted and were published. Developing a proposal into a manuscript during the semester helped students enhance their cognitive skills. Since the students set their own deadlines, there was a feeling of ownership and responsibility to meet those deadlines. Posting all course materials on the Blackboard learning system ensured transparency, made students aware of each other's projects, seemed to develop a healthy competition among students, and was beneficial for most students. The results of this work show that a higher graduate-level class could be made more research- and publication-oriented.

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