

Humanistic Mathematics Network Journal

Issue 23

Article 11

9-1-2000

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Recommended Citation

Oberhoff, Ken and Barnes, Ron (2000) "Senior Seminar: A Capstone Course in the Computer and Mathematical Sciences," *Humanistic Mathematics Network Journal*: Iss. 23, Article 11.
Available at: <http://scholarship.claremont.edu/hmnj/vol1/iss23/11>

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Senior Seminar: A Capstone Course in the Computer and Mathematical Sciences

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SUMMARY

This paper describes the evolution of a course developed to tie together many strands of activity encountered by students in the computer and mathematical sciences (CMS). The senior level course is required of all majors in our computer science, applied mathematics and statistics undergraduate degree programs. One of the primary purposes of the course is to refine writing and presentation skills needed for those who will later pursue individual research projects. Writing projects are organized around the theme of "Ethical Decision Making in the Computer and Mathematical Sciences". Numerous case studies are investigated. Additional topics in the course include designing resumes, starting a placement file, and a general introduction to the CMS culture. A course outline is given and various projects are discussed.

This paper is based on a talk given by the authors at the joint national meetings of MAA/AMS in San Antonio on January 14, 1999.

INTRODUCTION

Since 1984, all students at UH/D, regardless of major, must fulfill writing and speech requirements to graduate. These include at least one writing course given in their major department. In addition, since 1995, the university has required all graduating seniors to successfully complete some course material on ethics as it relates to their major.

The CMS department has developed a general approach to meet these requirements, utilizing its pre-existing Senior Seminar (SS) course, which had been introduced in 1987. Originally the ethics requirement was satisfied by a separate course, but the material was added to the seminar in 1997 by increasing the credit hours from one to two.

In addition to the usual CMS courses, each major is

required to successfully complete a speech course (SPCH 1304) and a technical writing course (ENG 3302), offered outside the department. These are prerequisites for our senior seminar course (CS/MATH 4294). Based on student performance in the seminar and other factors, the student follows up with either an individual research project (CS/MATH 4395), directed by a faculty member and/or an outside mentor, or the student selects one of our senior level writing courses (W) in the department to fulfill his/her writing requirement. W-courses, cross-listed, include Math Modeling and Computer Simulation (CS/MATH 4306), History of Mathematics and Computer Science (CS/MATH 4312), Parallel Programming (CS/MATH 4328), and Advanced Numerical Methods (CS/MATH 4301).

SENIOR SEMINAR—AN EVOLVING COURSE

While the original purpose of the SS course was to refine the writing and presentation skills needed to successfully complete later senior research projects, the course has now evolved to address the changing needs and college requirements.

To address the college-wide ethics requirement (noted earlier), the SS has developed a focus on ethical issues in some of the written and oral projects assigned. Because of the large number of required courses in our degree programs, we did not have the luxury of offering an entire course in ethics, in our department, as some other colleges have done [7].

EARLIEST VERSIONS OF SENIOR SEMINAR COURSE

Originally this course consisted of a number of readings from somewhat "popular" books oriented towards the computer and mathematical sciences, and then the assignment of short written and oral reports on the results of those readings. Among the books assigned were *Godel, Escher, Bach: An Eternal Golden Braid* [3], *Mathematics—The Loss of Certainty* [5], *The*

Dream of Reason [6] and *A Brief History of Time* [2].

In addition, each student prepared a one page vita / resume. Students discussed each others resumes and we discussed how to tailor different forms of a vita to different audiences. Students also critiqued each others' oral presentations and quickly learned to be more diplomatic in their criticisms as they discovered the truth of the adage that "What goes round, comes round."

The final written and oral projects in this SS course were the individual student Senior Project Research proposals. In the earlier years of our CMS programs, **all** our majors were required to follow the SS course with individual Senior Projects. However, as the number of majors increased dramatically, it became clear that other alternatives to individual Senior Projects were needed. Also, as noted earlier, in 1995, the college instituted an **ethics** component for all degree programs.

PRESENT FORM OF SENIOR SEMINAR COURSE

Course outline of topics:

a. Our present course begins with material from our text on *Ethical Decision Making and Information Technology—An Introduction with Cases* [4]. For ethical viewpoints focused on statistics see articles in the column Ethical Statistics, by Janice Derr, especially [1] in *AMSTAT NEWS*. We begin with definitions and draw out the distinctions among ethical, moral and legal actions and activities. We cover the first three chapters of the text, which deals with why ethics is important, how to make defensible decisions with a series of informal and formal guidelines, and different approaches to developing ethical principles, via various ethical paradigms, that can be used to support ethical decisions.

We also consider special ethical challenges in the computer and mathematical sciences and how to respond to them. In addition, we consider material on how to solve ethical dilemmas by using sample case studies and applying the techniques covered earlier.

In our course, each student is required to write short papers on two ethical problems recently in

the news (CMS related)—either from the print media or from the WEB. In each paper, the student first summarizes the ethical issues involved, and then attempts suggestions for a resolution, using the text guidelines. In addition, each student selects one of the 19 case studies included in part II of the text and "works it out" in written and oral presentations.

These case studies have generated considerable student discussion, and it is important to point out that, in general, there does not always exist a "best solution" to an ethical dilemma. What may work in one environment, may not succeed in another. These discussions have often caused students to re-evaluate various viewpoints as they apply ethical guidelines to the "real world". Some of our students, who are already working full time in CMS professions, often point out to the other students how other "side" issues, office politics, etc...may affect the success of various approaches to solving ethical dilemmas. Discussions help to underscore the value of constructive criticism and teamwork to make better decisions.

We believe that this added **ethics** component in our course has been extremely valuable, not only in introducing and developing ethical principles (as they relate to CMS), but also in introducing our students to the CMS cultural paradigm that they are becoming a part of.

b. In addition to writing projects, students have discussed ethical problems and issues that they perceive in the CMS department, the university and / or in their fields. Such discussions can have meaningful impact on the true importance of ethics. Past discussions have led to student proposals for written ethical guidelines for the use of departmental computer facilities and labs to augment the written ethical guidelines already in place for the academic computing center. Some of our math education students have also pointed out ethical problems related to the manipulation of public school student assessment statistics on state mandated test, and also noted problems with the abuse of emergency staffing guidelines in public school math and science hiring.

c. In addition to the ethical components of our SS

course, each student is required to make an oral presentation on some topic in his/her field, that is not required, but that he/she believes should be understood by all graduates in the field. Some of the past topics discussed include:

1. How to do basic business math calculations such as amortization schedules for house and car payments, annuities, IRAs, credit cards and lotteries;
2. How to navigate the WEB;
3. Use of graphical/programmable calculators;
4. Understanding basics of computer hardware—e.g. take the back off your PC, how disc drives, etc...actually work;
5. How to use spreadsheets for taxes, investing, record keeping...as well as for math/stat analysis.
6. Logic
7. Graph Theory
8. Current computer languages and innovations

From these and similar suggestions, we occasionally have added short discussions on some of these “slighted” topics. Among other topics added for brief discussions are cardinality, methods of proof, and the problems of completeness and consistency in mathematics.

In these discussions, students have expressed a serious interest in contributing to the continued development of our CMS programs.

- d. Each student constructs a one-page vita/resume. In introducing this subject, the class is first introduced to the student placement center facilities. They are encouraged to develop a student placement file which will include copies of letters of recommendation and transcripts as well as a copy of their vita. The idea of tailoring different vitas for different audiences is noted. Each student constructs a first draft vita, then copies are provided to all students, and they discuss which features they want to add/or delete. After these discussions, each student constructs a “final” vita. = It is emphasized that there is no “right” or “wrong” format. If it works, go with it. These discussions can lead to such issues as whether foreign students should mention foreign language abilities, green card status...; as well as how much and how

should they include in the vita on their areas of specialization or special competence.

- e. Students are required to attend the weekly CMS Colloquium Series. These talks expose them to the CMS culture, with speakers from industry and government as well as academia. In addition, some of the talks in Bio-mathematics, bio-statistics and other areas have generated student senior projects as well as graduate studies by some of our graduates.
- f. The capstone of this course is the writing and oral presentation of potential Senior Project proposals. The merit of these proposals is considered when deciding which students will continue with individual Senior Projects, in the following semester, and which students will take W-courses to complete their final writing requirements in CMS. A few of the over 150 individual Senior Projects are listed below.

Note that many of our projects were developed jointly with NASA, industry or other non-CMS co-sponsors including grants and the large Bio-medical community in the Houston Medical Center.

1. Investigations of Certification Issues for Secondary Teachers
2. Bio-mathematical Modeling of the RNA Cell Cycle
3. Data Gathering and Analysis of Student Usage of the Math Lab Tutoring Center
4. An Investigation into the Feasibility of Incorporating a Fuzzy Logic Control System into a Spider Robot
5. Neural Networks and Fuzzy Logic to Control an Unmanned Reconnaissance Vehicle
6. Economic Cost Models of the NASA Space Station
7. Decision Tree Analysis of Gas Pipeline Options—A Feasibility Study
8. Reliability Investigations Using Fault Tree Analysis
9. A Comparison of Inner City, Suburban and Rural High Schools to Determine Differences (if any) in Qualifications, Background and Experience of Math Teachers
10. Development of a 2-Dimensional Video Game

11. Statistical Survey of Math Students at the University of Houston-Downtown and at Houston Community College
12. Mathematical Simulations for a Megaplex Theater
13. Applications of VRML and Java in Simulation
14. Job Scheduling on Heterogeneous Networks Using Mobile Agents

SOME COMMENTS ON THE PRESENTATION OF SENIOR SEMINAR

Since incorporating **ethics** and the other additional topics described above, three different faculty members have offered the modified course. The course is offered as a one semester, 2 credit hour course meeting on two days a week for 50 minutes each class. All instructors have included basically the same material as outlined above. Each supplies the students with a detailed syllabus including due dates for the various projects. While all weight the written and oral presentations at about 60 percent of the course grade and the resume and class participation the same (10 percent each), the instructors vary on the relative allocations for the Senior Project proposal and the final exam.

It is important to stress the need for student attendance and participation in the classes and for attendance at the Colloquium. When students enter their senior year, many demands are made on their time, and if the instructor is not careful, students may tend to skip classes to work on their projects and other course work. At least one of the SS instructors reduces the final grade for missing classes. Similarly, students need to be strongly encouraged not to miss project deadlines. In the real world, missing days of work and failing to meet deadlines can have a real impact on your career (or lack of one). Since this seminar is to help the students prepare for the real world that CMS practitioners will live in, the instructors should settle for no less than industry, government and the rest of the real world will demand.

STUDENT FEEDBACK AND RESPONSES TO THE COURSE

In addition to observations by the students in classes and on course evaluation forms, the final exams included questions that asked the students to (1) briefly describe an ethical problem that you perceive in the university or in your job and explain how you believe the problem could be addressed; and (2) briefly de-

scribe what you liked or disliked about this course and topics you believe should have been added, changed or excluded.

Note: The student breakdown in the course is approximately 60% computer science majors and 40% in applied mathematics and/or statistics.

Student comments on ethical problems, they perceive at the university, included the following:

1. "One of the ethical problems I see in the university is the loopholes around prerequisites for certain classes...it shouldn't be so easy for students to circumvent this. The telephone registration system has been updated, so it may not allow it now, but before you could sign up for any class you wanted, regardless of whether you had the prerequisites or not...I think the teachers shouldn't be able to give final approval about whether the prerequisites should be waived; the final approval should come from the department (chair). They need to know how many people are getting around prerequisites and track how well those who are waived do in those courses.

Similar comments in the classroom generated a considerable amount of discussion and in the course of this discussion, it became clear why one of our courses offered in the previous semester had an extreme bimodal grade distribution. Incidentally, the telephone registration did not solve this problem! These and similar comments were helpful in addressing issues of which some of the faculty were unaware.

2. "Some instructors use the same assignments and tests every semester. Students who have access to this have an unfair advantage."

Suggestions to address this issue included: "Students should have to explain their solutions." and "Can solve the problem by asking instructors to collect all tests and assignments they plan to reuse or by assigning different projects/tests for every semester."

3. "In classes where there is a computer based assignment, both math and computer science courses, students routinely have other fellow stu-

dents do/complete (or overly help) them with their computer based assignments. Since most of these types of assignments are done outside of the actual classroom, the instructor has no way of knowing who actually completed the work. To solve this, since more and more computer classrooms are available, more in-class time needs to be devoted to mini program-based quizzes to force students who routinely rely on others to do their own work in order to receive a passing grade.”

With the increasing integration of computer projects into math courses, this is becoming a serious issue in courses in the applied mathematical sciences and statistics, as well as in computer science courses. The calculus sequence and linear algebra courses at our university require considerable computer activity as do the numerous statistics courses that are heavily dependent on statistical software packages.

4. “One of the ethical problems...Allowing too much freedom to students in the labs. More often than not, I find students chatting, surfing the net or doing other things that are not school related. The problem is that they are using computer resources and university resources for personal pleasure. The computers that we have should be used for school related projects only.”

“The problem can be addressed as such: Only allow students to use the computers during lab hours and enforce that...Allow the assistant to monitor activity of the students working in the lab and allow them to report what they find. Make people sign in and explicitly detail why they are there (make this mandatory to use the labs).

In this regard in earlier classroom discussions, one student employed by one of the major computer companies noted that in an unannounced inspection 60 workers were terminated for unacceptable employee use of the WEB during office hours.

5. Other real or imagined ethical problems were noted. Many of these provide interesting material for use in the next semester.

SOME STUDENT COMMENTS ON THE COURSE

1. “I liked the ethics portion; it made me think seri-

ously about some practices that I have seen or even considered practicing myself and ask, is this right? Is it ethical?”—This student mentioned that at his job one employee complained of sexual harassment, and before it ended, a number of employees were terminated!

2. “I liked this course because you were allowed and encouraged to openly discuss problems of and solutions for the CMS department with a reasonable amount of discretion. This tells the students that the university is concerned about the type of education they are providing.”
3. “It was easy to talk in a small group of people.” Another noted that “I liked the open discussions we had in class about different ethical issues...relaxed environment.”
4. A number were concerned that the 50 minute class period didn’t give enough time to get into particular discussions. Some comments included: “More time should be included for more discussions” and “Change time of offering, since once discussion begins, it is hard to stop.”
5. “A type of exam based on the material from the first and second chapters of the ethics book is needed.” At the present time the course consists of only a series of projects (described earlier) and a final exam.

SUMMARY AND CONCLUSIONS

From the student comments and class participation, we believe that our present Senior Seminar course has been very successful in exposing the students to the ethical dimensions of the CMS professions and providing them with tools to make good ethical choices. We believe that the written and oral projects have helped them to more effectively communicate their own CMS related ideas and activities. The high quality of the various student discussions of issues indicates that they have a serious stake and interest in being a part of the CMS community. Their many thoughtful comments on how to solve ethical problems as well as suggestions to improve our academic community are greatly appreciated. We believe that this course has helped not only our students to become more active and involved members of our profession, but it has also helped our faculty to become

more aware of some ways we can act to improve our departmental programs.

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Weizmann Day's "Math Night" Brings Parents to their Knees

*Jewish Community News
Covina, CA*

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It didn't approach the scale of the Atlanta train yard scene in *Gone with the Wind*, but a visitor entering the long assembly hall a Weizmann Day School in Pasadena on the evening of February 1 would have witnessed the kneeling, sitting or reclining bodies of dozens of children and their parents scattered across the carpeted floor.

It was Weizmann's first annual "Math Night" and everyone was busy, very, very busy counting, measuring, estimating, spinning, stacking, building to the hum of voices and delighted laughter. Weizmann parents were receiving a hands-on demonstration of the activities generated by the school's new math program, and everyone had something to do. "This isn't math as I remember it," one parent remarked as his daughter carefully slipped a tape measure around his head. "It's not just math, Daddy. It's fun." The smiling faces around the room offered this assessment their clear and enthusiastic support.

Approached as a sequenced series of games and involving tasks, each appropriate to the grade level engaged, Weizmann's new math curriculum draws students into the pleasures and challenges of quantitative analysis. This innovative program, pursued in progressive steps from kindergarten through sixth

grade, employs the student's natural curiosity and delight with problem solving to generate the enthusiasm so central to successful learning. In kindergarten, toothpicks and marshmallows become a creative gateway to geometric form. In third grade the length of the big toes and the circumference of the neck give insight into measurement and proportion. In fifth grade estimating games, such as "How many beans in the jar?" and "How many rubber ducks in the frog pond?" illustrate new approaches to volume and spatial relationships.

Progressing from simple activities in the early grades to the more complex skills required by "Top It," a uniquely designed series of card games in the higher grades, students are invited into a process geared toward making "math anxiety" an oddity of the distant past.

On "Math Night" parents were invited to the school to join their children in this process not simply to involve the parents in their children's education—Weizmann parents are well-known for their eager and very active support of the school's mission—but also to give everyone a fun night out learning new ways of looking at traditional studies. By all estimates, from the 80% attendance record to the 100% consumption of the cookies and ice cream provided for dessert, the event was a un-compromised success no matter how you add it up.