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1. Background

At the Graduate Student Committee meeting in September 2002, Jeff Shaman, the student representative on the Curriculum Reform Committee, reported on the committee's efforts to consolidate perennially under-enrolled classes, agree upon core courses for each discipline, and modernize the offerings at the department. There was a feeling among students that the objectives of the Curriculum Reform Committee would not completely address the principal student concerns, namely improving the quality of graduate instruction and providing a logical progression of courses that prepares students for advanced research in their disciplines. Therefore it was agreed that students would meet in discipline-based groups in order to provide the faculty with concrete recommendations. This document summarizes the main issues discussed during these discipline-based group meetings.

2. Large-Scale Concerns

2.1. *Improved quality of graduate instruction*

L-DEO is well known for its innovative research and for the achievements of the department's graduates. In order to continue this tradition of success, it is essential that there be an institutional commitment to excellence in teaching.

While we recognize that quality of research is the predominant factor when making decisions about faculty advancement we would encourage the department to provide incentives and resources that encourage excellence in teaching beyond those which currently exist. Reform of the curriculum must be accompanied by a parallel effort to improve the quality of instruction in those classes that each year are under-enrolled and/or receive poor student evaluations. While in theory there are a number of courses that fill curricular needs, they do not meet those needs when they are poorly taught.

We therefore recommend the following:

- a. **Improved Course Organization.** Some classes do not provide students with a syllabus. Even if class organization depends on student interests, it is important to have a template to use as a point of departure.
- b. **Web-based Organization.** Course organization can be greatly facilitated by use of the user-friendly 'Columbia Courseworks' website. Recent utilization of the 'Courseworks' site by certain professors has provided improved structure and coherency to a number of courses. Putting lecture material online is an invaluable reference for the students, both during the semester and leading up to exams and orals.
- c. **Peer Feedback.** Encourage (or require) faculty members to seek written feedback on teaching methods by asking another faculty member with relevant experience to sit-in on a class. Specialists in teaching pedagogy from Teachers College could also make such 'teaching evaluation' visits. If these evaluations were made mandatory, they might be more effective and less likely to bruise egos.
- d. **Current Research.** There must be an update of material to include current, relevant advances in the field and an emphasis on relevance.
- e. **Primary Texts.** Courses, especially introductory level courses, tend to have a more coherent perspective when either one primary textbook is used or readings are given as a course packet.
- f. **Applied Learning.** More focus is needed on 'learning-by-doing'. Whenever possible, classes should employ lab sessions or homework that make use of real data.

- g. **Team-taught Courses.** Generally, students view team-taught classes to be successful - combining expertise from two viewpoints is invaluable. In certain instances however, students pinpointed a lack of coordination between professors as the downfall of such classes. Consistent notation and a clear progression of material must be maintained. Consequently, team-taught classes should have a lead instructor who is directly responsible for the quality of the course. This is not currently the case in most team-taught classes.
- h. **Student Feedback.** Teaching accountability is important. Better use must be made of student evaluations. The Dean should provide a letter of recognition to professors whose course evaluations are above average.. A mid-semester evaluation might also be made. This could be done using standard written course evaluations or by a third party (such as a post-orals student) who would confer with the class, then with the professor.
- i. **Regular Review of Curricular Issues.** All students and faculty in each discipline should gather at least once in the academic year to discuss curricular issues.

2.2. *Alternative graduate learning styles*

A number of groups discussed the two end members of graduate learning styles:

- a) UK model: tutorial style, no formal classes, and research-driven independent study.
- b) MIT model: classroom style, two years of strict coursework and testing, and no research until the coursework requirement is completed.

The students generally prefer a middle ground approach with formal coursework in the first year and a gradual transition toward independent work in subsequent years. A large number of students felt that 45 credits over 5 semesters is too much classroom time. Some mentioned that this requirement led to them taking one or two courses that were irrelevant to their research major and/or minors. Suggestions were made to reduce the 45-credit criterion to allow for more independent study time. Alternatively, many students felt that student-led, faculty supervised learning groups or formal group tutorials would be an ideal allotment for credits in the latter years when more advanced material is covered.

2.3. *Transition between introductory courses and the upper level courses*

Many students find the collective presentation of their major subjects to be incomplete. In particular, material drawn upon in upper-level courses is sometimes not covered in corresponding introductory level courses. Consequently there is a need for increased coordination among professors, such that all subjects are appropriately introduced before more advanced topics are addressed.

2.4. *Oral Examination Goals*

Complete documentation for the requirements of each major and minor is requested (i.e. more outlines of ‘suggested preparation for a minor in...’ as included in Appendix I of the DEES Graduate Student Guide. Right now the best of these outlines are the ones for Geophysics, Physics and Seismology).

3. Cross-Discipline Courses

Common concerns were raised on the status of Math, Data Analysis (QMDA), and Computing skills in the current curriculum.

3.1. *Math*

A common debate involved the need for a more comprehensive ‘Math Methods for Earth Scientists’ Class. It is not suggested that the course currently taught by Cane and Richards be overhauled, but that there is also a need for a more basic class covering the fundamentals of linear algebra, vector calculus, and O.D.E’s for those that may not have had this material before/ or for some time. Some of these fundamentals could be offered to incoming students as a 5 or 6 week short course taught in September and October. More senior graduate students could be heavily involved in the teaching of this short course. It is also possible that the APAM taught ‘Topics in Applied Math’ course could provide the necessary introduction or reintroduction to the topics that students will need to get the most out of their Earth Science classes during their first year. It may be useful to provide students with a handout on ‘Math Resources’, to inform them of classes in the Applied Math and Pure Math Departments. Furthermore, as significant demand for such a course does exist within the DEES graduate student body, a similar course could be offered by the department itself.

3.2. *Data Analysis*

The students welcome the recent decision that QMDA be taught every year and required of all students. Many agreed that the course would benefit from incorporating more demonstration of the methods using real data series within class time and that similar material be covered year-to-year irrespective of the instructor. Some students also expressed concern that the number of hours per week devoted to coursework for this class should be reduced to a reasonable amount, so that students taking multiple classes are not overwhelmed. A basic knowledge of MATLAB and linear algebra is a prerequisite for the course. As such, the 'Computing in the Earth Sciences' short course (explained below) would help prepare incoming students deficient in these skills who wish to take the course in their first year (which is recommended). A number of students also expressed an interest for an advanced statistics course (as a follow-up to QMDA).

3.3. *Computing*

The overall consensus is that there is a paucity of hands-on teaching of computer skills for DEES graduate students. For methods classes, and research work in general, knowledge of UNIX, MATLAB and graphical packages is often presumed of incoming students. As work in all areas of the department is becoming increasingly computational, establishing a learning resource for incoming students is essential to making their computer/classroom/cultural adjustment smoother. One option would be to include basic computer-skills training in a 'Computing in the Earth Sciences' 5-6 week short course. However, a number of the discipline-based groups concluded that a short course would not be adequate, and instead recommended that a full semester course entitled 'An Introduction to Computing for Earth Scientists' be introduced. This course would cover the use of PINE email, basic operation of the SUN system and UNIX/ LINUX (as required), student group computing resources, an introduction to programming on MATLAB, Fortran, and programming libraries for Climate/Earth sciences as well as exposure to a number of frequently used graphical and editing packages. Again senior graduate students could be heavily involved in the teaching of these courses. It was also suggested that students could make greater use of the three 2-hour workshops taught by AcIS on Basic UNIX commands, Working with Files in UNIX, and UNIX File Sharing. It should be noted that these courses are heavily oversubscribed since they have a maximum enrollment of 24 total students in two course sections.

4. Role of TAs

While there has been an admirable effort in recent years to provide *ad hoc* instruction to new TA's (namely a discussion led by Professor Christie-Blick and handouts sent to all TA's) this instruction needs to be provided by the department on an annual basis rather than being offered only when students demand it. It was also proposed that the department provide incentives for any interested, dynamic, senior graduate students to take a major teaching role in broad survey courses. In addition, there was strong support for TAs to have the option to be more involved in lecturing during their assistantships. It was noted that TAs in other disciplines have this responsibility/opportunity. This will increase teaching experience (for those students who would like more) and could make DEES students more competitive professorial candidates.

5. Field Trips/ Field Requirement

Hands-on experience courses (e.g., field trips and cruises) are an essential part of learning in DEES but were left out of the Curriculum Committee's plan. We would like to address two issues concerning these courses:

5.1. Field Requirement: While we believe that the field requirement is an essential one, we think that hands-on experience should not be restricted to Geologic Mapping.

Students in disciplines other than solid earth may benefit more from a cruise or fieldwork that is more directly relevant to their research. We note that physical oceanography and GISS students are officially exempt from the Geologic Mapping course, and suggest that this be applied to students in other disciplines. Furthermore, the students required to participate in such a course should not be made to pay for it (last year participants spent more than \$400 on the field trip with Prof. Anders).

5.2 Field Courses: Students in the solid earth disciplines strongly recommend adding field geology classes. Professor Christie-Blick's excellent course, Field Geology, is oversubscribed when offered, and is offered only every two or three years.

6. Curriculum Reform Issues – by Discipline

See the following pages for Curriculum reform suggestions as raised by students from individual Disciplines.

6.1. SG&T, MG&T and Solid Earth Group

- The Curriculum Committee's proposal to include core courses and the creation of an intro survey course were welcomed. Additionally, the students suggest that there should be one course to survey all geophysics fundamentals, similar to Advanced General Geology. It is proposed that an updated combination of Plate Tectonics and Principles of Geophysics be made.
- The main advantage of combining courses is that some fundamentals could be taught every year with a quorum of students. These yearly core courses could be sampled from the following:
 - Plate Tectonics (combined with Principles of Geophysics)
 - Deformation & Earthquakes
 - Math Methods in Earth Science
 - Earth's Deep Interior
 - Tectonophysics II
 - Advanced General Geology
- Advanced elective courses we recommend keeping:
 - Myths & Methods in Modeling
 - Field Geology
 - Advanced Seismology
 - Marine Seismology (n.b. This course has only been taught once in the past 5 years. It is suffering from serious inattention)
- By combining courses a number of advanced topics are not addressed. These can be taught on an "as needed" basis. We propose the inclusion of the following NEW advanced electives or seminars:
 - Deformation and Earthquakes II (using material from Geophysical Theory II & Tectonophysics I)
 - Sedimentary Processes II
 - Earth's Deep Interior II

6.2. Paleoclimate & Low-Temperature Geochemistry Group

- The students liked the idea of suggested sequences, but firm requirements inevitably allow some people to fall through the cracks.

- Courses that haven't been taught enough in recent years, or are not taught at all, that we'd like to see:
 - A soils and sediments class (including transport of sediments, transport through sediments, shallow subsurface geochemistry, liquid/solid interactions, etc.)
 - Hazard Remediation/Bioremediation.
 - An Introduction to Low Temperature Geochemistry: including radiogenic isotopes in sediments.
 - Incorporation of skills based problem sets into existing paleoclimate classes, including data analysis, modeling applications, chronological tools. Perhaps the existing paleoclimate classes could be re-structured into: 1) Intro to Paleoclimate; 2) Advanced Paleoclimate.
 - Hydrology (needs to be taught!)
 - Continental Waters (needs to be taught!)

- Courses that could be combined:
 - Climate Change, Paleoceanography, Isotopes II (stable). This could be made into the Advanced Paleoclimate course (mentioned above)
 - Carbon cycle into Chemical Oceanography (co-taught by Wally Broecker, Jean Lynch-Stieglitz, and Bob Anderson).

- A potential Paleoclimate/ Low-T geochemistry set of recommended courses:
Intro to Low-T Geochemistry
 - Intro to Physical Oceanography Chemical Oceanography (n.b. adding Atmospheric Chemistry to Chemical Oceanography would be inappropriate as these are very distinct research fields))
 - either Climate Dynamics or Atmospheric Science or Paleoclimate
 - Sediments & Soils class (new course)

6.3. Physical Oceanography & Climate Group

- The students of this group, along with those at GISS feel, that there currently is little integration between Ocean and Atmosphere topics.
- Recommended Program:
 - Students begin the program by attending the Math and Computing Short Courses as required.
 - Year 1 - students focus on core courses in climate:
 - Introduction to Atmospheric Science
 - Introduction to Physical Oceanography
 - A solid introductory GFD course (new)
 - Introduction to Data Methods (QMDA)
 - Any catch –up Math classes as required (i.e.. O.D.E’s and/or Applied Math I or II)
 - Classes for minors
 - Years 2 and 3 – students apply their solid base from the intro courses to more advanced coursework and seminars:
 - Climate Dynamics
 - Myths and Methods in Modeling
 - Atmospheric Dynamics and/or Ocean Dynamics
 - Several ‘Problems in Oceanography’ or ‘Problems in Climate’ advanced seminars
 - The possibility of student-driven, faculty supervised learning groups or tutorials on more advanced problems in Climate Physics/Physical Oceanography.
 - see suggestions for new Atmospheric courses by the GISS group
- The students (along with those at GISS) strongly felt the need for a new introductory level course in Geophysical Fluid Dynamics to be made available every fall semester. This course would serve as a building block for Ocean Dynamics, Atmospheric Dynamics and the new Tropical Oceanography class. Restructuring of these existing courses could then eliminate the need to cover introductory GFD concepts repeatedly. The students in the Oceans & Climate and GISS groups have prepared a separate document outlining the aim and proposed structure of this new GFD course (see GFD Proposal). This would also have strong implications for the content of "Ocean Dynamics" (D. Ou) and "Atmospheric Dynamics" (D. Rind), which needs to be addressed in the Curriculum Reform.
- Many current students in the P.O. and Climate groups come from diverse backgrounds. An ‘Introduction to Computing for Earth Scientists’ class is particularly welcomed.
- There should be an improvement in the communication between the Lamont and GISS faculty on issues of curriculum co-ordination.

6.4. GISS Group

The students made the following suggestions for curriculum reform:

- Improved integration of ocean/ atmosphere topics.
- Addition of a computing course incorporating programming in UNIX, MATLAB and Fortran.
- Addition of a course on Clouds (microphysics, dynamics, role in Climate etc.)
- Requirement of Atmospheric Radiation for Atmospheric Science majors. Since the number of students involved is so few, the Department has to be willing to accept low enrollment. It is suggested that Atmospheric Radiation and Radiative Processes of Climate (Andy Lacis' two classes) be combined into a single Radiative Transfer class.
- Development of a new class on Remote Sensing for the Atmospheric Sciences is requested.
- There is interest in the possibility of a new course on Atmosphere/ Ocean/ Ice Thermodynamics (based on Curry & Webster's text). There was also a suggestion for a new course on Climatology (based on Peixoto & Oorts 'Physic's of Climate')
- More teaching of advanced statistical methods.
- More incorporation of 'real' data examples and exercises in courses.

6.5. Biology/ Plant Group

- The general feeling is that there is little support for the grad students in this group at DEES. They feel that this is not solely an LDEO problem but a Columbia problem.
- Classes the students would like to have at LDEO (in order of importance):
 - An Ecosystem level class (i.e. biogeochemical cycles and relations to plant nutrient availability etc.)
 - A Bio-Stats class (as much of QMDA is irrelevant to the students of this group).
 - An Ecology course (the only one is at CERC and is a soft science class, and largely anecdotal). CERC classes are all based on taxonomy and systematics and so are not useful to us in general
 - Biological Oceanography (this must be regularly offered).
 - Some non-plant bio- courses
- The general feeling of the students is that there are few classes for them to take that are relevant to their research such that their transcripts end up being a mish-mash of non-bio classes. This reduces their competitiveness for funding opportunities (i.e. from the Ecological Society of America related sources). The students feel that they are generally self-taught regarding the material they may need in their post-docs/ later research. This is not necessarily a bad point, but some middle ground must be reached.
- Another important curriculum related issue is the Geological Field Mapping course requirement. The students are strongly opposed to taking this requirement as they feel that it is completely unrelated to their research interests. They agree with DEES that fieldwork is an essential part of their education, but feel that a GEOLOGICAL field course is not what they need. Most of these students do their own field work (i.e. at Black Rock Forest, Okarito Forest in NZ, Toolik Lake LTER in Alaska or at Biosphere...) - weeks and weeks of it each year. If DEES feels that there should be a mandatory field requirement, the students in this group would like to fulfill this in a way that is more relevant to their research interests.

6.6. High-Temperature Geochemistry Group

- The Advanced General Climate class should be a broad survey of physical, chemical and biological properties of the ocean and atmosphere, including the terrestrial carbon budget. It should cover the basics that govern climate. Topics to be addressed would include the Carbon cycle, budgets of various elements in the exosphere, and how the Earth compares to other planets in our solar system (*i.e.*, the requirements for life), etc. It should give all students taking the class a rudimentary understanding and appreciation for what their fellow climate students study at Lamont.
- The idea of a course on the Earth's Deep Interior is supported. It is suggested that material covered should include: major phase changes with depth in the mantle; equations of state; experimental methods for studying the deep interior; and basic mineral physics. The students of this group would like to have input in deciding the structure of the course.
- The addition of a General Geochemistry class for Petrology students was suggested. This new intro-level class would be taken in the first year of study, ideally to be followed by a hands-on quantitative analyses class in the second semester. The following structure was proposed by the students:

Geochemistry class

- The geochemistry class should cover basic properties of all the elements in the periodic table (*i.e.*, volatility, solubility, natural abundances, etc.). It would teach oxidation-reduction in geologic environments, including the oxygen buffers, practical calculations of solubility in various mediums, properties of acids and bases, etc. Elemental and isotopic budgets within the Earth (where these elements live). All these geochemical tools can then be used to help a student develop (if they want) a new procedure for how to measure something, or better understand a current procedure that they are using.
- The second part of this is a hands-on class or seminar that introduces students to a wide variety of analytical techniques and equipment. It would teach them both the theory behind an instrument as well as how to prepare and run a sample on that instrument. Examples are...wet chemistry, ICP-MS, TIMS, Electron Microprobe, FTIR, SEM, maybe laser ablation ICP-MS, multianvil, diamond cell, shock wave experiments, piston cylinder etc. This class could be team-taught.