

A. Summary and Specific Aims

Over the five-year project period beginning in Spring 2006, MCDB proposes to “transform” the five large courses required of our majors plus a few of our larger elective courses. Beginning with the introductory course, we will transform these courses sequentially, with the help of several Senior Teaching Fellows, as follows:

- Formulate a set of learning goals for these courses that will together constitute a coherent curriculum.
- Develop and validate assessments that will allow us to judge how well these learning goals are met.
- Administer such an assessment to current MCDB majors to provide a baseline measure of conceptual understanding for students at different stages in the major.
- Develop and test protocols and new teaching materials for these courses, informed by current research on learning, that will promote achievement of the desired learning goals.
- Use assessments to measure learning gains in each course as well as retention from one year to the next, and to determine whether our modified teaching methods increase levels of student conceptual understanding of MCD Biology.
- Train new faculty members who take over these courses to use protocols and methods that are shown to be effective, so that improvements in student learning can be maintained over the long term.

B. Background – Preliminary activities in MCDB supporting the SEI application

Several ongoing activities in MCDB have helped to prepare the department for participation in the SEI:

1) STEM-TP Participation.

Three MCDB faculty have been active in the STEM-TP program, funded by NSF (R. McCray, P.I.) and designed to promote improved teaching of undergraduate science courses and attract science majors into teaching careers. B. Wood is a co-P.I. on the grant; he, M. Klymkowsky and J. Knight are members of the project steering committee. M. Klymkowsky is also a Co-PI on a recently submitted NSF proposal to examine the efficacy of the LA model for science teaching recruitment and preparation.

2) Established course transformations.

Over the past three years, in conjunction with involvement in the STEM-TP program a few individual faculty members have already started to make changes in how courses are taught. Currently, the following courses employ learning assistants, clickers, and active learning techniques:

MCDB 1111 – Biofundamentals, alternative introductory course, Klymkowsky

MCDB 1041 – Human genetics, non-majors, Knight

MCDB 4650 – Developmental biology, upper division majors, Knight and Wood

3) Incipient course transformations.

Our majors Genetics course, 2150, which follows the introductory course, is using clickers for the first time in 2005-2006 (both semesters: Fromherz, Winey). These courses will also use learning assistants for tutorial teaching in the future when resources become available. Instructors in the

Introductory course, Cell Biology, and Molecular Biology are interested in using clickers beginning in 2006.

4) Faculty professional development.

B. Wood is Co-Director of the National Academies Summer Institute for Undergraduate Education in Biology (academiessummerinstitute.org), supported by the Howard Hughes Medical Institute (HHMI). The Institute holds annual 1-week workshops for biology instructors from up to 20 universities each summer in Madison, WI (www.pubmedcentral.nih.gov/articlerender.fcgi?artid=533119). B. Wood and J. Knight participated as the team from C.U. in summer 2004, and were designated National Academies Teaching Fellows for the year 2004-2005. They received financial support from both the Dean's office at C.U. and from the Institute to disseminate knowledge gained there to colleagues at C.U. on their return. J. Knight subsequently served as a facilitator at the summer 2005 workshop. Over the past two years, B. Wood and J. Knight have given four presentations in the weekly MCDB faculty lunch seminar, in which they discussed recent research results on how people learn as it applies to undergraduate teaching, demonstrated clickers, and led discussions of teaching and learning questions.

B. Wood organized and has taught a weekly seminar on Teaching and Learning during the spring 2004 and spring 2005 semesters, in collaboration with J. Knight (www.colorado.edu/MCDB/MCDB6440). It will be offered again in spring 2006. The course may be taken for credit (1 unit) by undergraduate or graduate students, and post-doctoral research associates headed for academic careers and current MCDB faculty are encouraged to attend. From 12-20 participants have regularly attended the seminar during the past two years, including 6 MCDB faculty members.

5) Other activities related to improvement of MCDB undergraduate teaching.

Over the past three years, M. Klymkowsky has developed and taught to 60 - 80 students during spring semester an alternative version of the large fall MCDB Introductory course (which until now has been taught in the standard fashion). The alternative course, Biofundamentals (www.colorado.edu/MCDB/MCDB1111), is web-based, uses learning assistants, clickers, and a highly interactive class format. It includes virtual laboratories (simulated laboratory experiments) that students carry out online.

M. Klymkowsky is also P.I. on a funded NSF grant with Kathy Garvin-Doxas to develop a Biology Concept Inventory (BCI; www.bioliteracy.net), with help from contributors nationwide, which can be used for assessments of conceptual learning in the same way that the Force Concept Inventory has been used in physics. As part of this project, they have developed on-line tools (Ed's Tools) that greatly facilitate the capture and analysis of student responses; these tools will be used in the generation and validation analysis of assessment instruments for the classes to be transformed during the project. The experience gained through this project will be invaluable in developing assessments for MCDB, and some of the BCI itself may be directly usable in our assessments.

During the spring 2004 and 2005 semesters, B. Wood and J. Knight have taught the upper division required "capstone" course MCDB 4650, Developmental Biology (www.colorado.edu/MCDB/MCDB4650/), using learning assistants, clickers, and a variety of interactive in-class activities in place of some lecture time. Using the same pre- and posttest questions, they measured student learning gains in these courses compared to learning gains in the same course taught traditionally by the same instructors in fall 2003. The results demonstrate a 30% increase in average normalized student learning gains in the two more interactive classes. These

results have been presented at several national biology meetings and have been published in *Cell Biology Education – a Journal of Life Science Education* (2005; www.cellbioed.org/article.cfm?ArticleID=169).

B. Wood, with help from MCDB Chair L. Leinwand, R. McIntosh, and J. Graf of the undergraduate HHMI initiative, has raised internal funds and obtained a commitment for 2000 square feet of space in the basement of Porter Biosciences to construct and equip a classroom for about 100 students with café-style seating and networked laptop computers that will be far more suitable for interactive teaching than the currently available lecture halls. This room should be ready for use in the spring 2007 semester and will be made available on a limited basis to other departments participating the SEI as well as to MCDB courses.

6) Formulation of integrated learning goals for the required MCDB majors courses.

The MCDB Undergraduate Committee (UGCOM; Chair, B. Wood, members include M. Klymkowsky, J. Knight) has nearly completed a set of draft learning goals (see www.tedi.uq.edu.au/teaching/assessment/learningGoals.html for a good definition of learning goals and how to formulate them) for the four largest required majors courses, after interviewing the faculty who teach these courses and discussion within the committee. We expect that this exercise may lead to recommendations to change the way curriculum content is distributed between these courses and the order in which it is presented. However, its main purpose is to create a draft integrated set of learning goals, eliminating gaps and unnecessary overlaps, designed to include about 70% of the content of each course. (The remaining 30% would be dictated by the interests of the course instructor.) The plan is to present these goals to the faculty in January 2006 for general approval, and then to work individually with the instructors who will be teaching these courses during the next two years, to revise and refine the goals to their satisfaction.

C. Administration of the MCDB effort

MCDB activities under the SEI will be under the direction of UGCOM, which will be responsible for overseeing the program and managing its budget, and keeping records. A part time Coordinator, appointed by and reporting to UGCOM, will manage day-to-day operation of the program. Senior Instructor J. Knight will be proposed for this position.

D. Objectives and timeline for MCDB activities under the SEI

Because this is a new endeavor for MCDB, still involving many unknowns, it is difficult to predict how rapidly the project can proceed. What follows is a tentative timetable, which we will follow as closely as possible. Our approach will be to begin augmenting the ongoing process of change in MCDB teaching and assessment slowly in spring 2006, accelerating during subsequent semesters as we recruit STFs and build on our initial experience.

Spring semester 2006.

Learning goals will be finalized for the first four required MCDB courses.

The first of three Senior Teaching Fellows (STFs) will be recruited, to work with UGCOM and the Director on interviewing students for development of assessments and design of the Introductory course MCDB 1150, informed by work that has already been done on the alternative introductory course MCDB 1111. The larger course will be taught in a partially transformed format in fall 2006 by Assistant Professor Jennifer Martin and Professor Attendant Rank Nancy Guild, with assistance from J. Knight.

Summer 2006.

A second Fellow (STF2) will be recruited to begin development of assessments and design of the Genetics course MCDB 2150, which will be taught in the fall by Instructor Sylvia Fromherz and in spring 2007 by Professor Mark Winey. Both STFs will work on creating teachable units that use interactive learning techniques for each of the two introductory courses, as well as interviewing students and developing tools to assess mastery of MCDB concepts.

Fall 2006.

Work on developing a validated assessment instrument will be continued.

MCDB 1150 and MCDB 2150 will be taught with pre- and posttests, clickers, and learning assistants (partially transformed courses). The Director will assist with 1150, and the STF2 will assist with 2150.

The STF3 will be recruited to work with STF1 in development of assessments and design of the Cell (MCDB 3120) and Molecular (MCDB 3500) transformed courses.

Spring 2007.

If a validated assessment of conceptual knowledge is completed, it will be administered to students in all required MCDB courses to provide baseline data. If more time is required for development, this assessment will be carried out in fall 2007.

MCDB 2150 will be taught as a transformed course, with assistance from STF2.

2007 – 2008 AY.

MCDB 3120 and 3500 will be taught as transformed courses. Assessments will be administered as pre-tests and post-tests in the transformed courses to measure student learning gains, as well as retention of concepts from one year to the next.

2008 – 2010.

This process will be continued for the alternative capstone courses Development (MCDB 4650; already partially transformed) and Immunology (MCDB 4300), which will be taught by Assistant Professor Corrella Detweiler, followed by the larger MCDB elective courses. Assessments will be administered as pre-tests and post-tests in the transformed courses throughout the project to determine the effects of course transformations on student gains in conceptual learning and retention of these gains.

E. Tentative Budget

We anticipate a budget of about \$300 K per year on average for the five years. These funds will be used for:

- Salaries for 3 PhD STFs
- Compensation for a programmer for development of technological teaching aids, such as animations and applets.
- Part-time compensation for the Coordinator based on time and effort required for the job.
- Additional part-time help and consulting for development of assessments as needed.
- Activities to inform faculty about the transformation process and encourage faculty buy-in, such as a regular seminar and a summer workshop.

A more detailed budget will be submitted if MCDB is chosen to participate in the SEI.