

Interactive Electronic Textbook for Physical Chemistry

Professional Development Grant Proposal

David J. Gross, Associate Professor, Department of Biochemistry and Molecular Biology, University of Massachusetts, Lederle GRC, 710 N. Pleasant St., Amherst, MA 01003, dgross@biochem.umass.edu, 413-545-3170, Principal Investigator

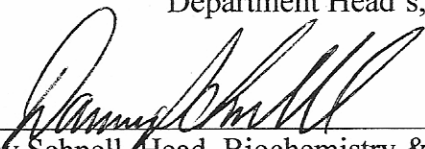
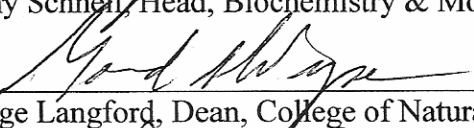
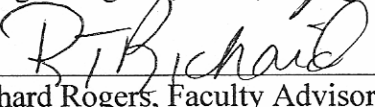
Campus involved: Amherst
Disciplines involved: Biology and Chemistry

Total funds requested: \$8000

Project Summary

The goal of this project is to develop an online, interactive evaluator-integrated electronic textbook (an EIB) for use in upper division physical chemistry courses. The target audience of the EIB will be biology and biochemistry students for whom physical chemistry is a required course. The material will cover basic physical chemistry, with emphasis on biochemical examples and techniques. The unique aspect of this EIB will be addition of Flash interactive figures, interactive examples and interactive homework problems, all produced and delivered via the UMass Amherst OWL (Online Web-based Learning) system. This EIB will be deployed in the Fall 2007 semester for the course Biochem/Chem 471, which the PI will be teaching. If the deployment is successful, Thomson Publishing has expressed a strong interest in marketing the EIB.

Department Head's, Dean's and Provost's Signatures

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|----------------------------------------------------------------------------------------------|---------|
|  _____ | 2/20/07 |
| Danny Schnell, Head, Biochemistry & Molecular Biology | Date |
|  _____ | 2/20/07 |
| George Langford, Dean, College of Natural Sciences & Mathematics | Date |
|  _____ | 2/20/07 |
| Richard Rogers, Faculty Advisor to the Provost for Undergraduate Education | Date |

Project Narrative

Physical chemistry is one of two subjects (the other being organic chemistry) that many life science students consider to be the tough courses that they need to master to graduate. This view comes from the very real fact that mathematics, including calculus, is needed to develop and present physical chemistry, which employs quantitative, physical methods to understand the interactions of matter and molecules. It is primarily this heavy use of mathematics in this 3rd or 4th year course that students find daunting because many life science students have had little need to use the math that they learned in their first year of college. Many physical chemistry textbooks develop the subject by employing antiquated examples (steam engines are often cited) and offering insight into areas of chemistry that are not particularly relevant to biologists (the physical properties of inorganic compounds, for example). The goal of this project is to develop an interactive learning suite combining text, active graphics, parameterized mathematical examples and embedded student evaluation that delivers the subject of physical chemistry in a context that will engage and enlighten life sciences students. The specific focus of the project is to build and deliver an evaluator-integrated electronic textbook (EIB) with these attributes for the students of Biochem/Chem 471 (Elementary Physical Chemistry, a course crosslisted between the Departments of Chemistry and Biochemistry & Molecular Biology).

Physical chemistry combines the concepts of physics and chemistry in a treatment that requires mathematics through calculus. An understanding of physical chemistry is becoming more important to life science students because an increasing use of physical measurement techniques is found in current biological and biomedical research as noted in the 2003 report by the National Research Council 'Biology 2010: Transforming Undergraduate Education for Future Research Biologists' (National Academies Press; Washington, DC: 2003). This report also noted that students frequently approach physical chemistry with 'math anxiety'. The report also promotes increased student training in these disciplines.

There are few textbooks available that develop physical chemistry with a focus on life science applications and that present the material at an appropriate level. One book, Physical Chemistry: Principles and Applications in the Life Sciences by Tinoco, Sauer, Wang and Puglisi (Prentice Hall, Upper Saddle River, NJ, 2002) covers physical chemistry with many biochemical examples, but it suffers from a dry, mathematics-heavy treatment and a relative de-emphasis of practical techniques. Another book, Principles of Physical Biochemistry by van Holde, Johnson and Ho (Prentice Hall, Upper Saddle River, NJ, 2006) does a better job with practical techniques, but is lacking in the development of fundamentals. Nelson's Biological Physics: Energy, Information, Life (W.H. Freeman and Company, New York, 2004) does an excellent job of describing the physical aspects relevant to biology, but has no development of fundamental principles. In short, there are no good textbooks that develop physical chemistry from basic principles and yet provide life science students with practical examples. Lisa Lockwood, Chemistry Acquisitions Editor with Thomson Learning/Brooks Cole, concurs with this in her letter of support for this proposal.

A previous Instructional Technology Professional Development Award (Interactive Online Homework for Chemistry 471) was used to develop online homework exercises for Biochem/Chem 471. During the summer and fall of 2006 the PI wrote approximately 250

parameterized homework exercise questions for the course inside the OWL (Online Web-based Learning) system. These questions were packaged into 55 assignments covering all of the material discussed in the course. In addition, seven online quizzes were written. All of the online exercises were offered to students taking Biochem/Chem 471 in the Fall 2006 semester (a total of 73 students). The class successfully completed 94% of the online homework and received an average grade of 73% on the online exams. In the Student Response to Instruction (SRTI) questionnaire taken by the class at the end of the semester, students felt strongly positive toward the statement “The OWL homework was helpful in learning the course material.” (on a scale from 5-very helpful to 1-not at all helpful the student response was 4.70). Students’ grades on written exams also improved slightly compared to previous years. Thus, the use of online exercises that allow students to receive active feedback on their mistakes and provide grade credit appears to be an effective tool for student learning in physical chemistry.

This proposal aims to expand on the success of the OWL online homework suite developed last year, to deliver a fully integrated online physical chemistry textbook with content appropriate for life science students. A portion of this project is already complete: the development of interactive online homework exercises and the bulk of the textual portion of the book (see PDF notes from the Fall 2006 offering of Biochem/Chem 471 at www.chem.umass.edu/~dgross/chem471/lecture/index.html; these will form the core of the text for the EIB). What remains to be developed is the actual EIB layout, interactive figures, example problems and inline evaluative problems. The layout of the EIB will be similar to that developed by Prof. Robert Moll of the Department of Computer Science. The physical chemistry EIB will be divided into chapters (approximately 10) to be covered roughly one chapter every 4-5 class sessions. Introductory chapters will build on each other while later chapters will be independent of each other to permit flexibility in course material coverage. One unique aspect of the EIB within the OWL system is the availability of inline example problems within the text of the book. For example, a subchapter covering Gibbs free energy could include two or three interactive questions for credit that would reinforce the material in the subchapter. Such questions include feedback so that students can learn the application of theory as they are reading the textbook, and these questions can be the same ones already developed in the first phase of this project. General support for EIB developers is available from the Center for Educational Software Development (CESD; see letter from CESD Director David Hart). In order to support this EIB as well as two others (one from Computer Science and one from Chemistry), a separate Strategic Initiative Grant is being concurrently submitted (Robert Moll, PI). Should Prof. Moll’s proposal not be funded, a limited version of the EIB will be employed in the Fall 2007 semester for Biochem/ Chem 471. The interactive Flash figures and examples will be incorporated into the textual portion of the EIB to the extent possible, but it is unlikely that inline evaluative problems will be incorporated due to limited availability of CESD staff time. The Flash content will be fully incorporated into the existing OWL homework. Completion of the project may require further future funding.

Development of interactive figures for the EIB will require substantial programming effort. Envisioned are Shockwave Flash modules that would allow students to interact with the figure to explore the relationships between parameters, to go stepwise through a derivation, to plot results of an example calculation, and to probe into aspects of the material that are of interest to them. (A simple example of such a Flash module can be seen on the OWL

demonstration site, owl.cs.umass.edu/owl-c/demo/owldemo.cgi. From this page select “Examples from Various Departments”, “View Assignments”, and “Dept: Chemistry - Discovery [NSF, FIPSE]”. On the second Info Page, click the “View Page” button to see the interactive Flash module.) Similar Flash modules can quiz students and deliver student answers back to OWL for grading.

The Flash modules to be developed will be designed for dual purpose. They will be available to use as embedded, interactive figures within the structure of the proposed EIB. They will also be available within the standalone online OWL exercises already developed. These Flash modules will serve as interactive tutors and interactive exercises or examples, applicable either within the EIB or within the standalone homework assignments. The addition of these Flash-based active figures will bring a new dimension to the students’ textbook experience. Students will be encouraged to explore quantitative relationships, to flesh out concepts and to be active participants with the course material. The hope is that such interactive course materials will engage students more than hardcopy textbooks and paper-and-pencil calculations.

The immediate goal of this project is to produce a functioning EIB for Biochem/Chem 471 for the Fall 2007 semester. This EIB should be sufficiently complete that it will take the place of the hardcopy text. This EIB will form the core of a refined version with somewhat broader scope that will be shown to Brooks-Cole/Thomson Learning, the textbook company that licenses OWL materials developed at UMass Amherst. A letter of support from Lisa Lockwood of Thomson expresses interest in the EIB. Further development costs, if any, will be requested from Thomson. If Thomson markets the physical chemistry EIB, a royalty revenue stream will be returned to the University.

Project Deliverable

Completion of this project during the course of the summer and fall of 2007 will produce a fully functional OWL EIB for Biochem/Chem 471. The EIB will include all of the online OWL homework problems already developed for the course as well as text equivalent to a one-semester physical chemistry textbook. Interactive figures will be included within the text of the EIB as well as within the standalone homework problems. This EIB will be used during the Fall 2007 semester by the students in Biochem/Chem 471.

Should Prof. Moll’s proposal not receive funding, some components of the Biochem/Chem 471 EIB will likely not be incorporated into the EIB during the Fall 2007 semester. Integration of inline evaluative problems and some Flash figures may require subsequent funding.

Project Dissemination

All content produced for this project will be available to chemistry and biochemistry instructors using the OWL system. With suitable modification and addition, other physical chemistry courses (that do not have significant biochemistry content) can employ the Biochem/Chem 471 OWL course materials. Further dissemination beyond the UMass system can be accomplished by licensing the physical biochemistry OWL content through Thomson

Learning, which currently licenses and distributes UMass-developed General Chemistry, Organic Chemistry and, recently, General, Organic and Biochemistry (GOB) OWL content. See the letter of support from Lisa Lockwood, Chemistry Acquisitions Editor for Thomson, who expresses interest in the development of this EIB.

Project Budget

The major software development needed for this project is the construction of approximately 5 Flash modules per EIB chapter. The scientific content of the modules will be designed by the PI, and the necessary behavior of the modules will be created as storyboards by the PI. The Flash modules will be developed by programmers proficient in Flash programming. The CESD, home of OWL, provides Flash module development. Matthew Mattingly, Multimedia Director at CESD, will be the primary consultant with the PI on Flash module design. He will direct a multimedia programmer to build and refine the modules. Approximately 50 modules will be built, some quite simple and others involving multiple “pages” of interactive text and graphics. The budget calls for about 50 hours of Mattingly’s time and 80 hours of the programmer’s time, which will provide between two and three hours of programming time per module. It is anticipated that the first dozen or so modules will take more time, but then they can be used as templates to speed development of subsequent modules.

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| Matthew Mattingly, 53 hours | \$4000 |
| Multimedia programmer, 80 hours | \$4000 |
| TOTAL | \$8000 |

Project Timetable

- May 2007: layout of the EIB format, initial discussions with CESD on Flash module development
- June-July 2007: storyboard development, production of first Flash modules, incorporation of text into the EIB chapters, insertion of embedded questions and problems into the text, initial incorporation of Flash module figures into the EIB chapters
- August 2007: final production of all materials for the first half of the EIB, ongoing module development for the remaining Flash modules, testing of the first half of the EIB, completion of all text chapters
- September 2007: deployment of the EIB for students in Biochem/Chem 471, troubleshooting of any student issues, continued development of modules
- October-December 2007: insertion of completed modules into the last 5 chapters of the EIB on an as-needed basis, continued refinement of the material
- January-May 2008: review of the first use of the EIB, demonstration of the EIB at the UMass Instructional Technology conference, initialize contact with Thomson about marketing the EIB

Investigators

David Gross, Associate Professor of Biochemistry and Molecular Biology, is the PI and primary contact for the proposal. He has taught many biochemistry and chemistry courses including advanced biochemistry (Biochem 623), majors biochemistry (Biochem 523 and 524), biochemistry lab (Biochem 526), biochemistry writing (Biochem 391H), physical biochemistry (Biochem/Chem 471), general chemistry (Chem 111 and 122), plus several others. He was a TEACHnology Fellow at the Center for Teaching at UMass Amherst during the 2001-2002 academic year. His project for the TEACHnology Fellowship was to develop Chime-based interactive molecular visualization OWL content for Biochem 523. He has authored considerable OWL content, including the biochemistry portion of the new General, Organic and Biochemistry (GOB) offering from Thomson Learning-Brooks/Cole Publishing which is now being used in courses across the country. Content for GOB developed by Gross includes parameterized OWL questions with feedback, interactive Jmol-based macromolecular visualization materials and Marvin Sketch-based interactive molecular drawing questions.

Letters of Support

David Hart, director of the Center for Educational Software Development (CESD), writes a letter supporting this project. CESD is the home of OWL and will be the deployment point for the Biochem/Chem 471 EIB on OWL.

Lisa Lockwood, Chemistry Acquisitions Editor for Thomson Learning-Brooks/Cole Publishing, writes a letter expressing interest in marketing the physical chemistry EIB.

David Gross, PI, writes a letter indicating his level of participation in the project.

Letter from Dave Hart

Letter from Lisa Lockwood

Letter from Dave Gross