Incorporating Public Sharing into Existing Curriculum as a Solution to Bridge the Perceived Gap between Classroom and Real World Biochemistry

Catherine Y. Cheng and Didem Vardar-Ulu
Department of Chemistry, Wellesley College, Wellesley, MA 02481

Abstract

There is a perceived gap in society between biochemistry as covered in the classroom and that pertinent to real societal concerns. Most traditional outreach efforts remain disconnected from the curriculum and exhibit a unidirectional information flow, from experts to society, widening the gap between "scientists" and "the public." Here, we present a case study on how an explicit public sharing component can be effectively incorporated into an existing upper-level undergraduate biochemistry course. In the spring of 2012, 5 seniors and 6 juniors enrolled in Biochemistry II were given a choice of disseminating their understanding of a health related biochemical problem to a general audience via i) a layman's abstract or a letter to a senator, ii) an article for the Molecular Anatomy Project initiative at the Protein Data Bank, or iii) a lesson for a non-science majors chemistry class, in addition to the existing formal research proposal write-up. Student, audience, and expert feedback on this more student- and society-centered course format were largely positive, pointing to student growth in a diverse set of transferable skills including independent content learning. This outreach-focused implementation of an existing assessment tool in a terminal course ensures that majors graduate not only with a well-founded understanding of the field, but also with the ability to effectively communicate it to a diverse audience.

Objective and Hypothesis

To explore student learning gains and the public impact of three distinct approaches to public sharing as an integral part of an upper-level biochemistry course that are tailored to students' unique strengths, skills and interests

Incorporating an explicit, peer-centered, and student-led "public sharing" component to the course expectations and assessments of an existing biochemistry course reinforces student learning of the course content while initiating a rewarding dialogue between the well-informed and the general audience.

Project Design

Biochemical Content Core

Goal: To demonstrate mastery of biochemical content, the ability to conduct an in depth critical analysis of existing biochemical information on a student chosen specific topic, to form hypothesis, propose biochemical experiments to confirm or refute hypothesis, and discuss in-depth multiple interpretations of possible outcomes of the proposed experiments

Options for Reinforcing Biochemistry Content through Independent Projects

Grant Proposal format | *Mini Proposal format* | *Mini Proposal format*

Dissemination of Biochemical Knowledge

Goal: To demonstrate the ability to communicate effectively and appropriately the in-depth understanding of the independent project biochemistry content to representative public audiences.

Options for Sharing Classroom Content with the Public

NIH-style Grant Proposal Extension

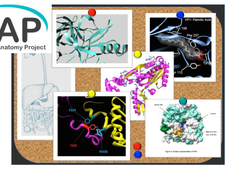
A layman's abstract, an open letter to a senator, or a news release piece addressed to a general audience to convey the importance of the proposed research and justification for public funding followed by an oral defense in front of a 'Grant Review Panel' composed of classmates.

Molecular Anatomy Project (MAP) Article

A deposition of a disease article to MAP (map.rcsb.org): An online educational site harboring articles authored by students as well as experts since 2006 about various diseases discussed at a molecular and structural level.

"Teach for Chem102" Lesson

A Face-to-Face 15 minute lesson with Live Audience enrolled in Chem102: A non-science majors course offered in the chemistry department titled "The Chemistry of Drugs".



Workflow and Timeline of the Project

Formulation (Weeks 1-4) → Preparation and Revision (Weeks 5-11) → Finalization and Delivery (Weeks 12-15)

Biochemical Core: formulate >2 project topics to pursue; review expectations of project proposal; finalize project topic choice and hypothesis
Dissemination: decide on the outreach mode to pursue

Biochemical Core: Develop project proposals; submit for peer review
Dissemination: Form outreach groups and review expectations
Grant/MAP: develop drafts of outreach work and collect feedback from other group members
Teach: survey Chem102 students and develop lesson plan

Biochemical Core: revise and finalize project
Dissemination:
Grant: submit written public correspondence and defend proposal in front of grant review panel
MAP: deposit MAP article to website
Teach: deliver 15 min lesson to Chem102 students

Examples of Public Sharing

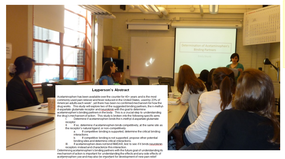


Figure 1. A student doing grant extension is presenting her proposal in front of a grant review panel composed of classmates

Distribution of students across the three content sharing options

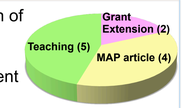
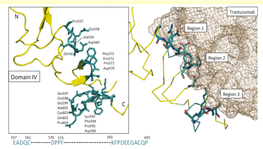
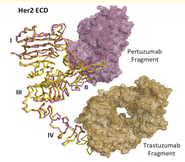


Figure 2. Sample figures from a MAP article on Her2 positive breast carcinoma Other diseases covered by the students included Alzheimer's disease, sickle cell disease and phenylketonuria



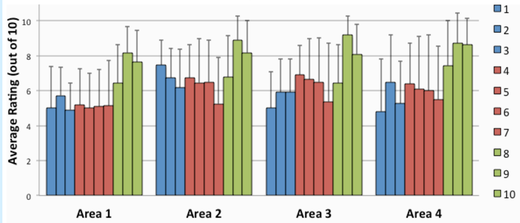


Human epidermal growth factor receptor 2 (Her2) and Breast Carcinoma A. Residues in binding regions of Her2 domain IV with monoclonal antibody fragment of Trastuzumab. (Cho et al., 2003; Adapted from PDB 1N8Z) **B.** Binding of monoclonal antibodies Pertuzumab and Trastuzumab to human Her2 extracellular domain. (PDB 1N8Z, 1S78)

Figure 3. Snapshots from "Teach for Chem102" lessons Biochemistry II students demonstrating a blood clotting cascade with audience members (left) and teaching about the role of serotonin in the gut and its implications in gastrointestinal disorders (right).

Results

IMPACT ON STUDENT INTEREST, CONTENT LEARNING & SKILL DEVELOPMENT



Self-Assessment Areas
1. In your developing further interest in biochemistry (i.e. motivation to learn more about it)
2. In acquiring new biochemical knowledge
3. In acquiring skills to be a more successful and effective independent learner in the field of biochemistry
4. In acquiring skills to be a more successful and effective communicator of biochemical concepts

Figure 4. Comparison of the impact of various classroom tools across four student self-assessment areas

In-class Tools
1. PowerPoint lecture slides
2. In-class worksheets
3. Clicker questions

Outside Class Tools
4. Problem sets
5. Optional study problems
6. Supplemental resources
7. Office hour study groups

Bridging/Scaffolding Tools
8. Office hour/in-class individual discussions with professor
9. Independent project proposal/content work
10. Independent project public sharing

PUBLIC IMPACT:

Grant Proposal Extension

- For this first implementation of the project the written piece of the grant proposal addressed to the general audience was not made public. However, typically all current grants require a layman's abstract shared with the public through grant websites or directly with the benefactors, while letters to senators and news releases are considered as influential contributions that raise public awareness and help in policy decisions.
- The oral defense in front of the 'Grant Review Panel' was very effective in facilitating the transfer of the information obtained by a single student throughout the semester to the entire class in 15 minutes.

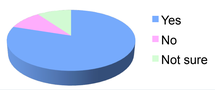
Molecular Anatomy Project (MAP) Article

- All articles contributed to MAP are made publically available on www.map.rcsb.org after a formal review process established by the PDB.
- PDB does not yet have a formal tracking of how many hits the website or individual articles have received for this project, however a similar PDB project site the Molecule of the Month (MOM) that started 13 years ago now gets thousands of page views (e.g. the hemoglobin feature was viewed >34000 times by 2012).

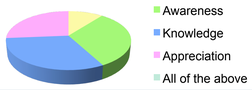
"Teach for Chem102" Lesson

- Feedback from a post-lesson questionnaire shows encouraging learning gains by Chem102 students.
- An overwhelming majority indicated that the lessons at least moderately enhanced their learning and understanding of topics in Chem102, that the topics had some relevance to their life, and thought that other non-science majors would benefit from them.

Do you think the presents were easy to follow/accessible?



What did you gain the most from the presentations?



Sample Student Reflections after Completion of Public Sharing

Grant Extension Student

"The process of coming up with a research proposal and writing a NIH grant was exciting to me, because it was a look into what I hope to be doing in my future. It also solidified my goals of going to graduate school and pursuing a career in scientific research. By the time I finished, I felt proud of the body of work I had accumulated, so I also enjoyed presenting to my peers as a grant review board."

MAP Project Student

"I have never worked on something like the MAP project before. The prospect that my work would reach a broader audience than just my professor and classmates stimulated me to think about my work in different ways than usual. I enjoyed thinking about ways to present information that would draw people in as well as clearly present scientific ideas. I felt much more purpose and responsibility in the final presentation of my work than I have in many other assignments."

"Teach for Chem102" Student

"I really enjoyed the independent project, and especially the outreach portion where I got to teach Chem102 students. I loved the fact that we got to think about what were some of the relevant biochemical problems seen in the news today and use the knowledge we learned in class to create experiments about these hypothesis. Not only this but we got to impart what we learned to other students and make them more knowledgeable about the subject of our interest."

Collaborator Feedback

Prof. Paul Reisberg (Chem102 instructor): "Overall, the students were positive about the presentations for several reasons. They learned interesting material they wouldn't have otherwise. They get to connect with "real" biochemistry and find the gap is not as giant as they may have feared. It legitimatizes what they learned (the class is not Baby Chem as many believed entering the course). I thought the whole experience went very well and would like to repeat it in the future."

Dr. Shuchismita Dutta (Initiator of MAP, Rutgers University): "The students were very enthusiastic about the project and actively communicated with Dr. Vardar-Ulu and me in order to ensure that they completed their assignment well and in a timely manner. About three weeks prior to the final submission date the students put up their reports on the MAP website and got feedback from their peers and from both Dr. Vardar-Ulu and me. One of the students got really motivated by looking at the quality of her classmate's work and made significant improvements to her paper and figures before the final submission deadline. This was a great outcome of the course design. Dr. Vardar-Ulu and I have since spoken about trying this again with some modifications."

Conclusions

- The collective feedback from students, audiences, and experts for incorporating public sharing of classroom biochemistry content into course expectations was substantially positive.
- The bridging/scaffolding tools that were the backbone of the independent project consistently had the greatest impact across all four assessment areas (interest, knowledge, independent learning, communication of understanding) with public sharing rating similarly to the proposal/ content work.
- Our approach illustrates not only the meaningful and impactful ways in which upper-level biochemistry students can relay their respective investigated content of their independent projects to a diverse audience, but also exemplifies how the manner of communication can be tailored to individual students' strengths, skills and interests.
- This public sharing model can be easily integrated into any undergraduate upper-level biochemistry course with an existing independent research component and would be a valuable addition.

Future Directions

- To leverage the web platform to disseminate all the written public sharing components of this project
- To expand the "Teach for Chem102" option to the more encompassing "Teach the Public" initiative: a form of student-led public engagement modeled after the high impact TED Talks
- To incorporate a modified version of this public sharing model into an existing introductory undergraduate biochemistry course

Acknowledgements

We would like to give a very special thank you to Prof. Paul Reisberg and Dr. Shuchismitta Dutta for their collaboration in our public sharing initiative.

References

S. Dutta, C. Zardecki, D. S. Goodsell and H. M. Berman. J. Appl. Cryst. (2010). 43, 1224-1229 [doi: 10.1107/S002188981002371X] Promoting a structural view of biology for varied audiences: an overview of RCSB PDB resources and experiences.