Looking at Genetic Literacy, Course and Curricular Design in MCDB - Summary Report
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Summary: The primary goal of this project, and my current biology education research efforts, is to characterize "the extent to which the topics and skills taught in lower division courses are relevant to upper division courses." My initial strategy was "to survey MCDB faculty for their opinions on the core concepts, facts, and skills that they believe students should have acquired in the early MCDB required course sequence (the “core”)." I began by sending such a question to members of the biology education research community, but that produced a disappointing response. At the same time, I have been considering the various forces driving course and curriculum design and educational outcomes at the departmental and campus levels. At this point in time, departments are not explicitly required to report on objective measures of student learning outcomes on a regular basis, nor are they given access to the resources needed to generate such reports or institute course / curricular redesign efforts in cases where learning outcomes do not meet expectations.

In that light, I revised the project so that, while true to its original aims, it has morphed in important ways. MCDB 4650 Developmental Biology is the last of the five courses MCDB majors are required to take, coming after the introductory course (MCDB 1150), genetics (MCDB 2150), and the cell and molecular biology course sequence (MCDB 3135/3145). In past studies of student learning outcomes with Melanie Cooper's group at Michigan State University (e.g. Klymkowsky et al., 2016; Williams et al., 2015), we have used beSocratic, "a formative assessment system forfree-form responses". While not available for the Spring 2019 version of MCDB 4650, the rebuild project has progressed and we were able to use beSocratic in the Spring 2020 version of the course, at no cost to students.[1] The availability of beSocratic offered the possibility to capture data on the types of resources students called on when explaining various molecular and cellular events and processes relevant to developing systems. Analysis of student responses to beSocratic activities can reveal i) how well the students' previous courses prepared them to recognize and apply concepts relevant to developmental processes and ii) provide the instructor of the developmental biology course with insights into concepts that need to be revisited and practiced with appropriate coaching. Twenty one beSocratic activities (each from 5 to 14 pages in length) were incorporated into the Spring 2020 version of the MCDB 4650 course. While the overall design of the developmental biology course did not change significantly from the first version (in 2019), the availability of beSocratic feedback impacted the 2020 course, and as student responses are analyzed are expected to lead to significant changes in the overall presentation of topics in the first third of the course in 2021.

Describe the challenge you addressed in your department with this project. The primary challenge of the project is to insure that earlier courses prepare students for later courses, as well as their post-graduation careers. More specifically, a practical challenge was the "on the fly" analysis of student responses while preparing materials for the next class presentation. After the first few class periods, in the which the activities were primarily aimed at providing a base line of what students were already familiar with, I changed my strategy so that the beSocratic activities were more focussed on reviewing materials presented in the previous class; responses to the activities were then included into the start of the next class. In some cases, these review sessions revealed that materials previously presented (either in previous courses or in the previous class period) had not become useable to students, that is, their ability to draw on them when building explanatory models of specific developmental processes. While this had a direct impact on the course, "slowing us down" somewhat, my feeling (not having analyzed associated data in an objective manner) was that student understanding of key concepts and processes improved steadily as the semester progressed. That said, there was a significant impact of COVID-19 on in class instruction, and the need to transfer to Zoom classes without adequate preparation, training or support. One obvious factor that emerged from this experience, at least for me, was the need for a "co-pilot" to monitor the chat window and to facilitate "background" conversations.[2]

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[1] The system has been rewritten from Silverlight to HTML5, a project funded by students in chemistry courses at Michigan State University.

[2] Described here: Going virtual without a net https://bioliteracy.blog/2020/03/19/going-virtual-without-a-net/

That said, it is clear from a preliminary analysis of students' beSocratic responses, that a certain level of course reorganization is needed. Specifically, a recurrent phenomena is the generation of threshold responses to signaling gradients of various types.[3] In particular, it became clear that the idea of the molecular mechanisms associated with response on-set and saturation, key for understanding signaling thresholds, as well as the molecular interactions between transcription factors and gene expression were not always easily grasped by students. To address these issues, these topics will be incorporated into materials presented earlier in the course, and returned to more explicitly as the course proceeds.

The final challenges of the project are i) to complete the analysis of student responses, and based on those responses consider how the beSocratic activities can be improved for the 2021 course, ii) to make a short presentation to the MCDB faculty and the DBER group on the resources students use when considering cellular and molecular mechanisms in developing contexts, and iii) finally, to write up both one or more blog posts and a description of students responses for publication in a peer reviewed journal. I expect the data and lessons learned from this work will inform the revised NSF proposal I am planning to submit in December 2020.

Describe desired result. The desired results were a better understanding of the resources, in terms of molecular, cellular, and genetic concepts, that students can apply to their analysis of complex systems, such as those that occur during embryonic development. When the analysis is completed, I plan to present the observations to the MCDB faculty in the hope that it will help spark a reconsideration of what content is presented, and how students are asked to use it in the four core courses that MCDB students are required to take before MCDB 4650. A secondary, and more immediate resultwill be the revision of the order in which particular ideas are presented within MCDB 4650 (see above).

Describe the project. What did you do? I built 21 beSocratic activities (all of which can be downloaded together with suggested responses) from the MCDB 4650 course web site (http://virtuallaboratory.colorado.edu/DEVO@CU/1. While I had originally planned to hire an undergraduate to help me analyze student responses, the impact of the COVI D-19 pandemic has put these plans on hold. I am currently downloading all student responses and have begun the analysis of particular activities associated with the nature of the gene, the regulation of gene expression, and the behavior of genetic networks capable of producing alternative outcomes - with a particular focus on the system described in detail by Saka and Smith (2007).

Describe the outcome. What worked, what didn't work, lessons learned. What "worked" is a difficult question to answer, as it depends on an objective, research-based evaluation of student responses, and in the optimal situation, a third party evaluations of student thinking. I will say, editorially, that all too often what "works" is based on instructor or student feelings rather an objective evidence. In part this is due to the limited resources available through the University for this type of analysis, and the general lack of importance given to the objective characterization of student learning outcomes for specific courses and curricula as a whole.

That said, the primary lesson learned is that students do not appear to emerge from the four preceding courses with a confident command of many underlying concepts and their application. Certainly recurrent and critical processes need to be introduced into the course earlier, and more time spent on their application in various settings. Students need more practice applying ideas presented.

Reflect on your experience in the Faculty Fellows program and working on your project. My primary conclusion is that the Faculty Fellow program could be significantly more impactful if it addressed educational issues that departments deemed important to address. That departments need to explicitly address students educational outcomes, based on objective metrics, needs to be a priority for the campus, and so requires explicit and significant administrative emphasis, emphasis that directly incentivizes departments to take undergraduate outcomes seriously, and provides them with the resources needed to improve course design, delivery, and curricular (as opposed to individual course) outcomes.

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[3] Ideas that were outlined in the series of blog posts I generated before teaching MCDB 4560 for the first time in 2019 - see https://bioliteracy.blog/on-devo/

If appropriate, please include other artifacts and visuals: All data from the project will be described in a series of (bioliteracy) blog posts, a report to MCDB faculty, and one or two manuscripts to be submitted for publication in a peer reviewed journal sometime within the next year or so.

Currently, the beSocratic activities and suggested responses are available through the MCDB 4650 course web site, (see: http://virtuallaboratorv.colorado.edU/DEVO@CU/T Anonymized student responses are available to interested parties for research purposes.

Literature cited

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