Enhancing Engineering Student Learning in Foundational STEM Courses of Biology, Chemistry, Mathematics, and Physics: Transforming the Faculty Culture

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Executive Summary of NSF-IUSE grant:

Enhancing Student Success in Biology, Chemistry, Physics and Mathematics by Transforming the Faculty Culture

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Introduction

We report preliminary and ongoing efforts of an NSF-supported multidisciplinary program to enhance learning in foundational STEM courses taken by virtually all engineering majors. Two foundational assumptions run through our efforts: (1) the incorporation of active learning modalities supports increased student learning and student success; and (2) the willingness to incorporate these changes in teaching by faculty requires both a supportive local departmental culture as well engagement by upper level administrators. Thus we support faculty changes in their use of research-based instructional techniques focusing on STEM student learning and success in lower division courses and support cultural changes in the STEM departments fomenting a new respect for the central role of teaching excellence in enhancing student learning and success. We describe briefly several of our efforts which are guided by a straightforward theory of change and carried out within the departments of Biology, Chemistry, Mathematics, and Physics.

Teaching and Learning Liaisons

To support faculty who are new to active learning, the department heads appoint two Teaching and Learning Liaisons (TLLs) in each department. The TLLs are provided with customized training by the Center for Teaching and Learning and act as liaisons to the Center activities as well as providing direct support to faculty members who are adopting new research-based instructional strategies into their courses. These new efforts range from the use of just in time instruction to a completely flipped classroom. The TLLs from the four departments meet regularly to exchange experiences and to discuss teaching matters in a scholarly way. In some sense the TLLs are analogous to the Departmental Action Teams of the American Association of Universities (AAU) STEM undergraduate education initiative. The TLL efforts are considered a significant service load and may result in a reduced teaching load.

Like many Research I universities, the University of Cincinnati has non-tenure track appointment for those whose central role is teaching. These are called professor-educator lines and these faculty play an important role in changing the teaching culture in a department because of their expertise in the pedagogical area. The departmental TLLs, including several professor-educator faculty, as well as others in a department organize regularly scheduled "Teaching and Learning Lunches" which provide an informal forum for topical discussions of teaching matters with topics that vary by department. Both internal and external speakers contribute. Since these topics focus on an individual department, local data is available and transparent which is a key to engaging the full faculty. Attendance at these lunches across all of the departments exceeded 65%, indicating faculty engagement and perhaps the beginning of a faculty culture that values teaching.

Institutional Changes

Beyond individual faculty changes, the Provost, Dean, and Department levels have initiated several actions. The Provost has significantly increased faculty development funds including those for the development of teaching excellence. The Dean of the College of Arts and Science has asked for evidence beyond the usual student teaching evaluations to be included in all tenure and promotion dossiers. At the departmental level, as we discuss in the next section, we find increased faculty engagement, a dramatically increased use of learning assistants in the classroom, and provide below a specific example of enhanced student learning in Physics, where changing to a flipped classroom resulted in a dramatic decrease in DWF rates. The support and interest of the Provost, the Dean, and the Department Heads are key elements that are required to achieve a sustainable change in the faculty culture with respect to teaching excellence.

Two Specific Outcomes

1. Use of Learning Assistants (LA's): One notable change across the departments is the use of Learning Assistants in the classroom. We have adapted the CU-Boulder model of using undergraduates who have done well in the course to help facilitate in-class group efforts To become a LA, a student is required to take a Learning Assistant Seminar Course crafted so that he/she understands both the underlying pedagogical issues as well as some practical issues within an active classroom. The usage of LA's has increased from a handful to more than 41 LA's for Spring Semester of 2016, a measure of number of faculty using research based instructional strategies in their classrooms.

2. Algebra-based Physics: This first year course has a long history of high DWF (grades of D or F or W for withdrawal) exceeding 30% before one of the con-authors

(LMS) instituted several changes including flipping the class. As the graph below

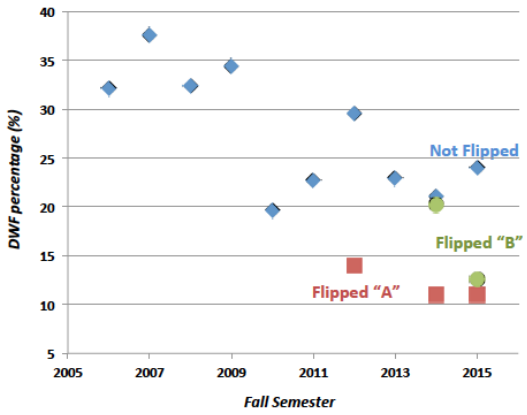

Figure 3: The DWF rate for algebra-based Physics. Note changes starting in 2012 and differences among instructors.

illustrates, flipping the classroom and using an adaptive tutorial (ALEKS) made significant differences. The most recent DWF rate of 10% or 11% for the two instructors using the flipped classroom model probably represents a realistic minimum. The results for three different instructors (color-coded including one who did not flip the class) show quite different results even though common or block exams were used in all three sections. The flipped classroom always had the lowest DWF rate, but not that the "flipped B" instructor (green) achieved lower DWF rates the second time he taught the course suggesting that the use of the flipped classroom may take some experience - even with substantial help—to implement most effectively.

Summary

We have provided here an executive summary of several efforts to transform the faculty culture with respect to teaching and with the result that student achievement and success has been strongly enhanced. These preliminary results reflect the efforts of individual faculty members who have benefited from the support of Teaching and Learning Liaisons and the vertical integration of support from department heads, the Dean and the Provost.

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