Report of the Division of Science Curriculum Task Force

May, 2021

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Introduction

The task force, composed of faculty and students from the Division of Science, was appointed by Bulbul Chakraborty, head of the Division, in February, 2021 to examine issues in the Division related to student retention and success, with particular emphasis on diversity, equity and inclusion. The task force has had six meetings to date and anticipates meeting through the 2021-22 academic year. The Lead UDR representative, Andrew Baxter, is graduating in May and will be replaced by Liz Gong. Our initial meetings focused on pinpointing obstacles to student success and retention, particularly in introductory courses. As common themes began to emerge, we sought to develop a set of recommendations aimed at remedying perceived flaws and making the Division more hospitable to a population of students from diverse backgrounds and levels of preparation. This report discusses the major issues that we have identified to date and offers recommendations for addressing them.

We also take note of the activities of the faculty learning community, the *Justice League*, which has been actively discussing issues of curriculum and pedagogy for the past several years, leading to significant experiments and improvements in a number of areas. This group has expanded its membership each year, and now includes about 20 STEM faculty as well as 3 social science faculty.

We thank Keith Merrill and Becci Torrey of the Mathematics Department for an enlightening presentation to the task force on specifications grading.

I. Differences in Mathematics Preparation

Perhaps the most challenging aspect of introductory and core STEM courses at Brandeis, for both students and faculty, is the enormous range of quantitative skills with which students enter the university. This disparity makes it difficult for faculty to know what to assume about their students' capabilities and to aim the material at an appropriate level. Students find it problematic to compete with better prepared classmates, to know before enrolling in a course if their preparation is adequate, and to find ways to improve their quantitative skills. The university and several departments have made efforts to address this situation, and there are useful resources on the internet, but student awareness and usage of these opportunities has thus far been limited. We note as examples the Quantitative Skills Center (QSC), the Physics Department's Resource Room, and online resources such as Paul's Online Math Problems. The task force feels that it is essential to (self-)assess student quantitative skills at an early stage, provide students with reliable information about the expected skill set required for each course, and afford students access to resources that will allow them to address any deficits in their skills *before* enrolling in a course.

Recommendation I.1: Each introductory STEM course should post on the web a list of quantitative skills that students will need in order to succeed in the course. The list should be accompanied by a set of representative problems that students can use to assess whether they need to improve their skills before taking the course. Ideally the skills list and representative problems should be drawn from a standardized, more comprehensive division-wide list rather than being generated entirely *de novo* for each course. This will help emphasize the continuity of required skills and reduce confusion. Students seeking to enhance their skills should be directed to a central resource.

Recommendation I.2: An instrument should be developed for accepted students to assess their quantitative skills before pre-registration for first-year classes. Just as we assess all students' writing skills, this evaluation should ideally be mandatory, as an aid to advising and self-awareness.

Recommendation I.3: An online repository of procedurally-generated questions for practicing basic mathematical skills should be identified or locally developed and made available to all students. Several free resources are currently available, but it would be worth devoting some effort and funding to evaluating these and to exploring the possibility of generating our own.

Recommendation I.4: We should undertake an evaluation of the QSC, looking at usage, effectiveness and other issues, and consider linking it to other departmentally-based programs that offer drop-in office hours staffed by graduate and/or undergraduate students.

Recommendation I.5: Training of TAs should include instruction on how to recognize student difficulties caused by a lack of quantitative skills and how to guide students toward seeking appropriate help.

Recommendation I.6: A summary of available resources should be regularly provided to all faculty teaching courses requiring quantitative skills. Students should be made aware of the existence and availability of helpful resources early and often. We propose some mentioning of the QSC and the central repository during orientation, and the addition of a (short) blurb to the boilerplate syllabus template provided by the University reminding students of the various resources available. Faculty members should also remind their class often of where they can find help for the quantitative skills necessary to be successful in the course.

II. High Stakes Grading

One issue that has emerged in our recent experiences with the challenges of remote learning and assessment, as well as in discussions within the Justice League and in the pedagogical literature is whether evaluating students primarily on the basis of a small number of tests – typically two or three "hour" exams and a final – is an effective way of promoting and assessing student learning. Much evidence suggests that more frequent, lower-stakes assessments, with the possibility of repeating an assessment until mastery of the material is demonstrated, may result in greater retention of material and higher levels of student satisfaction, as well as lessening the correlation between prior preparation and grades, thereby promoting equity. While the results obtained thus far with "specifications grading" in several courses have been encouraging, we recognize that more data and systematic assessment of this approach are needed and that creating the necessary test items and grading multiple tests, particularly if students are allowed to take tests multiple times, will be extremely labor-intensive for faculty and TAs.

Recommendation II.1: Explore more widespread introduction of specifications grading and similar approaches in introductory classes, seeking where possible to obtain data, e.g., by comparison with results from earlier "high-stakes" versions of the course, that allow for meaningful assessment of the value of the new approach. This is likely to require significant resources from the university or external sources.

Recommendation II.2: Seek funding, e.g., from Teaching Innovation Grants, for graduate students to evaluate and compile test items from existing sources and/or to develop platforms and test items tailored specifically for Brandeis courses.

Recommendation II.3: Explore options for automated grading of skills-based assessments.

III. Student Climate

At Brandeis, as at almost all elite universities, introductory STEM courses are regarded by many students as "weed-out courses" whose primary function is to whittle down the number of students who are able reach their educational goals to some target. This perception is especially acute among, though not limited to, our premedical students. A related issue is a toxic climate of competition and cliquishness, which results in a number of students, often from underrepresented groups, feeling (and being) excluded from study groups or other social interactions that can make the STEM experience more manageable and palatable. Even a program like STEM Posse, which was designed to promote inclusion of traditionally excluded students, is seen by some as one more clique, since it is limited to 10 students per class, who form tight ties with one another even before arriving at Brandeis. The Galaxy program was developed in large measure to address these issues by providing a cohort, supportive discussions of issues such as imposter syndrome, and a near-peer mentor to each participant. It has evolved and expanded to over 100 first-year students and is now available to any entering STEM-interested student. Initial data on retention in STEM majors for Galaxy students are extremely encouraging.

Recommendation III.1: Expand, continue to enhance, and provide sustainable funding for the Galaxy program, which is currently funded by an Inclusive Excellence grant from HHMI.

Recommendation III.2: Explore pedagogical innovations, such as assigning students to study groups or creating team-building class activities, to minimize cliquishness and exclusion.

IV. Resources

Several of the above recommendations require little or no funding, though they do place additional calls on another scarce resource: faculty time. Others will need financial as well as human resources. Several of our most valuable programs, such as STEM Posse, Galaxy, and the pedagogical partnership initiative, have been made possible by grants from external sources, notably HHMI and AAU. Internal funding from the Center for Teaching and Learning/Provost Teaching Innovation Fund has been another source of support for curricular and pedagogical innovation. It may be possible to reconfigure or reallocate some existing resources to more effectively address the needs of our students.

Recommendation IV.1: Identify and develop proposals for potential sources of external funding for some of the initiatives recommended above. The proposal currently being developed for the HHMI Driving Change program is one such vehicle. Other sources to be explored include NSF education and diversity programs, the AAU STEM Initiative, and private foundations (STEM Posse has received substantial funding from both the Carnegie Corporation and the Arthur Vining Davis Foundations).

Recommendation IV.2: Work with Institutional Advancement to find potential donors for sustained support and expansion of Galaxy and the QSC.

Recommendation IV.3: Create an inventory of existing resources devoted to improving students' quantitative skills (QSC, BUGS, departmental resource rooms, …) and assess whether resources might more profitably be linked, restructured or reallocated.

V. Assessment

None of the recommendations above is guaranteed to "solve the problem." We recognize the need to assess the impact of any changes on student learning as well as on diversity, equity and inclusion in STEM. We also acknowledge, as have many others, the inadequacy of student course evaluations as currently constructed to provide meaningful assessment of the quality and effectiveness of teaching. We therefore urge that regular evaluations be conducted of any innovations that are introduced, and that efforts be made to improve current assessment tools.

Recommendation V.1: Conduct annual evaluations, through focus groups and, where appropriate, survey instruments of the effectiveness of new and existing pedagogical approaches.

Recommendation V.2: Compile and analyze a multiyear database of statistics on student performance in STEM courses, rates of continuation to higher level courses, etc., broken down according to such categories as gender, race and Pell grant eligibility.

Recommendation V.3: Pursue funding from the AAU STEM Network Department Demonstration Project on Teaching Evaluation (proposal currently being developed by several members of the Justice League) and other sources to strengthen our ability to meaningfully assess teaching effectiveness.