

# Curriculum Development

## Leading Change: Curriculum Reform in Graduate Education in the Biomedical Sciences<sup>S</sup>

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### Abstract

The Division of Graduate Medical Sciences at the Boston University School of Medicine houses numerous dynamic graduate programs. Doctoral students began their studies with laboratory rotations and classroom training in a variety of fundamental disciplines. Importantly, with 15 unique pathways of admission to these doctoral programs, there were also 15 unique curricula. Departments and programs offered courses independently, and students participated in curricula that were overlapping combinations of these courses. This system created curricula that were not coordinated and that had redundant course content as well as content gaps. A partnership of key stakeholders began a curriculum reform process to completely restructure doc-

toral education at the Boston University School of Medicine. The key pedagogical goals, objectives, and elements designed into the new curriculum through this reform process created a curriculum designed to foster the interdisciplinary thinking that students are ultimately asked to utilize in their research endeavors. We implemented comprehensive student and peer evaluation of the new Foundations in Biomedical Sciences integrated curriculum to assess the new curriculum. Furthermore, we detail how this process served as a gateway toward creating a more fully integrated graduate experience, under the umbrella of the Program in Biomedical Sciences. © 2015 by The International Union of Biochemistry and Molecular Biology, 00:000–000, 2015.

**Keywords:** graduate education; curriculum reform; biomedical science; interdisciplinary; doctoral education

### Introduction

Doctoral education has been based on an apprentice model in the biological sciences for many decades; however, even given this practical emphasis on the applied science, it has still been noted that, “We should focus less on the production of PhDs and more on the production of scientists. They are not necessarily the same thing” [1]. Certainly, the apprentice model does run the risk of pro-

ducing graduates with highly specialized knowledge about their area of expertise with little appreciation of the context of their work [2]. Moreover, there has been a national call toward moving our scientific educational programs in an interdisciplinary direction, and much of the initial focus of these efforts has been at the undergraduate level [3, 4]. However, a shifting funding landscape toward interdisciplinary and translational science [5] has helped to catalyze discussions on teaching science as an integrated process of inquiry that is less concerned with discipline-specific facts [6, 7].

As this educational movement has filtered into the arena of graduate education, a number of proposals have been put forth from encouraging curriculum fellows to develop integrated graduate courses [8, 9] to developing graduate-level laboratory courses [10]. What these interventions have in common is a focus on developing interdisciplinary educational opportunities that apply to the research paradigm in which graduate students will be embedded [11–13].

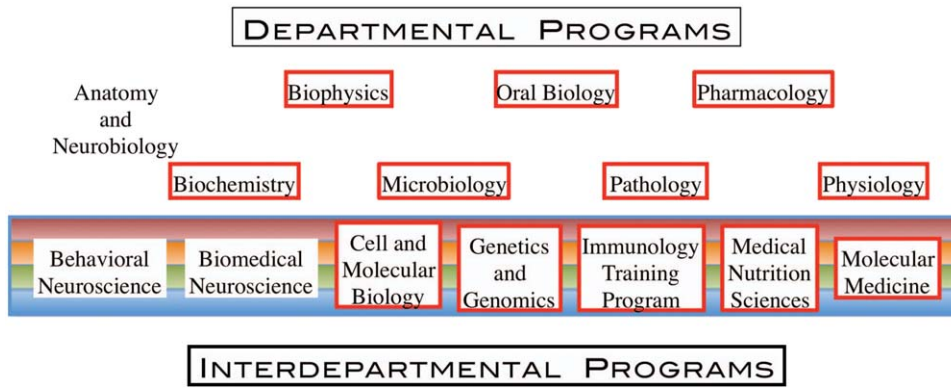
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**FIG 1** Graduate programs affected by curricular overlap. Highlighted programs shared elements of their curricula, and individual program-specific courses tended to experience convergent evolution in content.

In many ways, conceiving of these differing approaches to creating integrated curricula at the graduate level is the easy part. Many scientists do believe in the foundational concept that an integrated curriculum is an important goal in graduate education, but driving curriculum change and getting to consensus on the shape of these initiatives can be the most challenging part of the process [14]. In this essay, we share our approach, based on the literature from the management sciences, to create an integrated curriculum structure that fit the goals of our institution.

## Graduate Studies at Boston University School of Medicine

The Boston University’s Division of Graduate Medical Sciences is the home for graduate education in the School of Medicine. More than 900 students, both Master’s and PhD students, pursue their studies in 33 fields. On the doctoral side, students engage in cutting-edge research on a wide range of topics that are directly related to improving human health and treatment of disease. Before transitioning to full-time thesis research, our students focus their efforts on their research rotations as well as on their classroom studies. Prior to the curriculum reform described here, our students were entering through multiple pathways of admission and had multiple programs of study with partial overlap and a number of gaps as well (Fig. 1). Rather than try to retrofit the curricula to the complex and evolving graduate program structure, it became necessary to consider a dramatic change in curricular structure to address these structural issues. To embark on this journey, we needed to create a culture that encouraged our community to adopt a new educational paradigm. Toward this end, we implemented the process for leading change, a system born out of the business world [15]. The guiding principles of the Kotter method focus on helping organizations to take advantage of windows of opportunity by creating an adaptable culture of change. In this culture, the necessity

of the change is emphasized, as is the engagement of organization members impacted by the change. Thus, it focuses on the development of an environment in which people become invested in working together to bring about change. We also considered the process of curriculum development in medical education [16]. In the Kern model, the process begins with problem identification and needs assessment. It then focuses on the curriculum design as it is related to the learning objectives that are the ultimate goals of the curriculum and the teaching pedagogies that will be used in the execution. It does not address the difficult reality of implementing change when there is already an existing curriculum in place that the faculty have devoted time, effort, and emotion into delivering, and when

### BOX 1

#### Comparison of the key steps in Kern’s Curriculum Development Method and Kotter’s Leading Change Method

Kern’s Curriculum Development	Kotter’s Leading Change
1. Problem Identification and General Needs Assessment	1. Create urgency
2. Targeted Needs Assessment	2. Form a powerful coalition
3. Goals and Objectives	3. Create a vision for change
4. Educational Strategies	4. Communicate the vision
5. Implementation	5. Remove the obstacles
6. Evaluation and Feedback	6. Create short-term wins
	7. Build on the change
	8. Anchor the changes in institutional culture

**TABLE 1**

*Stakeholders engaged in curriculum reform process*

<i>Individual or group</i>	<i>Rationale for inclusion in process</i>
Associate Provost of Graduate Medical Sciences	As a senior institutional administrative leader for graduate education, the Associate Provost could initiate the process and empower the stakeholders to begin the curriculum design process.
Department Chairs	Many of the graduate programs were affiliated with Departments, so Chairs were invested in how the graduate curriculum was organized.
Graduate Program Directors	Some of the Program Directors worked closely with Department Chairs on graduate training initiatives, but others led interdepartmental graduate programs. Both groups were included as Program Directors were responsible for organizing training paradigms for each individual PhD program.
Course Directors	These individuals taught courses that were utilized in the former curriculum structure by one or more graduate programs. The content of these courses was under consideration for reorganization into the Foundations module structure.
Faculty	Faculty were engaged in delivering content in the old curriculum and would be called on for the new curriculum as well, so they were included to give fresh perspective following the initial working group discussions. In addition, to help liaise between Departments, a faculty member invested in the integration process was recruited to the final committee.
Students	Senior PhD students who had taken the previous courses and then entered laboratories were engaged in the process to ensure that a student perspective on preparedness for thesis work was included.
Registrar	Because we were designing a modular schedule that did not fall within typical semester limits, we needed to engage the registrar to work through the details of making this possible.
Academic Policy Committee	This committee is responsible for reviewing and ultimately approving courses before they can be officially offered to students, and they assisted with advance feedback on the courses to facilitate their expeditious review.
Room and resource scheduling	Given the consolidation of independently operating courses and the larger resulting student cohort size, we needed the assistance of this office to ensure facilities needs could be met for the new curriculum.

there is limited time to spend on curricular initiatives. Kotter’s method also includes additional steps not present in Kern’s model that aim to engage stakeholders. For these reasons, we felt that Kotter’s more encompassing process took into account both the personnel and intellectual aspects of curriculum reform (Box 1). In this case study, we present the application of the leading change method to the academic process of curriculum development.

## Leading Change in Graduate Curriculum Reform

At the Boston University School of Medicine, many critical stakeholders were involved in the curriculum reform including the Associate Provost for the Division of Graduate

Medical Sciences (Associate Provost), a senior administrator at the institution who spearheaded the effort; all basic science Department Chairs; all faculty directors of departmental or interdepartmental education programs (Program Directors; see Fig. 1); faculty involved in the institution’s teaching effort including Course Directors; Ph.D. students; and key administrative personnel including the registrar and room and resource scheduling (Table I).

Kotter’s process to leading change begins with creating urgency (Step 1, Box 2). Urgency was conveyed by the Associate Provost (L.H.) who documented the loss of talented prospective students to institutions with integrated curricula, as well as the existence of curricular redundancy and an uneven level of instruction in courses offered by different departments. Calling attention to these educational needs, the Associate Provost assembled the powerful



**BOX 2**

***Kotter's Leading Change in Graduate Curriculum Reform***

1. Create urgency

- Document students choosing other graduate schools based on the presence of integrated curriculum.
- Identify areas of curricular redundancy.

2. Form a powerful coalition

- Catalyze the curriculum reform with the support of the Associate Provost of Graduate Medical Sciences.
- Involve stakeholders from each of the affected programs and departments.

3. Create a vision for change

- Charge Integrated Curriculum Committee to determine core values for curricular reform.

4. Communicate the vision

- Reach out to key stakeholders (e.g., Department Chairs and Program Directors) individually.
- Create opportunities to share the curriculum vision publically through retreats, faculty meetings, and web sites.

5. Remove the obstacles

- Open dialog to help stakeholders embrace change.

6. Create short term wins

- Recognition for incremental achievements such as creation of curriculum outline, identification of module directors, and completion of first year.

7. Build on the change

- Empower module directors to begin detailed course design.

8. Anchor the changes in institutional culture

- Move to formally approve courses.
- Create curriculum oversight body in Foundations in Biomedical Sciences Steering Committee.
- Implement standard student and peer course evaluation processes

The numbered steps correspond to Kotter's method for leading change, and the bullet points describe their applications in a graduate curriculum reform setting.

coalition of Kotter's second step (Step 2, Box 2) and empowered them to design a curriculum that addressed these needs in a way that reflected the unique requirements of our institution and the participating programs. Notably, the powerful coalition was given a great deal of

freedom in designing this curriculum in that there were no preconceived ideas or models for the integrated curriculum, which facilitated a bottom-up design process. The coalition began with a partnership involving stakeholders (Table I) from each of the affected 15 programs. Because many of the existing programs were also affiliated with departments, the Department Chairs were also included in early discussions and were involved in choosing representatives for the Integrated Curriculum Working Group (ICWG). The ICWG was ultimately composed of all Program Directors and the Course Directors of core courses taken by students from multiple graduate programs and courses whose content was to be incorporated into the new curriculum. The leader of this working group (S.D.) was both a Program Director and Course Director for graduate-level courses. The Associate Provost then charged the ICWG with Kotter's third step, creating a vision for change (Step 3, Box 2). As this process of defining the core values of the curriculum reform grew out of discussions from all of the doctoral programs on campus, the values (Box 3A) and proposed structure (Box 3B) were able to incorporate the needs of the majority (12 of the 15) of the existing programs. The representatives of the programs (3 of the 15) who contributed to the initial discussions but ultimately decided their curriculum needs were too disparate from the core curriculum taking shape to proceed, stepped off of the ICWG.

As the curriculum began to take shape, the Associate Provost convened an official Integrated Curriculum Committee (ICC; Step 3, Box 2). This committee was composed of former ICWG members selected to represent each participating education program, and one additional faculty member with a leadership role in the education mission of

**BOX 3A**

***Core values and goals of the integrated doctoral curriculum***

*What are the goals of moving to an integrated curriculum for first-year students?*

- Encourage students to think in a rigorous and interdisciplinary fashion
- Coordinate content across courses and programs
- Reduce redundancy in course content
- Decrease lecture hours
- Promote collegiality among participating doctoral students
- Compete with peer institutions to recruit prospective students

This box highlights the key principles guiding the design of the modular Foundations in Biomedical Sciences curriculum.



**BOX 3B****Key structural elements of integrated doctoral curriculum**

*What are some important features of the integrated curriculum?*

- A critical thinking component is integrated into each module. Example activities for critical thinking include paper discussions, structural workshops, bioinformatics sessions, and development of lay abstracts.
- Critical thinking activities are carried out in small (6–8 students + 1 faculty member or teaching fellow) breakout groups.
- Each module has a separate course number, exam(s), and grade.
- Each module has two course co-directors from different disciplines who sit on a curriculum steering committee with the other module course directors.
- The core curriculum spans 1.5 semesters; the second half of the spring semester allows students to choose from optional-related offerings including molecular metabolism, physiology of specialized cells, and translational genetics and genomics.
- Students can take program-specific courses beginning with their first semester of study.
- Formalized, anonymous student course evaluations and peer review are standard practice for all modules.
- This structure will provide more trainee teaching opportunities as senior students and postdoctoral fellows are selected through a teaching fellowship program to lead the breakout discussion sections.
- Individual programs can choose to opt into this curriculum.
- Former doctoral courses in Biochemistry, Molecular Biology, Cell Biology, and Advanced Genetics and Genomics are no longer offered in their previous form.
- The general schedule includes three 110-min lectures and one 80-min breakout session per week. The total contact time is 7 hr per week, which replaces a time commitment of 12 hr per week for equivalent course loads in the former curriculum structure.

This box delineates structural elements that support the key principles.

the Biochemistry Department and an investment in the development of an integrated curriculum (K.S.). The ICC was co-chaired by this additional faculty member (K.S.) and the leader of the earlier working group (S.D.). It was thought important to bring in a co-chair with extensive expertise in education, who could bring a fresh perspective

to the committee, and who would act as a liaison to a Department whose teaching investment in the prior curriculum was substantial. The ICC gained three additional stakeholders (Table I), namely, senior graduate students with a previously identified interest in graduate education, who shared their valued perspectives. The Associate Provost's charge to the faculty working on the curriculum was to create a set of foundational and dynamic courses that would serve students' needs in an interdisciplinary fashion. The result of this effort is the curriculum called Foundations in Biomedical Sciences. The curriculum is modular, which is composed of four compulsory sections and a fifth that has three elective options in focused areas of specialization (Fig. 2). The curriculum format is designed to encourage students to think in a rigorous and interdisciplinary fashion, to coordinate content across courses and programs, to decrease lecture hours from previous courses, and to promote collegiality among participating doctoral students. The interdisciplinary nature of the content was also further embedded into the structure of each module by pairing course co-directors from different disciplines for each module (Fig. 2). Each module contains a critical thinking component that occurs in small breakout groups. Literature discussions, structural workshops, bioinformatics sessions, and development of lay abstracts are examples of strategies used during these sessions. In keeping with Kotter's leading change model, this vision was communicated to key stakeholders (Step 4, Box 2), including the Department Chairs, faculty, and students, and the vision was also shared publicly at faculty meetings, through web sites, and at retreats. The planned curriculum was also communicated with key administrative stakeholders (Table I) such as the registrar, the room and resource scheduling office, and the Academic Policy Committee, all of whom played critical roles with respect to the success of this curricular change. Importantly, through each of these channels of communication, there was a mechanism for feedback, both anonymous and open, to the ICC and to the Associate Provost. This process identified potential obstacles that were removed (Step 5, Box 2) through open dialogs. For example, concerns regarding faculty support and time required to design and implement the new curriculum were addressed both publically and during personal discussions between the Associate Provost and Department Chairs. Thus, although the Associate Provost handed over the design process to the stakeholders, she also remained in a position of support to help remove obstacles as they were identified. Along the way, short-term wins were celebrated (Step 6, Box 2), including recognition of incremental achievements such as creation of a curriculum roadmap and identification of course directors. Celebrating these accomplishments involved both social festivities and communication with Department Chairs about the important accomplishments resulting from their faculty members' contributions. With the input of the

## Foundations in Biomedical Sciences: A Core Curriculum for GMS Doctoral Students



**FIG 2**

*Foundations in Biomedical Sciences Modular Integrated Curriculum. The scientific expertise of the core module co-directors is listed in the purple blocks, and below that the curricular demographics and context are described. The green blocks indicate the credits for the Foundations modules, the teal blocks indicate other potential coursework credits, and the red blocks show the semester each course is offered.*

committee, the authors assembled teams of interdisciplinary course directors to spearhead development of the new curriculum, and using Kotter's Step 7, we built on these changes by empowering the course directors to engage in detailed course design (Step 7, Box 2). At this point, we have firmly anchored this curricular approach, from the modular structure to the interdisciplinary approach, in institutional culture (Step 8, Box 2). The former curriculum structure is no longer offered, and incoming students in participating programs are automatically registered for this curriculum as part of their first-year coursework.

The curriculum is now in its fourth year. The students evaluate each module immediately after its completion (sample course evaluation in Supporting Information). These evaluations are systematically assessed as part of an annual peer review of each module, where module directors from the Foundations modules review each other's modules and present their findings to the Steering Committee, composed of all of the module directors and the Associate Provost. Themes that emerged in the free comment boxes of the student evaluations suggest that trainees, including individuals who experienced elements from both the former and new curricular structures, are very satisfied with the challenge and pace of the new curriculum (see Box 4 for representative comments).

From the faculty perspective, program directors appreciate the coordinated structure of the curriculum because they receive timely, holistic feedback on their students' performance throughout the curriculum, which allows for better student support during what can be a challenging academic transition.

The substantial institutional commitment to promoting our curriculum reform was a key ingredient to the success of this initiative, in terms of allowing course directors significant release time to design, implement, and run these complex modular courses as well as mentor teaching fellows with an interest in higher education. Importantly, the creation of mentored teaching opportunities for our senior graduate students and postdoctoral fellows was meaningful not only for their scientific development [17] but also to allow them a professional development opportunity in education that is not as readily available on a medical campus as it might be on an undergraduate campus. The importance of professional development opportunities outside of experimental science has become increasingly essential as the diversity of students' professional goals has come to light [18, 19].

Because the development of the integrated Foundations in Biomedical Sciences curriculum was well supported and faculty member's contributions to this educational initiative were highly valued, we were able to develop a final product that was well received and that became embedded in the

## Student feedback

### BOX 4

- "Overall I really enjoyed the course. It caused us to work really hard and forced us to apply the information presented to us to different problems that we were given. It was challenging, yes, but I feel as though I have learned a lot from it and I hope this class continues for years to come."
- "Comparing this module to last year's course, I think this is a huge improvement. It was very well-organized, the lectures flowed together very smoothly, and the lecturers themselves were excellent at teaching their subjects... Thank you to all of the professors and the course directors for an excellent job."
- "I thoroughly enjoyed both the pace and format of this module, especially using last year's curriculum as a reference point."
- "I'd like to stress that I enjoyed each module, I thought each was well run and was successful in giving first-year students a vital knowledge base that truly is interdisciplinary."
- "I'd like to thank every faculty member and teaching assistants (TA) associated with this course. It has made me think in a different way when approaching my work at the bench, and is making me a more complete researcher."

These student quotes are representative of themes that emerged in response to the comment boxes throughout the course evaluations (see Supporting Information).

institutional culture. The value placed on these efforts [20] and the recognition of accomplishments along the way [15] were critical elements of rooting the new curriculum and educational culture in our institution. Furthermore, this opened the door for further integration of the doctoral education program. When the Foundations curriculum was first introduced in fall 2011, the students entered the Division of Graduate Medical Sciences from the independent pathways described in Fig. 1. However, the success of the integrated curriculum paved the way for a transition to a common admissions portal, with the first group of students matriculating from this common pathway in fall 2013. The students in the Program in Biomedical Sciences enroll in the four-core Foundations modules and electives of their choosing. Those electives can ultimately serve to fulfill requirements for the programs, which will grant their degree; however, they are not required to commit to a degree-granting program until the end of the first year, after a minimum of three laboratory rotations. Evaluation of the success of this program will continue as this initial cohort of students progresses through their graduate studies, and we will be able to gain a deeper sense of the long-

term outcomes for students in terms of completion of and time to degree, publication productivity during graduate school, and successful postgraduation employment. Furthermore, what is clear is that we would not have been able to implement an integrated program on this level without the curricular successes brought about by the Leading Change model.

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