Faculty reflections on the process of building an integrated preclerkship curriculum: a new school perspective

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Faculty reflections on the process of building an integrated preclerkship curriculum: a new school perspective. Adv Physiol Educ 38: 199–209, 2014; doi:10.1152/advan.00055.2014.—This is a reflective essay based on the experience of developing a structure and function module within a new integrated medical curriculum. Our hope is that the insights we gained during a 4-yr journey in a new medical school will be transferable to others engaged with curriculum development. Here, we present an interpretive analysis of our personal experiences together with some original research data and a synthesis of the literature. We will argue that a focus on teaching faculty is the key to successful curriculum integration and suggest an agenda for faculty development. Our essay begins by exploring what curriculum integration really means and what its purpose might be. Our case study explores the challenges of building a shared understanding among stakeholders and of negotiating learning outcomes and methods of teaching as well as the process of developing content and assessment. We feel that many of our experiences in the new medical school are applicable in other settings, such as curriculum reform in established schools and for developers of competency-based premedical curricula. We conclude with recommendations to assist other curriculum planners and teachers by offering some benefits of hindsight.

Curriculum integration; team process; active learning; medical education

CASE (9) referred to integration as “...any intentional uniting or meshing of discrete elements or features.” A definition from the learner-centered approach referred to situations in which knowledge from different sources (basic science, clinical, factual, experiential, etc.) connects and interrelates in a way that fosters understanding and performance of the professional activities of medicine (29). One operational definition by Muller et al. (36) described integration as interdisciplinary block courses in preclerkship years that bring together basic, clinical, and social sciences into one course or weave longitudinal curricular themes across the curriculum. However, a detailed and complete description of integration should include its steps and levels (20) and the specific contexts (19, 42).

Curriculum integration may be viewed as a continuum, with discipline-based teaching at one end and full integration of disciplines at the other (22). To clarify the concept of curriculum integration within a course, Harden (23) went on to describe a taxonomy that defines an 11-step integration ladder. The lower steps of the ladder emphasize the role of disciplines, whereas the upper steps of the ladder require centralized curriculum management to organize integration across several disciplines. The highest step of integration in Harden’s ladder is transdisciplinary integration, in which the faculty member provides authentic learning opportunities and integration occurs in the mind of the student.

Goldman and Schroth (19) presented a framework in which integration is a strategy for achieving curricular goals at the program, course, and session levels. They indicated that decisions about integration should be made first at the program level, then at the course level, and finally at the session level. The alignment of decisions at each of these levels was argued to be important for achieving the goals of integration and for better management of the curriculum. Later in our narrative, we will describe data indicating that achieving such alignment is easier said than done, and very deliberate efforts are needed to communicate with teaching faculty members about a school’s integration philosophy.

In a recent article, which we believe is a seminal contribution to the discussion about curriculum integration, Kulasegaram et al. (29) extended Goldman and Schroth’s discussion to argue that the cognitive activities required of students, rather than curriculum design, are the most critical elements needed to achieve high levels of integration. In other words, the cause-and-effect relationships between basic and clinical science learned at the session level create conceptual coherence and allow learners to build sophisticated schemas that apply an understanding of basic sciences to real clinical problems. As we describe our experiences starting a new medical school, in the 4 yr preceding Kulasegaram et al.’s article, it will be apparent that our data support the view that real integration happens at the session level and, as a consequence, success hinges on the choices made by individual teaching faculty members. In general, at least in our experience, subject matter experts in basic sciences do not spend a lot of time thinking about curriculum design and pedagogy. Therefore, we will make the argument that a focus on faculty development is a critical step in any curriculum reform effort.

Why Attempt Curriculum Integration in the First Place?

After the Flexner report (18), medial schools in the United States adopted curricula that laid down a formal basic science foundation for clinical medicine. During the following century, the most common curriculum was the “2 + 2” model, in which basic science disciplines were taught in isolation during a 2-yr preclerkship training ahead of 2 yr of mostly hospital-based clinical clerkship training. Over the last 40 yr or so, many schools have experimented with alternative curricula. For example, problem-based learning (PBL) curricula probably represent the most globally adopted innovation that embraces the philosophy of integration (7, 28, 37, 40, 41, 47). In PBL, students use authentic clinical problems to establish their own learning issues and then attempt to assemble the requisite knowledge in facilitated peer teams. In the past decade or more, the pace of curriculum reform has quickened, and schools are adopting...
many strategies to integrate basic and medical sciences (14). Recently, a highly influential Carnegie Foundation report, *Educating Physicians: a Call for Reform of Medical School and Residency* (13), has explicitly recommended the integration of formal knowledge and clinical experience. That is, the learning experiences of the basic, clinical, and social sciences should be integrated with clinical experiences.

On the face of it, there is strong common sense argument for curriculum integration, since a physician’s job requires her/him to seamlessly apply basic science knowledge in the diagnosis and treatment of patients. In addition to blue ribbon panels, such as the Carnegie Foundation, many commentators have emphasized a need for integration since the millennium (e.g., 13, 17, 23, 39, 43, 45). Some of the advantages of integration have been summarized by Bandaranayake (4) to include increased retention of learning, enhanced deep learning, and development of creative thinking. From the student perspective, feelings of enhanced learning and retention have been expressed if faculty members intentionally build on a student’s background to deliver integrated teaching and to provide them with conceptual frameworks (36). There have been isolated reports of superior performance in which students educated in an integrated curriculum made more accurate diagnoses than those trained in a conventional discipline-based curriculum (40). However, as Kulasegaram et al.’s review (29) points out, there is little evidence yet, at least at the program level, that integrated curriculum design is more efficacious, more efficient, than those trained in a conventional discipline-based curriculum. The authors were hired in 2008, the year preceding matriculation of the charter class, and were among a small group of ~20 founding faculty members charged with populating and implementing the newly designed curriculum. The governance structure was also established at this time, as the original

Our Context

The College of Medicine of the University of Central Florida was founded in 2006 with a core mission to focus on excellence, innovation, inquiry, and partnership. The first strategic plan laid foundations that called for an innovative and integrated medical curriculum, with a strong focus on medical simulation during training. Active learning was a high priority, and the inaugural strategic plan set the goal of <30% lectures in the curriculum. During 2007, the founding dean engaged university and community leaders from the biomedical sciences and healthcare fields to join a curriculum planning group. This large team consisted of a small group of senior medical school administrators and a large supporting cast of community physicians, scientists, and other stakeholders. They studied the literature, examined other curricula, and visited several established medical schools to arrive at the precursory curriculum blueprint shown in Fig. 1.

Our curriculum is essentially a spiral design (21): in the first year, the foundational sciences are taught in modules that leverage traditional synergies (e.g., cell biology/biochemistry/genetics, anatomy/physiology, microbiology/immunology, etc). In the second year, the focus is on pathophysiology, formation of differential diagnoses, and pharmacotherapy and is organized according to body systems. A Practice of Medicine course runs concurrently with the basic science modules during the first 2 yr to deliver instruction on clinical skills. A mandatory research project is a prominent feature of the curriculum, representing our commitment to inquiry, and this occurs during the first 2 yr. The final turn of the curriculum spiral is the translation of knowledge and skills into practice, which is represented by the clinical clerkships and electives during the third and fourth years. The curriculum is not quite a conventional 2 + 2 design since several longitudinal curricular themes (e.g., medical ethics, sex-based medicine, cultural medicine, and geriatrics) span all 4 yr and are threaded throughout the modules and clinical clerkships.

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Lessons Learned in Curriculum Integration

A Personal View

The next critical step would be to actually build out our new courses. In the structure and function module, a group of subject matter experts in anatomy, histology, embryology, physiology, surgery, and neurology, with disparate prior experiences in medical education, was assembled to develop the sequencing and content of the course. The curriculum committee did not provide any mandates about specific pedagogy (beyond a general emphasis on active learning) or any guidelines about what level of curriculum integration was required. It was at this time that the authors decided to design a research project to assess the perceptions of stakeholders on concepts of integration during course development as well as perspectives of faculty members and students on how things turned out once the curriculum went live. We briefly describe the methods we used below, and the results obtained are subsequently used to guide our narrative.

Research Surveys

Participants included 23 founding faculty members (5 administrators, 8 module directors, and 10 faculty members) and 163 students (classes of 2013, 2014, and 2015). Faculty experience ranged from >10 yr (15 faculty members), 6–10 yr (4 faculty members), 3–5 yr (2 faculty members), and 0–2 yr (2 faculty members). Student ages ranged from 20–25 yr (125 participants), 26–30 yr (31 participants), and >31 years (7 participants). Most students had at least 4 yr of college education before matriculation into the MD program. This study was reviewed and exempted by the Institutional Review Board of the University of Central Florida; participants gave informed consent before they completed the surveys.

Faculty members were asked to complete two online surveys asking about their perceptions and experience with regard to the integrated medical curriculum. The first survey was administered before the beginning of classes for the charter class of 2013. The second survey was administered toward the end of the second academic year. The first survey included closed-ended and open-ended items. The closed-ended items assessed the extent of curriculum integration (5 items), writing learning objectives (6 items), designing course framework (3 items), developing integrated instructional materials (4 items), writing assessment items (4 items), and faculty collaboration (3 items). Open-ended items addressed the effective strategies and challenges when developing an integrated curriculum. The second survey included closed-ended items that assessed the extent of curriculum integration (5 items), curriculum delivery (5 items), and module assessment (4 items). Two open-ended questions address additional effective teaching methods for teaching an integrated curriculum and the challenges that faculty members encountered in delivering an integrated curriculum. A five-point Likert scale anchored by strongly disagree (1) to strongly agree (5) was used to quantify responses.

At the end of their second year, students were surveyed to obtain information on class demographics and individual perspectives and experience with regard to the integration of basic medical sciences into medical curriculum. Closed-ended questions were grouped into five categories: extent of curriculum integration (5 items), curriculum design (4 items), curriculum delivery (5 items), module assessment (3 items), and retention of basic science knowledge (6 items). A five-point Likert scale from strongly disagree (1) to strongly agree (5) was used to quantify responses. Open-ended questions were designed to collect opinions and perceptions on effective strategies to integrate different disciplines.

Demographic data were analyzed to identify general characteristics of all participants, administrators, faculty members, and students. Data for closed-ended items are expressed as means ± SD. Statistical comparisons were included where faculty members and students were asked the same questions. To accommodate the discontinuous Likert scale data, Kruskal-Wallis ANOVA was applied with followup Mann-Whitney U-tests to locate significant differences, which were assumed at the 5% level. The open-ended questions were semiquantitatively analyzed to identify shared patterns or themes expressed by the participants during the design, development, delivery,
A Personal View

LESSONS LEARNED IN CURRICULUM INTEGRATION

Table 1. Administrator, module director, and faculty rankings of the important factors that should determine the sequencing and allocation of hours

<table>
<thead>
<tr>
<th>Factors</th>
<th>Administrators</th>
<th>Module Directors</th>
<th>Faculty Members</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers of respondents</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>Faculty opinions about the</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logical progression of learning</td>
<td>2nd</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
</tr>
<tr>
<td>Faculty perceptions of the</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>relative importance of topics</td>
<td>3rd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
</tr>
<tr>
<td>Relative numbers of learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>objectives for each topic</td>
<td>1st</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
</tr>
<tr>
<td>Nature of available teaching</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>space and facilities</td>
<td>4th</td>
<td>4th</td>
<td>4th</td>
<td>4th</td>
</tr>
</tbody>
</table>

and evaluation of the integrated curriculum. Quantitative data were analyzed using the IBM SPSS statistical software package (version 21, IBM, New York, NY).

Building Shared Understanding About Curriculum Integration

The data shown in Tables 1–3 corroborated our personal feelings at the time about a lack of shared understanding in the transition from curriculum design to implementation. As shown in Table 1, we asked about what factors should determine the sequencing and allocation of hours in a new course. The curriculum leadership logically felt that this should be driven by learning objectives (recall this was also the primary organizing tool at that time). In marked contrast, the module directors and teaching faculty members were firmly grounded in their own personal opinions and perceptions. The data shown in Table 2 reflected responses to who should make decisions about the sequencing and allocation of contact hours. The administrators were clear about the governance hierarchy, and all of them saw this (correctly) as a faculty responsibility. Most faculty members agreed, but it is notable that approximately one-quarter of the faculty sample wanted administrators to make these decisions for them, suggesting a lack of clarity about the governance structure on the part of some faculty members or perhaps a lack of confidence and experience.

Most striking to us were the data shown in Table 3, where we asked about what factors should determine the selection of learning materials in a module. The curriculum leadership took a scholarly approach (as they had done during the curriculum design process) and felt that studying other medical schools as well as the literature was the way to go. In contrast, faculty members and module directors opted to work from the very practical standpoint of using the number of available hours in the calendar! The faculty response came as no surprise to us because the initial implementation step of working exhaustively on learning objectives led to a focus on what content must be developed and the pressing concern of how to fit it all in. Overall, these data indicate that communication between curriculum planners and teaching faculty members was not optimal, despite the establishment of a rational leadership structure. In our view, an integrated curriculum design is a necessary but insufficient step to actually achieving integration for the learner. Moreover, it appears that nothing is implicit and a lot of work is needed on the part of planners to educate subject matter experts about the curriculum goals and how to realize them. Otherwise, there is a natural tendency for experts to retreat into their comfort zone and concentrate on how to deliver the usual content in whatever space is being allowed.

Muller et al. (36) performed an interview-based study in one school that underwent curriculum reform after a change from a traditional discipline-based model to an integrated curriculum. They also uncovered differences in the way stakeholders perceive and experience curriculum integration: “...they [different stakeholders] also have differing perceptions of what integration means, how it succeeds and where it faces important challenges.” The authors conclude that “For an integrated curriculum to succeed, these different perspectives should be given voice as medical schools envision, plan and embark upon redesign of their undergraduate medical education curricula.” In our experience, a great deal of time was lost in faculty meetings as we struggled with the intimately related questions of what content to teach, how to teach it, and what level of integration to strive for. One important lesson learned was the need for very clear communication between curriculum leaders and faculty members on expectations. Below, in Course Development, we expand on the issues we faced during development of the structure and function module.

Course Development

As described above, Goldman and Schroth’s framework (19) conceives integration at the levels of program, course, and session, and it is argued that success is more likely to be achieved when there is alignment between each level. In our case, curriculum leaders had previously furnished program-level structures that provided the potential for faculty members
to integrate the curriculum as they began building courses. According to Goldman and Schroth, who used an instructional design approach, the process of course development should involve learner analysis, development of course objectives, determination of content, decisions on sequencing, and creation of an assessment plan. In our module, we had an experienced group of faculty members with strong historical notions of what medical students should learn during traditional anatomy and physiology courses. Accordingly, our group decided on the time-efficient approach of developing separate discipline-based learning objectives. The 17-wk calendar was roughly broken into weekly blocks according to regional anatomy to create a framework in which to organize content. Each small group of discipline experts presented their objectives at weekly meetings until the scope of content to be learned was defined. We agreed there would be midterm and final written and practical examinations as well as an autopsy report and team oral presentation by students that would be based on cadaveric dissection. In our module group, the spontaneous process we adopted for course development mirrored the steps outlined by Goldman and Schroth. Some conflict arose in our group about organizing learning objectives by discipline, and this is discussed further below in Team Process.

The data shown in Table 4 show perceptions of the wider group of founding faculty members as they developed their courses. The items in the first block were specifically worded to reflect ascending degrees of integration according to Harden’s ladder (23). Thus, the first item described simple awareness of faculty members about other material taught (awareness being only the second of Harden’s 11 levels), whereas the last item asked about task-based learning needing several disciplines, which relates to Harden’s top two levels of interdisciplinary and transdisciplinary learning. Responses from faculty members showed a downward trend of scores as participants rated their degree of agreement with having achieved greater levels of integration. This result seems logical assuming that higher levels of integration are harder to achieve. Responses of faculty members about the development of integrated instructional materials showed high levels of agreement about collaborating with colleagues. We were surprised that most faculty members agreed that they had worked with others to create integrated learning objectives when subject discipline was a

Table 4. Faculty perceptions toward different aspects of an integrated curriculum using a five-point Likert-style scale where 1 = “strongly disagree” and 5 = “strongly agree”

<table>
<thead>
<tr>
<th>Evaluation Categories</th>
<th>Number of Respondents</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extent of curriculum integration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty were aware of what other faculty in the module covered</td>
<td>23</td>
<td>3.88</td>
<td>0.85</td>
</tr>
<tr>
<td>Faculty consulted and communicated with other faculty in the module</td>
<td>23</td>
<td>4.00</td>
<td>0.88</td>
</tr>
<tr>
<td>The timing of related topics in each discipline was coordinated</td>
<td>23</td>
<td>3.71</td>
<td>0.95</td>
</tr>
<tr>
<td>Individual sessions brought together ideas of common interest between subjects</td>
<td>23</td>
<td>3.67</td>
<td>0.82</td>
</tr>
<tr>
<td>The focus was on task-based learning that required knowledge of several disciplines</td>
<td>23</td>
<td>3.46</td>
<td>0.98</td>
</tr>
<tr>
<td><strong>Learning objectives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I consistently used Bloom’s taxonomy when writing learning objectives</td>
<td>23</td>
<td>4.04</td>
<td>0.91</td>
</tr>
<tr>
<td>Learning objectives were key elements in identifying the scope of instructional contents</td>
<td>23</td>
<td>3.79</td>
<td>1.02</td>
</tr>
<tr>
<td>Learning objectives guided the selection of teaching methods</td>
<td>23</td>
<td>3.25</td>
<td>1.11</td>
</tr>
<tr>
<td>I consider assessment strategies when writing learning objectives</td>
<td>23</td>
<td>3.58</td>
<td>0.88</td>
</tr>
<tr>
<td>Learning objectives facilitated the integration of different disciplines</td>
<td>23</td>
<td>3.29</td>
<td>1.23</td>
</tr>
<tr>
<td>My learning objectives were consistent in style and format with those of other disciplines</td>
<td>23</td>
<td>3.54</td>
<td>0.83</td>
</tr>
<tr>
<td><strong>Developing integrated instructional materials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have worked with colleagues to create integrated learning objectives</td>
<td>23</td>
<td>4.13</td>
<td>0.85</td>
</tr>
<tr>
<td>I have developed integrated instructional materials that will be team-taught with other faculty members</td>
<td>23</td>
<td>4.09</td>
<td>0.81</td>
</tr>
<tr>
<td>When I develop material for my own discipline, I revisit material already taught by other disciplines</td>
<td>23</td>
<td>3.96</td>
<td>0.64</td>
</tr>
<tr>
<td>I have developed clinical case-based instructional materials that will integrate information from different disciplines</td>
<td>23</td>
<td>4.43</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Curriculum delivery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The following teaching methods helped me to integrate knowledge from different disciplines:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active lectures</td>
<td>16</td>
<td>4.06</td>
<td>1.06</td>
</tr>
<tr>
<td>Team-based learning sessions</td>
<td>13</td>
<td>3.77</td>
<td>0.93</td>
</tr>
<tr>
<td>Case-based learning sessions</td>
<td>16</td>
<td>4.38</td>
<td>1.02</td>
</tr>
<tr>
<td>Laboratory sessions</td>
<td>12</td>
<td>3.92</td>
<td>1.16</td>
</tr>
<tr>
<td>Simulations</td>
<td>13</td>
<td>3.92</td>
<td>0.95</td>
</tr>
<tr>
<td><strong>Module assessment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I collaborate with other faculty to write integrated questions</td>
<td>14</td>
<td>3.64</td>
<td>1.22</td>
</tr>
<tr>
<td>The majority of examination questions required knowledge of two or more disciplines</td>
<td>14</td>
<td>2.86</td>
<td>1.17</td>
</tr>
<tr>
<td>Module practice quizzes emphasized integrated knowledge of different disciplines</td>
<td>14</td>
<td>2.93</td>
<td>1.10</td>
</tr>
<tr>
<td>Module examination emphasized integrated knowledge of different disciplines</td>
<td>14</td>
<td>3.13</td>
<td>1.30</td>
</tr>
<tr>
<td><strong>Writing assessment items</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I write examination questions I refer/intend to refer to the learning objectives</td>
<td>23</td>
<td>4.33</td>
<td>0.82</td>
</tr>
<tr>
<td>The majority of my examination questions require knowledge of two or more disciplines</td>
<td>23</td>
<td>3.58</td>
<td>0.88</td>
</tr>
<tr>
<td>An examination is adequately integrated when it consists of questions drawn from several disciplines</td>
<td>23</td>
<td>3.61</td>
<td>1.16</td>
</tr>
<tr>
<td>An examination is adequately integrated when most of the individual questions assess multiple disciplines</td>
<td>23</td>
<td>3.96</td>
<td>0.91</td>
</tr>
</tbody>
</table>
common organizing feature. Perhaps when faculty members have spent time presenting discipline-based objectives to a team, they regard this as integrating the objectives. On the other hand, a question asking if learning objectives had facilitated integration between disciplines produced a rather neutral response, with a large SD. Again, these data point to the different internal calibration and values we all have about integration and the need for open discussion and goal setting within a faculty team about integration.

Team Process

In the structure and function group, there was concern among some faculty members that starting with separate discipline objectives would limit the level of integration we could achieve (i.e., mostly at Harden’s middle levels of temporal coordination and sharing). However, our group elected to continue this approach, recognizing that time efficiency was an important advantage. It should be noted that we are a collegial group but our disagreement about the approach to course organization took time to resolve. This episode illustrated to us another critical point, rarely discussed in the education literature, about the importance of faculty teams when striving for curriculum integration.

Academia has traditionally recognized individuals rather than teams. We tend to congregate in our disciplines where there is implicit understanding about what is needed to succeed. Universities usually have promotion and tenure systems that emphasize individual achievement over team performance. Although it is inescapable that curriculum integration requires diverse teams of faculty members working toward common goals, it is rarely acknowledged that such teamwork is somewhat contrary to traditional university culture. On reflection, we assess our particular group to be well-qualified and talented individuals, but we discovered that simply putting us in a room together did not guarantee productivity! We found out that it takes a long time to build a team that can work efficiently and that can generate consensus and can cope with inner conflicts without harming team process. The environment of an integrated curriculum is also a new challenge for course directors and other curriculum leaders. Traditional hierarchical leadership structures such as “course director” and “assistant dean” provide a chain of command that may be efficient but in the setting of integrated curriculum especially favors skills such as the ability to listen to all points of view and to build consensus. We feel that specific training in team process and leadership would have been a great benefit to us before embarking on the journey of building a new integrated curriculum.

It has been documented that acquiring shared mental models (SMMs) about the team and tasks improve team performance (8, 32, 38). The following five major factors have been identified that affect the development of SMMs: 1) team knowledge, 2) team skills, 3) team attitude, 4) team dynamics, and 5) the team environment (24). These factors are important components of the interactions that occur between and among team members leading to the development of a SMM. Team interactions such as communication and coordination mediate the development of SMMs and impact team performance (32). Communication quality and quantity affect the ability of team members to acquire greater levels of sharedness (31). The communication process takes time, requires cognitive re-

Pedagogy and Integration

Several reports have discussed integration through the lens of pedagogy, most notably the PBL literature (7, 37, 40, 41). It seems common sense that interdisciplinary learning will result when students are forced to synthesize multiple disciplines in approaches such as PBL. However, it is interesting to note that PBL-based curricula tend to produce similar overall outcomes to traditional curricula (12, 28, 47). So is there a “best” method to achieve integration in the learning of basic and clinical sciences? In our case, the curriculum leaders decided not to constrain faculty members into using any particular teaching method. In our structure and function course, we decided that foundational content would be mostly taught using lectures and web-based self-learning modules (26). The foundational material from each discipline was temporally coordinated (e.g., the anatomy of the heart was covered in the same week as the physiology of the cardiac cycle). In some cases, particularly histology and physiology, the lectures were team taught, where histology was presented before physiology in the same session. Most lectures included clicker questions, small breakout discussions, and other techniques aimed at making the lectures engaging. Lectures were followed by application sessions such as laboratories (25) and small-group clinical cases and simulations (10). Overall, our module ended up with approximately one-third of the contact time devoted to lectures and one-third to laboratory sessions (cadaveric dissection, virtual histology, hands-on ultrasound sessions, and use of high-fidelity simulators). The remaining one-third of contact time was allocated to small-group case-based learning plus some team-based learning sessions (34, 35). On reflection, we are proud of the quality and variety of teaching and learning methods we produced but recognize that the goal of integration was not foremost in mind when deciding how to teach many of the sessions.

The primary driver when deciding these methods of instruction was a focus on “active learning” approaches. We have discovered that another whole article could probably be written on what faculty members think is meant by active learning! According to the Liaison Committee on Medical Education (30), under Element 6.3 (former standard ED-5A),

It is expected that the methods of instruction and assessment used in courses and clerkships (or, in Canada, clerkship rotations) will provide medical students with opportunities to develop lifelong learning skills. These skills include self-assessment on learning needs; the independent identification, analysis, and synthesis of relevant information; and the appraisal of the credibility of information sources. Medical students should receive explicit experiences in using these skills, and they should be assessed and receive feedback on their performance.
This definition of active learning is rather strictly interpreted and in our view would be better labeled as “self-regulated learning.” In our experience, most faculty members think about “engaged learning” when the term active learning is used. In such cases, a teacher probably defines most of the learning objectives and activities, but the sessions are characterized by dialogue between teacher and student and between learners rather than the one-way flow of information from the teacher to the learner. In contrast to the question of efficacy of curriculum integration, there is extensive evidence showing that engaged/active learning approaches are more effective than passive (lecture-based/highly teacher-dependent) methods. The reader is directed to an excellent review in *Advances in Physiological Education* by Michael (33) on the effectiveness of active learning. However, in designing and developing active learning activities, effective instructional design should consider and support learner progress from novice to intermediate learners. At the early stage of students’ development, guided instruction is viewed to be superior to minimally guided instructional approaches (27).

Following from our decisions to develop discipline-based learning objectives and then to temporally coordinate foundational content in lectures, the discussion about selecting pedagogy to achieve integration was more limited. The notable exception to this was our Case of the Week, which was a deliberate attempt to design cases that incorporated both anatomy and physiology concepts. Cases were presented using LabTutor software (ADInstruments, Castle Hill, NSW, Australia) and consisted of progression through a case starting with clinical history and physical exam findings and moving to interpretation of laboratory and imaging data. Groups of six students collaborated to answer questions at each stage of the case and to arrive at tentative differential diagnoses. Case sessions were 2 h long and concluded with a 15-min faculty wrapup. Development of each Case of the Week was time consuming and usually required input from several faculty members. Figure 2 shows a concept map we created to show the intended connections between disciplines within a particular case. Anecdotally, we feel this use of a concept map, which was agreed by the whole faculty group, was effective at making intentions about integration visible to facilitate discussion, and we include it as a suggestion to others who may be creating integrated learning sessions.

The survey filled out by the wider group of founding faculty members included a section about different pedagogies and which ones were best suited to integration. We had expected to see case-based learning as a clear winner (5), with lectures scoring poorly and other methods in between. However, the data shown in Table 4 demonstrate that all modalities were seen as opportunities for integration. Interestingly, the student data about this topic (shown in Table 5 and broken out across the three separate classes in Fig. 3) also made no distinction by teaching method in terms of what is best for achieving integration. In the review by Kulasegaram et al. (29), they noted good experimental evidence at the session level that linking basic science to causation of clinical problems leads to better diagnostic skills and retention of knowledge (48, 49). Furthermore, this attention to making learners develop cognitive connections between different domains of knowledge may
transcend the learning modality (3), consistent with the views held by our faculty members and students.

The evidence appears to point to two general principles that place teaching faculty members at the center of the puzzle of how to create effective integrated curriculum: 1) the need to create session-level activities that make causal connections between basic and clinical sciences and 2) active learning approaches in general are more effective for learning. Taken together, this means that expert faculty members are likely to need to work in diverse teams to create the necessary connections between content and that they also need to become practitioners of engaged/active learning methods. It was evident to us when developing all the different learning modalities in our structure and function module that some methods placed more demands on faculty members than others. Not surprisingly, there was a tendency for some faculty members to prefer lecturing. Lectures are familiar to us all and, from a development standpoint, usually allow a faculty member more autonomy and take less time to create. The comfort level among faculty members was highly variable when asked to work with new approaches, such as team-based learning, or when asked to facilitate sessions in areas where they were not an expert. Similarly the incorporation of technology such as clickers, developing SMMs, and use of high-fidelity simulation created significant discomfort for some faculty members. Our epiphany in all these experiences was that time spent on developing curriculum maps and objectives was probably useful but directing a major effort and adequate resources at faculty development to build integrated sessions with highly engaging teaching methods would have saved a great deal of time.

Assessment

It is axiomatic that summative assessment drives learning. According to Van der Vleuten (46), the overall utility of an assessment depends on several characteristics: high reliability (i.e., good statistical test-retest consistency), validity (that they test what they are supposed to test), cost effectiveness, feasibility, and positive educational impact. Our school placed
strong emphasis on assessment and evaluation from the outset, as demonstrated by investment in a centralized assessment office staff to support student and program evaluation. Faculty members were provided with training on item writing from the National Board of Medical Examiners, and all test items were peer-reviewed before being entered into a centralized item database. Summative assessments were blueprinted (11) against the learning objectives to establish validity, and standard-setting methods were applied (2) to control examination difficulty in the absence of historical data.

We use single best answer multiple-choice exams, which are the mainstay of knowledge testing, consistent with the United States Medical Licensing Exam (USMLE) format. Initial data showed that the faculty effort put into testing has been successful. Reliability coefficients have been uniformly good [e.g., Cronbach α-statistic (15) of >0.8 in almost all summative exams]. Content validity has been established through peer review of items, test blueprinting, and postexam review of items with students in coaching report sessions. Predictive validity has also proven to be good, with almost all module exams showing significant correlation to USMLE step 1. Of note, the highest correlations to the USMLE step 1 exam have come in modules that heavily feature physiology and pathophysiology. For example, the correlation coefficients for comparisons of final exams to USMLE step 1 for the structure and function module in year 1 as well as the cardiovascular, renal, gastrointestinal, endocrine, and reproduction sections in year 2 are consistently in the 0.7–0.8 range. In terms of feasibility and cost effectiveness, it should be emphasized that developing and validating item banks from scratch has been an enormous undertaking. Anecdotally, most module teams found that test development took much more time than expected and ideally should be started months in advance of test deployment. Van der Vleuten’s final criterion of educational impact is multidimensional and requires qualitative input from the stakeholders. In this article, we are concerned about the ability of the testing program to support curriculum integration and to require integrative thinking from the students. Given our primary paradigm during module development was to identify discipline-based objectives, it followed that most of our test development involved writing discipline-specific items. This was an area of significant debate among the faculty members and there was uncertainty about how to do otherwise. A minority of items were consciously written to integrate anatomy and physiology, e.g., by asking students to first identify a structure and then requiring an answer in the domain of organ function. Therefore, summative examinations mainly consisted of collections of discipline-based items, with the proportion of items from a particular discipline reflecting the number of learning objectives and contact hours assigned to each discipline. Our research surveys asked faculty members and students whether individual test items required knowledge of more than one discipline and to judge whether tests emphasized integrated knowledge. In these aspects, faculty member and student perceptions differed. Figure 4 shows that students were uniformly positive across all 3 yr studied that the tests were reaching these benchmarks of integration, whereas faculty members were more neutral. The differences in perceptions were significant between faculty members and students regarding the following items: 1) the majority of exam questions required knowledge of two or more disciplines ($P = 0.001$), 2) practice quizzes emphasized integrated knowledge of different disciplines ($P = 0.001$), and 3) module examinations emphasized integrated knowledge of different disciplines ($P = 0.002$). It seems that some faculty members felt negatively that more could be done through assessment to enhance integration. It is not clear what the student frame of reference to make a judgment was, and perhaps their more positive views just reflect general satisfaction with summative assessment. More recently, we have been developing and experimenting with novel assessments that are case based and that focus on reasoning and synthesis of information. These include an autopsy report, based on the anatomy laboratory dissections, and a modified patient note format that is used after case-based learning sessions. It remains to be seen whether these novel testing formats will have a stronger educational impact rating with respect to integration than conventional multiple-choice examinations.

Epilogue: Learning Outcomes and Recommendations

Ultimately, the most important question to ask is whether medical curriculum reform, toward more integrated models, produces better learning outcomes. Conventional metrics for the success of an undergraduate medical education program inevitably include outcomes such as USMLE step 1 and 2 scores as well as the student placement in graduate training programs. We are pleased at this point to report that our first two classes to complete the program have performed at or above the national averages in these milestones (unpublished data). We have therefore succeeded, with great effort and limited resources, to stand up a curriculum that is at least as good as the average medical school!

Although large-scale analyses will be needed to address the question of whether curriculum reform toward more integration is effective, we feel our experience in a new medical school can provide the following insights that are transferable both to the medical education community or faculty members engaged in other curriculum reform efforts:

1. Clear vision and goals for curriculum design and governance are necessary but are not sufficient to guide curriculum implementation. Strenuous and repeated efforts to translate the vision to teaching faculty members are needed.

2. The concept of integration should be openly discussed among faculty members. Integration can be viewed as a stra-
ergy to achieve other program goals. However, in our view, the level of integration expected at each stage of a program should be explicitly defined during the design process.

3. The construction of diverse faculty teams is an absolute requirement to implement curriculum integration. Deliberate emphasis should be given to coaching faculty members and curriculum leaders about the team process and team dynamics. Much time could be saved later on!

4. Impactful integration occurs at the session level and therefore depends on achieving shared understanding about integration among teaching faculty members. An infrastructure is needed that facilitates this faculty-to-faculty exchange of ideas and also allows for horizontal and vertical integration as the curriculum proceeds.

5. Integration can be achieved with almost any pedagogy so long as there is shared understanding about the intent. When selecting pedagogy, considerations about the level of learner expertise, i.e., from novice to advanced learner, is probably more important when considering what degree of exposure to active and independent learning formats is to be used at a particular stage of the curriculum.

6. Adequate resources for faculty development and for ongoing support in the areas of active learning pedagogy and educational technology may not be special barriers for achieving curriculum integration but are a critical need in the rapidly changing landscape of learning technologies and accreditation requirements.

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