Curriculum design for research-led teaching: Molecule to Malady



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Modern medicine is increasingly characterised by a personalised approach to treatment through producing therapies that target specific biological processes. When planning the new Bachelor of Biomedicine (BBiomed) degree, one of two completely new undergraduate courses crafted as part of the 'Melbourne Curriculum' introduced by The University of Melbourne in 2008, the paradigm that medical interventions should be evidence-based and driven by a molecular understanding of the cause of disease was a key design parameter. Our intention in developing the curriculum for *Biomedicine: Molecule to Malady* (M2M), a third-year compulsory capstone subject of this new BBiomed degree, was to enhance the ability of students to apply their core cross-disciplinary knowledge to unfamiliar problems in translational medicine by having expert clinicians/researchers explain the scientific reasoning applied to the development of disease interventions in their specialist areas.

Curriculum design at higher education institutions should be driven by the development of graduate attributes, described as 'knowledge, skills and values that students develop during their time at the university, and which shape their future contributions to their profession and as citizens'[1]. Throughout their undergraduate studies, students are led through a learning experience that is intended to prepare them for their postgraduate pathway, be it entry into the workforce or into postgraduate study and/or research.

The Melbourne Curriculum, launched at The University of Melbourne in 2008, 'featured six broad, three-year undergraduate degrees characterised by both disciplinary depth and academic breadth'[2]. In the Melbourne Curriculum, each major area of study culminates with 'a 'capstone' experience in the third year (understood as offering both disciplinary and cohort coherence and a bridge between the undergraduate experience and what lies beyond)'[3]. These capstone subjects are an integral part of the final year of each course, and are intended to 'enhance students' capacity to apply their theoretical knowledge to applied real world issues and demonstrate their ability to provide coherent solutions'[4].

In addition, it was intended that 'undergraduate education at a research-intensive university should be characterised by student encounters with teachers who are also researchers. . . (who provide) an introduction to the methodologies and ethics of research'[4].

The Molecule to Malady (M2M) story

The designers of the subject BIOM30002 Biomedicine: Molecule to Malady were in a unique position to develop a curriculum for a compulsory subject in the BBiomed degree that sat outside the 'major', the necessarily focussed and deep study stream in a particular area or discipline(s), and could thus focus on giving students an opportunity to examine scientific problem-solving,

demonstrated by eminent researchers in their various fields as authentic 'research-led' teaching.

Influenced by clinician-scientists like Graham Brown and Steven Collins, the M2M designers were blessed with a myriad of topic options but chose to highlight diseases in which world-class clinical and scientific expertise was held within The University of Melbourne, and/or one of its allied medical research institutes – the Burnet Institute, the Murdoch Children's Research Institute (MCRI), the Walter and Eliza Hall Institute of Medical Research (WEHI) and St Vincent's Institute (SVI). The chosen topics were pandemics (HIV and malaria), B-cells and diseases, cystic fibrosis, rheumatoid arthritis (RA), muscular dystrophies and neurodegeneration (Alzheimer's disease and Parkinson's disease).

A defining feature of the BBiomed degree is that, each year, students complete a number of compulsory cross-disciplinary core subjects that provide them with an extensive and common base of scientific knowledge – this prior learning is extended by the content of the M2M subject, giving students a much-valued context for their core studies. It is expected that students will utilise their core knowledge in microbiology and immunology, genetics, and anatomy and physiology of the brain, bone and muscle as they progress through the six modules of M2M.

In designing the M2M subject we asked our teachers to demonstrate that a better understanding of the molecular basis of disease leads to better diagnosis and prognosis, and especially treatment with drugs and other interventions that specifically target the disease and/or pathogen; i.e. by understanding the specific molecules that are key to the pathology, treatment of the malady becomes much more targeted and likely to work, with fewer side-effects.

Our aim was to develop two of the key graduate attributes specifically desired by employers in the health sector: *knowledge of industry* (through explicit teaching about diseases and related current medical research), and *critical reasoning and analytical skills/problem-solving* (through explanations of the scientific reasoning applied to the development of interventions in the diseases studied)[5].

M2M: the how

M2M seeks to deconvolute the students' understanding of selected maladies (diseases) to develop a way of thinking about any disease. Students are led through an exploration of the key molecules associated with diseases, where the module champions (leaders) and their fellow lecturers describe the development of current treatments and look at the possibilities for future treatments that target relevant molecules, allowing students to develop a thought process that aims to be applicable to any treatment (i.e. what molecule, process or cell does it target?).

The M2M subject touches on elements of many of the majors that students are undertaking, while remaining relevant to the class as a whole in its holistic approach to the understanding of disease. The topics and methods of presentation, e.g. patient interviews, were selected to complement rather than overlap the teaching and learning provided in the BBiomed majors.

The teaching team for M2M is wholly made up of clinician-researchers and research scientists who are leading and often world-experts in their fields. The current roster includes Professor Sharon Lewin (inaugural Director of the Doherty Institute for Infection and Immunity, co-convenor of the 2014 World AIDS Conference, and world-renowned HIV researcher and physician), Professor Brendan Crabb AC (Director and CEO of the Burnet Institute, and molecular biologist whose research focus is on the development of a malaria vaccine), and Professor David Tarlinton (Head of Department of Immunology and Pathology, Monash University). Our other module champions include Professor Sylvia Metcalfe, a medical genetics expert at the Royal Children's Hospital, and Professor Roberto Cappai, one of Australia's leading neuropathology researchers. Students are clearly engaged and inspired by the calibre of teachers with whom they interact in the M2M subject.

A key feature of the M2M curriculum is the inclusion of patient/parent interviews in each module to provide students with a personal perspective of diseases they are studying. Students have the opportunity to question these guest speakers to develop a deeper understanding of the diseases, and the effect of chronic illness on the lives of these generous and engaging people. The interviews have proven to be a powerful motivator for students to learn about diseases and possible treatments, giving them a glimpse of the impact of their potential future careers in medicine or research that would otherwise be difficult to convey.

The module champions and their fellow lecturers have been well-briefed on the core principles and aims of the subject and have worked with the academic coordinating team over the past six years to refine their lecture content, and to emphasise common themes between particular modules (e.g. the development of therapeutic monoclonal antibodies is discussed in the B Cells and Diseases module, while their use in rheumatoid arthritis therapy is presented in the RA module).

We believe we have developed authentic and pedagogically sound assessment tasks to evaluate student learning despite the large class

Table 1. Student experience survey data: Molecule to Malady.

Year	Class size (responses)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
2010	218 (130)[A]	4.1	N/A	N/A	3.4	N/A	N/A	3.0	N/A	N/A	N/A
2011	281 (245)[A]	4.4	4.1	3.7	3.6	4.4	4.0	3.9	3.9	3.5	3.7
2012	403 (216)[B]	4.3	4.3	3.9	3.9	4.6	3.6	3.6	4.0	3.5	3.9
2013	429 (154)[B]	4.4	4.0	3.7	3.8	4.7	3.1	3.2	3.9	3.5	3.8
2014	412 (166)[B]	4.6	4.6	4.3	4.3	4.7	4.3	4.2	4.2	4.0	4.0
2015	427 (167)[B]	4.6	4.7	4.2	4.2	4.7	4.0	4.2	4.3	3.9	4.2

Questions
(1) Overall, this subject has been intellectually stimulating
(2) Overall, this subject has been well co-ordinated
(3) Overall, this subject has been supported by useful learning resources
(4) Overall, this subject has been well-taught
(5) Focusing on my own learning in this subject, I have been required to work at a high standard
(6) Focusing on my own learning in this subject, I found the assessment tasks useful in guiding my study
(7) Focusing on my own learning in this subject, I received valuable feedback on my progress
(8) Focusing on my own learning in this subject, I learnt new ideas, approaches and/or skills
(9) Focusing on my own learning in this subject, I learnt to apply knowledge to practice
(10) Focusing on my own learning in this subject, I have been part of a group committed to learning

[A]2010–2011: paper-based survey (in lecture).
[B]2012–2015: voluntary online survey.
5 point Likert scale: 1 = strongly disagree → 5 = strongly agree. N/A, not available: change of question format in 2011.

size (427 students in 2015). The students complete three sets of multiple-choice questions (MCQs) examining key points in each pair of modules, as well as short answer questions (SAQs) that test the students' ability to integrate and apply their acquired knowledge in a final exam. Over the past six years questions used for assessment have been refined, with the introduction of innovative MCQs that require students to progress through a clinical scenario, answering questions for which they must apply their knowledge to the problem at hand. In the SAQs, students need to demonstrate both their grasp of the lecture content and their ability to apply this learning to a defined (new) situation.

Biomedical Science Threshold Learning Outcomes (TLOs) developed and ratified in 2013 by the Collaborative Universities Biomedical Education Network (CUBENET) using the Office of Teaching and Learning (OLT) Science and Biology TLOs[6] provide a benchmark for the M2M subject outcomes. The Molecule to Malady curriculum enhances the students' ability to 'demonstrate a coherent understanding of biomedical science' by giving them specific examples of the 'translation of biomedical science to clinical and medical outcomes' (TLO 1.2). Students who have successfully undertaken M2M will have exhibited 'depth and breadth of scientific knowledge by demonstrating integration of knowledge from across the disciplines contributing to biomedical sciences' (TLO 2) – this is a key driver of the M2M, and indeed the BBiomed, curriculum.

The Student Experience Surveys for the past six years represent the students' responses to the subject: the results from 2010 to 2015 are shown in Table 1.

It is particularly encouraging to see the excellent responses in Q1, Q4 and the improving responses in Q9. Given that this is a compulsory subject for an elite cohort (clearly-in ATAR usually >98.5), the survey responses are viewed as particularly strong testament to the excellent teaching within the modules and the very good 'back office' support.

More than 50% of the students in the M2M cohort seek admission to postgraduate medicine and allied health degrees, and a significant section of the cohort wish to pursue careers as research scientists. We believe that the exposure to leading clinical and research experts has been both motivating and enlightening for our students – providing them with a unique opportunity to understand the methodology behind the approaches to dealing with diseases in our society. This should allow them to apply these principles to unfamiliar problems they may face in the future.

We have included a portion of the video-taped interview of HIV-positive activist Paul Kidd by Professor Sharon Lewin (http://microbiology.publish.csiro.au/?acc=MA16022_AC.pptx). Sharon's concluding question and Paul Kidd's (unscripted) answer is, we

believe, a powerful educational moment for the students in the class, and exemplifies the core principles of M2M.

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Biographies

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