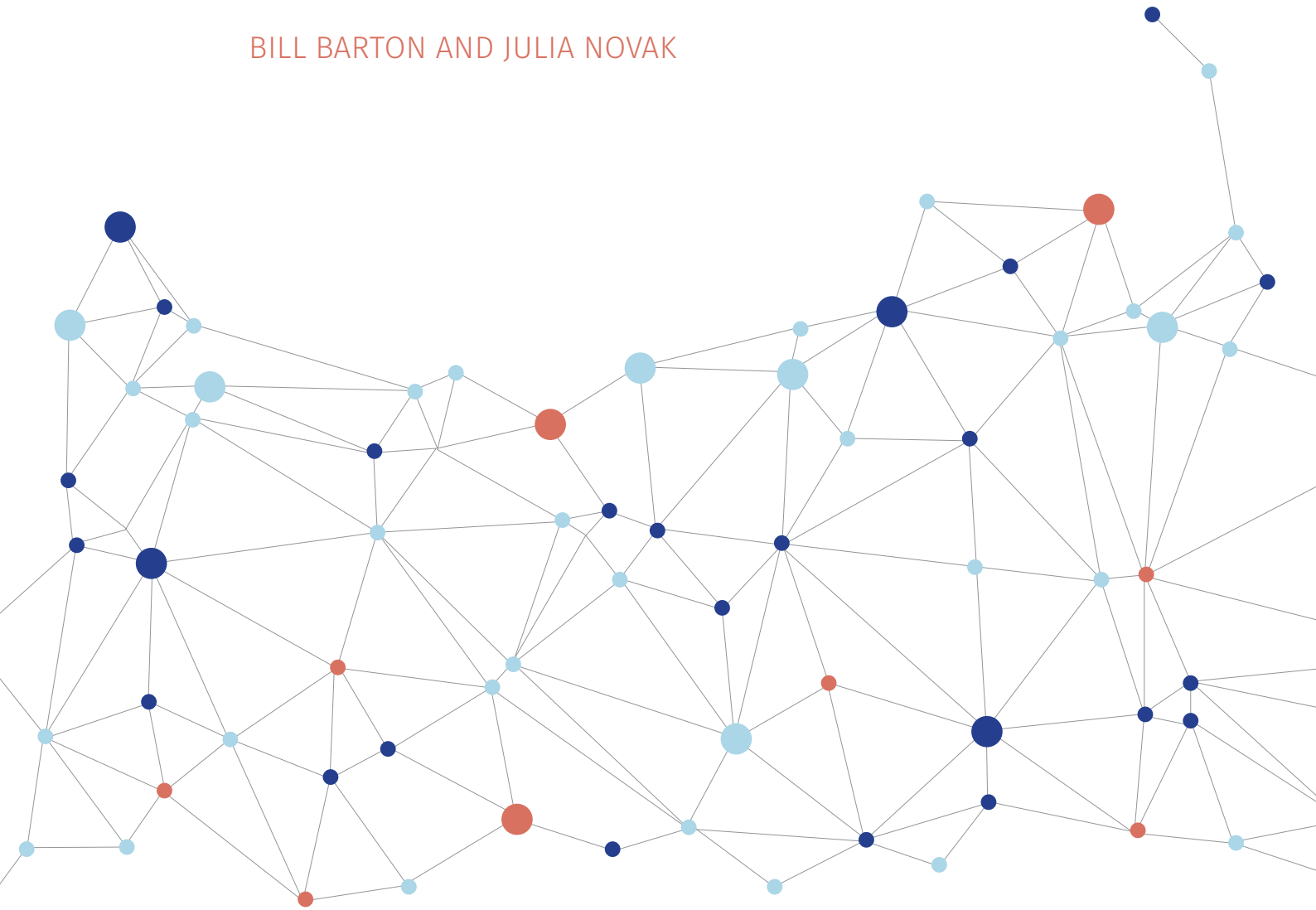
GUIDE #3

LEARNING IN UNDERGRADUATE MATHEMATICS: THE OUTCOME SPECTRUM (LUMOS) "HOW TO" GUIDES

Shift responsibility for learning onto students

BILL BARTON AND JULIA NOVAK



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"HOW TO" GUIDE #3: This guide is one of seven produced by the project Learning in Undergraduate Mathematics: The Outcome Spectrum (LUMOS). LUMOS examined the learning outcomes of undergraduates in the mathematical sciences.

The full list of titles in the series is:

"How to" Guide #1: Implement team-based learning

"How to" Guide #2: Implement semi-authentic mathematical experiences

"How to" Guide #3: Shift responsibility for learning onto students

"How to" Guide #4: Monitor feelings and beliefs about the mathematical sciences

"How to" Guide #5: Monitor the development of mathematical communication

"How to" Guide #6: Generate conceptual readiness

"How to" Guide #7: Develop mathematical habits

LEARNING IN UNDERGRADUATE MATHEMATICS: THE OUTCOME SPECTRUM (LUMOS).

"HOW TO" GUIDE #3: SHIFT RESPONSIBILITY FOR LEARNING ONTO STUDENTS

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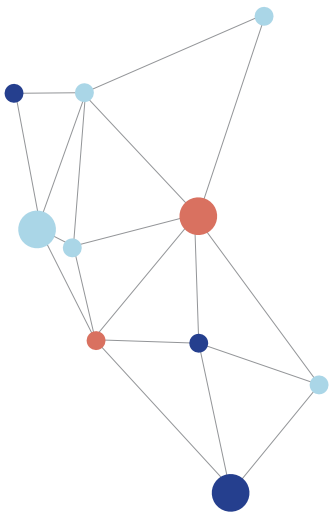

Contents

Shifting responsibilities

University education is a time when students become independent. This includes becoming independent learners.

At school, students usually have teachers who know them well and offer personal guidance, support, and encouragement for their learning. In recent years, aspects of this personal support have appeared in tertiary environments in order to make the transition to independent learning more gradual. Such changes were overdue, especially because of the larger cohort of students entering undergraduate education.

"Students need to take responsibility for their own learning, pursuing ideas and knowledge beyond the formal curriculum and developing an independent critique of the material they encounter.

Academics cannot make students do these things. At best, lecturers can provide a knowledge base to stimulate students' thinking; they can encourage intellectual risk-taking and inspire independent research.

Ultimately however, the interest, motivation, and sheer effort needed to master a subject can only come from students themselves. Learning cannot be done to people any more than it can be bought." (Williams, 2016)

While there is a responsibility on lecturers to inform students fully about course activities, course requirements, and assessment procedures, there is a fine line between communicating effectively, and over-defining and over-supervising learning processes to the extent that students focus solely on essential course requirements, university reminders and safety-nets.

As well as creating needed learning support, we need to explicitly transfer responsibility for learning to students as they grow in maturity and prepare for post-formal education in their careers. Many universities are making formal statements about student responsibility for learning, for example:

"... students should be given opportunities to acquire independent learning skills. In keeping with this expectation, students should anticipate that more responsibility will shift to them to learn independently as they progress through the levels of their studies. This may include identifying for themselves and/or making use of additional or supplementary learning resources that will aid them in their learning; recalling knowledge and skills previously learned; and developing new content knowledge upon which deeper and more refined learning activities can be based." Excerpt from Statement of Teaching and Learning Principles at Flinders University (Flinders University, 2016)

An overview of an approach

The LUMOS project trialled an approach to undergraduate delivery based on giving students more independence for content and skills learning in a first-year course. This guide describes this trial and the lessons we learned for future attempts to make students more responsible.

Called the Low Lecture trial, the aim of the trial was both to hand responsibility for basic learning and practising skills over to the students, and to use lectures in a more productive way. Research tells us that lectures, where students are passive, give lower cognitive outcomes than active learning environments (Michel, Cater, & Varela, 2009; Cui, 2013). However, in their "performance" characteristics, lectures are very good for motivating students, modelling mathematical behaviour, and giving overviews and colour to the material of the course.

The students were volunteers who were:

- offered only one lecture per week (instead of the usual three);
- given detailed descriptions of the content and skills to be learned;
- given references for written and on-line resources which would aid their self-study;
- offered self-monitoring quizzes, so that they could test their learning for themselves;
- offered the usual tutorials and learning supports available to all students;
- assessed in the usual way (quizzes, assignments, mid-semester test, examination).

The students in the trial entered a special stream of a large first-year class. In our three trials, the grade differences between trial and non-trial students were not significantly different. However, it became obvious that this mode particularly suited some students, but is not recommended for others.

Features of this approach could easily be incorporated into the standard delivery of undergraduate mathematics, with, we believe, positive effects. For example, this mode could be used just in a two-week section of a course that contains only straight-forward learning of basic skills, and for which many on-line tutorials exist. However, such a piecemeal implementation may not impact very much on the learning independence of students. We thus recommend that features such as self-monitoring quizzes and sections of the course where responsibility for learning is passed back to the students are seen as integrated and significant features of the course. We believe that 30-40% of the course in this mode is feasible and would have an impact on students' learning culture.

Details of the approach

Setting the environment

Many students arrive at university unsure of learning expectations, but ready for a different environment from their school experience. Thus, first-year courses present a good opportunity to reset expectations and learning habits. However, our experience is that this is not a simple process.

We recommend being explicit from the very first contact with students, and repeating the message in many forms. Thus, preliminary advertising and course information needs to highlight the new approach, and the fact that it is different. Again, at the first meeting with students, the changes they will experience, and the requirements on them, should be at the forefront.

Whatever changes are implemented; we recommend the creation of an early-warning system to identify students who are not responding to the new expectations and thus putting their academic careers at risk. We were able to monitor student use of the on-line self-monitoring quizzes as a first indicator, and then check the course-work assessments of the students identified as at-risk.

Lectures

The single weekly lecture was very different from "normal" lectures. It did not attempt to teach any specific course material. Rather, the lecture was used to orient the students to aspects of the course and the material that were important.

The lecturer always gave an overview of that week's course material, saying why it was important, how it linked to other topics in the course and, also in prior and subsequent courses, indicating applications, and alerting students to important learning issues or potential misunderstandings in the material. The lecturer also used time to discuss student work (e.g. assignments or tutorial problems), to motivate students in mathematics generally and in course material in particular, and follow up more fully than usual on student questions.

Rather than being a crammed lecture, there was always more time to discuss broad mathematical ideas, paradoxes and puzzles, or news items. The time was available because teaching course material was removed. Lecturers reported much pleasure in giving these lectures because of the freedom to express themselves mathematically.

Attendance at these lectures tended to be slightly better than the norm at standard lectures.

A final note. On two or three occasions, it was found that one lecture per week was too many (or not necessary). Two lectures every three weeks seemed to be sufficient to present the "colour" to the mathematical content and skills under consideration.

Information for students

All students in this course (trial and non-trial students) had access to a comprehensive course-book that detailed the content covered in each lecture. Thus, trial students knew what was being taught that week. (Indeed, trial students could attend normal lectures, and/or view the lecture recordings. In practice, this happened rarely). There was also a recommended text.

In addition to that, trial students were given a summary sheet of the material for that week, giving course-book and textbook references. It also gave a list of possible on-line tutorial sites, and encouraged students to share other useful sites they found. (In practice this did happen, but not frequently). See Appendix 1 for a sample Weekly Sheet.

Safety nets

The shift in learning culture compared with school and other university courses is significant. Therefore, safety-nets need to be in place. Three techniques we used successfully were as follows:

1. The use of the Self-Monitoring Quizzes (not the actual mark achieved) was a good indicator of whether the student was undertaking significant self-learning. All those who used the Self-Monitoring Quizzes as intended eventually passed the course, usually with good marks.
2. All students in the trial could use all the non-trial materials and attend lectures or view recordings if they wished. Few students did this, but some used this back-up on occasions when they wanted further input for a particular topic.
3. All trial students could return to a non-trial stream at any stage of the course. In all trials one or two students did this after the first or second lecture, but none did it after Week 3 of the semester.

Self-Monitoring Quizzes

The Self-Monitoring Quizzes were sets of twenty short-answer questions delivered using the on-line course system. One quiz was available every two-weeks, testing the material that students were expected to have learned in that two weeks. When they answered each question, the system indicated whether their answer was correct, and, if wrong, gave a clue as to why it was wrong, or what else to think about.

Students were allowed as many attempts as they wished, and each question had two or three alternative phrasings, so that each attempt was not identical. Students were told that a mark of 18/20 was an indication that the work had been learned to a satisfactory standard, but that 20/20 was desirable. The questions were set at a standard so that anyone with a basic understanding of the topic could answer them. The students were warned that these questions were easier than those in formal assessments.

The total score was indicated at the end. The number of attempts and total score for each student was available to the course coordinator, but was not used in any way other than to identify students having difficulty. No marks counted toward any assessment.

Issues to be aware of

Who does it suit?

The Low Lecture mode of delivery of the undergraduate course particularly suited the following groups of students:

- part-time students also involved in part- or full-time work or child-care;
- students taking more than a standard load of courses;
- mature students;
- highly organised students;
- highly motivated students.

It suited the first two categories because it meant that these students did not feel required to attend so many lectures. Hence, they could come to campus less often or avoid clashes with other classes. It suited those in the other three categories because they were already suited to the new learning culture. Students who belonged to two or more of these categories really appreciated the opportunity the course offered.

This mode did not suit students who were less well prepared and/or disorganised in their study habits. Such students could be supported by running extra tutorials during which their basic learning was supported with group or individual consultations with tutors.

We trialled this mode on large multi-stream courses. This was ideal because students could opt out of it and return to standard delivery modes if they wished. However, it would also work in a single-stream class provided sufficient safety-nets and back-up were created in the initial stages.

Resources

If the responsibility for doing the learning is handed back to students, the responsibility to ensure the availability of high quality resources for this learning remains with the lecturer or department.

Not only does there need to be detailed communication of the required learning, but accessible and free, or reasonably priced, print and on-line resources describing the content at an appropriate level must be provided. Opportunities to practise the skills required must also be provided. At first year level, students cannot be expected to know what are suitable exercises and problems.

As a side note, the now common practice of recording lectures for student revision is a very useful resource for this mode of delivery.

Teaching demands

At first, lecturers will probably have difficulty resisting the urge to “teach”. The weekly lectures cannot become teaching times because both students and lecturers will quickly become dissatisfied. It is not possible to cover all the necessary content of most undergraduate courses in one lecture per week.

However, if this urge is resisted, then lecturers can indulge their interests, show their wider knowledge, and enjoy the freedom to pick up topics from student interaction. Such freedoms do require lecturers to inform themselves much more widely about the course material—for example, historical background, modern applications, links to other courses and to other disciplines are all possible topics. While this puts new demands on lecturers, those in our trials enjoyed the more colourful and more mathematical result.

The lectures become more like performances and less like classrooms.

Is this a Flipped Classroom? Yes and No.

The Low Lecture mode of delivery is like a Flipped Classroom in the sense that a significant part of student learning is handed over to the student to undertake in their own time.

However, the Low Lecture mode is not like a Flipped Classroom in that lecture time is not used as a student working session. The expert role of the lecturer is retained for three major functions: fully orienting the material; motivating the material; and working mathematically.

To adopt the rhetoric of Flipped Classroom literature:

- conventional courses have ‘the sage on the stage’;
- flipped classrooms have ‘a guide on the side’;
- the Low Lecture innovation has both ‘a guide on the stage’ AND ‘a sage by your side’.

That is, lectures are used for guiding, and the Engagement Sessions are used for working together mathematically.

Appendix 1

Sample Weekly Reference Sheet

MATHS 108
Low Lecture Innovation Stream
Week 3 Reference Sheet

Week 3. Content & Skills

(Lectures 6, 7 and 8 of the Conventional Course)

The topic of ***Continuity*** finishes off this initial section of the course on functions. We then turn our mind to the first of two sections on ***Linear Algebra***. This is likely to be new material for most of you, even if you have seen vectors before in Physics.

Continuity

1. Identify whether functions are continuous or not from their graphs (assuming they are drawn with sufficient detail).
2. Understand the idea of the definition of continuity (see the three conditions in the box "Maths Translator" on p43 of the Course-book).
3. Understand how to determine whether a composition of functions is continuous.
4. Apply this understanding to particular functions, especially rational functions.

Scalars, Vectors and Vector Arithmetic

1. Understand the difference between a scalar and a vector.
2. Be familiar with the different notations and representations of vectors.
3. Understand what is meant by R, R 2, R 3, and R n.
4. Be able to add and subtract vectors, and represent these operations on a diagram.
5. Be able to multiply a vector by a scalar, and represent this operation on a diagram.
6. Understand the conditions for vectors to be parallel.
7. Understand the idea of linear combinations of vectors.
8. Be able to find the length (norm, magnitude) of a vector.

Resources for learning

MATHS 108 Course-book, Chapters 6, 7 & 8, pp44-65.
I recommend that you use the Course-book as an additional resource and reference, not for your initial learning.

By now you will be (or should be) familiar with several tutorial sites, and will have developed your own favourite ones. Keep using those sites. In addition to the ones I have mentioned before, for Vectors you might start with the very straight forward tutorial at http://www.mathsisfun.com/algebra/vectors.html (ignoring the last example on pulling boxes), or http://tutorial.math.lamar.edu/Classes/CalcII/Vectors_Basics.aspx. The word "vector" has many uses, so Googling "Vectors" is not entirely helpful. But if you try Googling "vector tutorial maths", then you get many useful hits.

Sites I have mentioned in previous sheets are:

SparkNotes Khan Academy Math Tutor mathtutor∞ HELM

Please make sure you use the Resources on the MATHS 108 CECIL site. It gives text references and extra examples.

PLEASE LET ME KNOW IF YOU FIND OTHER RESOURCES THAT ARE PARTICULARLY USEFUL.

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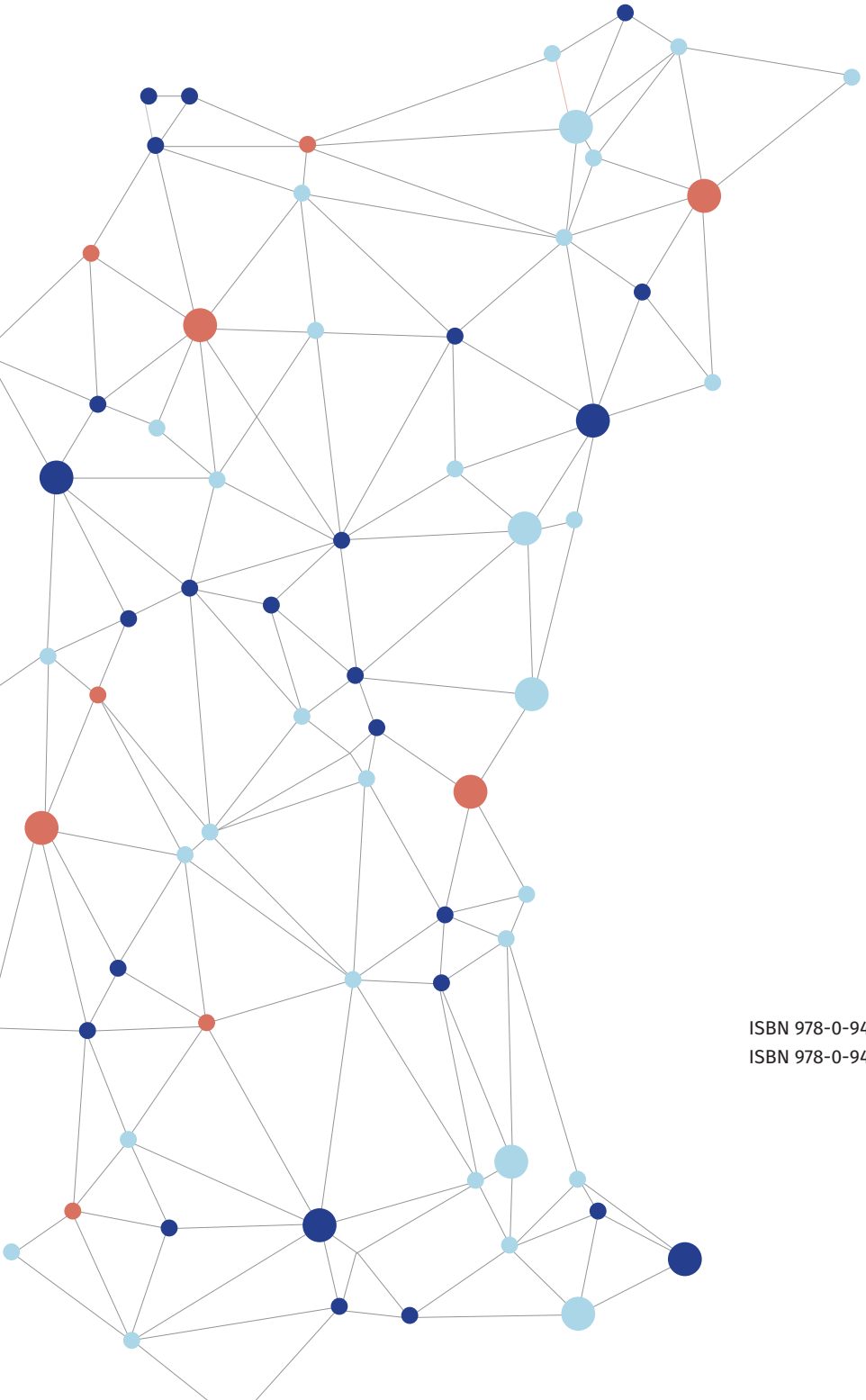

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