GUIDE #4

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

Monitor feelings and beliefs about the mathematical sciences

BILL BARTON AND LIZA BOLTON

TEACHING & LEARNING RESEARCH INITIATIVE
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“HOW TO” GUIDE #4: 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 #4:
MONITOR FEELINGS AND BELIEFS ABOUT THE MATHEMATICAL SCIENCES

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Contents

Feelings and beliefs and why we should monitor them

At undergraduate level our students have chosen to take our courses, so surely, they like mathematics and think it is worthwhile? Sadly, the answer is not universally "yes".

Many of our students, particularly first year students, have struggled with the subject, fear it, and doubt its relevance to their career aspirations, at least in the form that they have so far experienced mathematics. Hence the prime reason to monitor feelings, attitudes and beliefs is so that we understand our students better, and therefore understand their behaviour and reactions to aspects of our courses. We may, as a result, adapt what we do in order to achieve better engagement with our courses and our procedures.

More than this, the LUMOS project confirmed that lecturers hope to achieve development in the attitudes of students towards the mathematical sciences. But do we achieve this? Do students like, respect their mathematical subjects more, and fear them less, as a result of taking our courses? Do some of our courses achieve this outcome better than others? Why? Is it the content of the course, the way we deliver it, or what we do as individual lecturers?

Currently there are few, if any, systematic programmes that evaluate affect (the global term for feelings, attitudes and beliefs). We evaluate courses and lecturers, we assess content knowledge and skills, but not often do we check how students feel about their subject. And when we do check it, we use an ad hoc, unvalidated survey of some kind. This guide provides a reliable instrument that can be used to monitor any undergraduate course in the mathematical sciences. It is quick and easy to use, does not require special expertise, and may be used repeatedly.

The instrument is designed to give a picture of the feelings, attitudes and beliefs relating to the whole course. We know that it is both valid and reliable, and sensitive enough to detect changes at the class level over the period of a single semester course, and to show differences between courses at different levels and in different areas of the mathematical sciences. That is, this instrument will give a lecturer the information they need to understand the quality and development of student feelings and attitudes in their course. It may help a lecturer answer some of the questions posed in the second paragraph above.

What this booklet does not do is explain how to monitor individual students. The instrument we describe is not proven to be valid or reliable at the individual level. It will not tell you anything significant about a student who is causing concern, or for whom you need to write a reference.

The reader may be surprised by the claims we make for our affect survey, especially when you see how simple it is. Be assured that we were just as surprised that such a small survey was as sensitive and reliable as our testing told us. However, the explanation lies in the work that went into its development. This survey built on an earlier survey produced in Australia, went through several changes and trials, and was subject to extended and rigorous statistical analysis. We commend it for your use.

What feelings and beliefs can we monitor?

When we surveyed lecturers in the mathematical sciences about what outcomes they wanted for their students, few mentioned any affective outcomes. When challenged on this, many did agree that they hoped for improvements in the way students felt about mathematics—however, still no-one mentioned "liking" mathematics. This was surprising because, at primary and secondary level (where nearly all previous research has been done, see Chamberlin, 2010), the many surveys measuring "liking" for mathematics dominate the literature.

University lecturers, on the other hand, reported assuming their students liked mathematics, or said that such an attitude was not important to them. Rather, they wanted their students to "respect" mathematics, to understand its power, beauty, and place in the world.

Research on feelings, attitudes and beliefs is difficult because it is important that any instrument is measuring a dimension that is independent of other dimensions. For example, if a student is asked a question about mathematics anxiety, how is the answer related to the student's ability to do tests? If a student is asked about how worthwhile mathematics is, how is the answer related to their perception of relevance to their everyday life? Fortunately, it is possible to analyse responses to survey questions for just this characteristic, and hence obtain clusters of questions that seem to measure some dimension of affect, and are independent of other dimensions.

In our project, we were lucky to be able to build on the PhD work of Cretchley (2012), which had done just this analysis both for Mathematics and for Mathematics and Technology—the only such work we found at undergraduate level. She was able to identify two independent subscales for mathematics ("Confidence" and "Interest and Enjoyment"), as well as two that involved technology. In our work, we ignored the technology issue, but managed to create a third independent subscale using lecturers' prompting for something that reflected the respect and usefulness of the mathematical sciences. Our attempts to find other dimensions of affect were unsuccessful.

Hence the three dimensions of affect that make up our instrument are:

Confidence & Anxiety (CA)

Interest & Enjoyment (IE)

Respect & Usefulness (RU)

We believe that other aspects of feelings, attitudes and belief that are independent of these dimensions will be difficult to find, and may not exist.

An Affect Survey

The Affect Survey consists of 12 Likert-type questions on a five-point scale. Standard labels are attached to responses (Strongly Agree; Agree; Neutral; Disagree; Strongly Disagree).

Four questions apply to each of the three subscales (CA, IE, RU). While the questions are randomised in each survey, responses may only be amalgamated within each subscale. We advise reversing one or two questions when administering the survey. Remember to re-reverse the responses prior to amalgamating the data. Responses may be used either as each question independently, or as three subscale scores.

The questions are as follows. Randomised sample surveys with some questions reversed are given in the Appendix.

1. Confidence and anxiety (CA)
    a. I have less trouble learning mathematics than other subjects
    b. When I have difficulties with maths, I know I can handle them
    c. I am quicker to understand maths than the average person
    d. I do not find mathematics stressful
2. Interest and enjoyment (IE)
    a. When I hear people talking about maths, I listen
    b. I enjoy trying to solve new mathematics problems
    c. I find many mathematics problems interesting
    d. I find solving mathematics problems satisfying
3. Personal respect and usefulness (RU)
    a. Mathematics is a useful tool that helps me solve other problems
    b. I think mathematics is a way of expressing powerful ideas
    c. If I do not understand mathematics, it will be difficult to understand many other subjects
    d. Mathematics research contributes significantly to solving the world's problems

The survey may be administered entirely on paper, via PowerPoint or similar medium with answer slips, via Google Docs or similar public software (as we used it), or via internal course internet platforms. Our trials were all voluntary, where the url of the survey was given in lectures and students were asked to please respond. Response rates varied from 30-80%, with most greater than 50%; so, most were sufficient for statistically valid results.

Our advice for responses is as follows. A common threshold goal would be to have at least 30 respondents for classes of 40 or more and aim for above 60% response rate—students that don't respond may be different in some important way from those that do respond, which is why we seek a high response rate. For a class of less than 40, aim for 80% response rate with a minimum of 70%.

We strongly advise you to choose a rate that is acceptable before you start, and then work hard to meet that level of response. The following table is a rough guide, but do not stop trying for more responses when you have met your target; bigger is better!

Class size	*Target Minimum Response Rate*	*Minimum Acceptable Response Rate*
10	8	7
20	16	14
50	40	30
100	80	60
200	160	120

If your responses are lower than desired, then try some of the following:

- Give students time in lectures to complete the survey.
- Re-announce the survey and give follow-up emails or notices in lectures.
- Find a way for all respondents to go in a prize draw (while their answers remain anonymous).
- Select a smaller random sample (aim for more than 30) and work hard to get 100% of the sample to respond. If getting a high response rate is shown to be challenging, this approach would give better data than obtaining more voluntary responses that are not representative.

The time required to complete the survey is less than two minutes. We attributed good response rates to the very short time investment required. We found that there was some drop-off when administered a second time (at the end of the course), but again this was mitigated by the short time required.

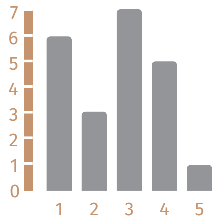
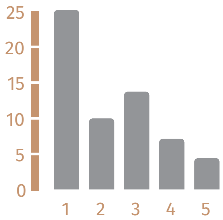
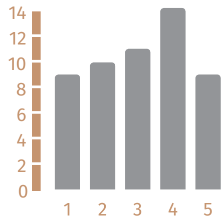
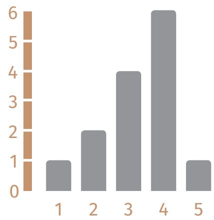
We strongly recommend that survey responses are kept anonymous (or as anonymous as web-based surveys can be). There is no use for individual data in any case, so no information is lost.

Using the results

We used the results of the Affect Survey in two main ways: for better understanding the cohort of students in a particular course; and for monitoring whether the attitudes and feelings of students changed over the duration of a course.

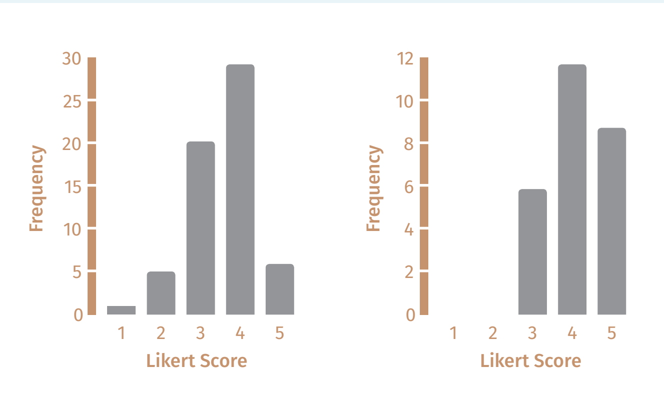
Understanding a cohort of students was enhanced because not only could we look at the raw responses, but also, we were able to compare different cohorts. For example, in our Department of Mathematics, as well as its courses for mathematics majors, there are courses for those not majoring in the mathematical sciences (MATHS 108), and a precursor course to MATHS 108 if you do not have Year 13 Mathematics (MATHS 102). If you pass MATHS 108 then you can take MATHS 208, which again is not recommended for mathematics majors. In addition, the School of Engineering have their own first year mathematics course (ENGSCI 111).

We were able to get data for all four courses in the same year. Here is the result for one question in the Confidence and Anxiety dimension (1 – strongly disagree; 5 – strongly agree):

	MATHS 102 (No Yr 13 background)	*MATHS 108 (Standard non-major first course)*	*MATHS 208 (Second course for non-majors)*	*ENGSCI 111 (Entry course for Engineering)*
I have less trouble learning mathematics than other subjects				

We would expect the Engineering students to be most confident, as they are a select group. We would also expect the Second course students to be more confident than the First course students, because only those succeeding will have continued. But why are those in the Introductory course (students with a poor background) more confident than those in the Standard course? And the Standard course students were much less confident than we expected. These results were consistent across most of the twelve questions, and consistent over later instances of these courses.

This survey is sensitive enough to detect changes over one semester. In our trials, we administered the survey both at the beginning and at the end of several courses. Nearly all changes that were significant (and there were not many) were small, but all were positive. For example, these pre- and post-course responses to the question “When I have difficulties with mathematics, I know I can handle them” show significant positive change.



Sometimes we were able to observe changes within a course even when the number of responses were quite small, although, of course, in general, the larger the cohort the more reliable and more valid is the instrument.

It would be possible to add questions to the survey that ask demographic or personal data, but we do not recommend it. First of all, we have no evidence either way on whether analysis of such data would be valid. Secondly, our experience (undocumented) is that adding to the length of the survey, and adding personal questions, reduces the response rate. We feel that keeping the response rate high is more valuable than any information we would get from demographically sorted data.

We would like to hear about others who use this survey, their results and experiences. We are willing to collate any information sent to us, and feedback the collated data to those who contribute to it so that this survey, and its developments, can better serve us in the future. Please write to Bill Barton, email: b.barton@auckland.ac.nz.

Appendix 1

Sample Survey 1

The first two versions of the survey below are the versions we used, randomised in different ways. Note that questions indicated by * are posed in reverse form, and responses need to be returned to positive form before any amalgamation of data within a subscale. The subscale (CA, IE, RU) is indicated for each question. This identification, and the asterisks, need to be removed before administration.

The third version of the survey includes alterations to which questions are reversed, and includes one new question. Note that this new question has not been statistically verified in our work, but we are confident that it will contribute to its respective subscale correctly. We welcome receiving any such analysis.

We recommend, if administering the survey as a pre-course/post-course survey, that exactly the same version is used in each administration.

1. I have less trouble learning mathematics than other subjects (CA)
2. I find many mathematics problems interesting (IE)
3. When I have difficulties with maths, I know I can handle them (CA)
4. I think mathematics is a way of expressing powerful ideas (RU)
5. It takes me longer to understand maths than the average person (*CA)
6. When I hear people talking about maths, I listen (IE)
7. I enjoy trying to solve new mathematics problems (IE)
8. I find mathematics stressful (*CA)
9. If I do not understand mathematics it will be difficult to understand many other subjects (RU)
10. I find solving mathematics problems satisfying (IE)
11. Mathematics is a useful tool that helps me solve other problems (RU)
12. Mathematics research contributes significantly to solving the world's problems (RU)

Appendix 2

Sample Survey 2

1. When I have difficulties with maths, I know I can handle them (CA)
2. I find many mathematics problems interesting (IE)
3. I think mathematics is a way of expressing powerful ideas (RU)
4. I find solving mathematics problems satisfying (IE)
5. I have less trouble learning mathematics than other subjects (CA)
6. Mathematics research contributes significantly to solving the world's problems (RU)
7. Mathematics is a useful tool that helps me solve other problems (RU)
8. I find mathematics stressful (*CA)
9. If I do not understand mathematics it will be difficult to understand many other subjects (RU)
10. I enjoy trying to solve new mathematics problems (IE)
11. When I hear people talking about maths, I listen (IE)
12. It takes me longer to understand maths than the average person (*CA)

Appendix 3

Sample Survey 3

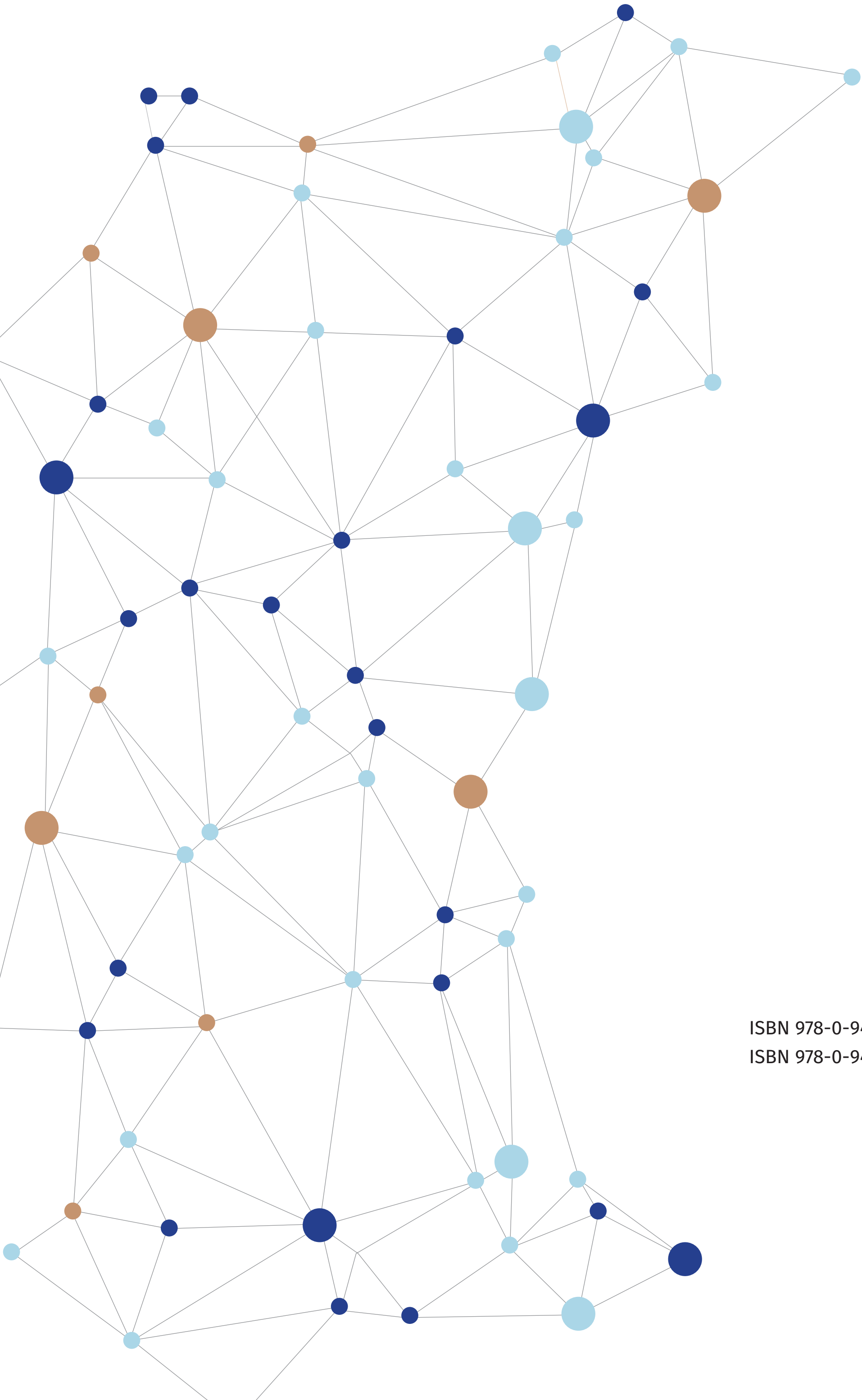
1. I find very few mathematics problems are interesting (*IE)
2. I think mathematics is a way of expressing powerful ideas (RU)
3. Mathematics research contributes significantly to solving the world's problems (RU)
4. I enjoy trying to solve new mathematics problems (IE)
5. I find mathematics stressful (*CA)
6. Mathematics is a useful tool that helps me solve other problems (RU)
7. If I do not understand mathematics it will be difficult to understand many other subjects (RU)
8. If I see articles about mathematics, then I usually read them (IE—new question)
9. When I have difficulties with maths, I know I can handle them (CA)
10. I am quicker to understand maths than the average person (CA)
11. I find solving mathematics problems satisfying (IE)
12. I have less trouble learning mathematics than other subjects (CA)

References

Chamberlin, S. (2010). A review of instruments created to assess affect in mathematics. *Journal of Mathematics Education*, 3(1), 167-82.

Cretchley, P. (2012). Students engaging with Professional Mathematical Software: A Study of First-Year University Mathematics Learning with Matlab. PhD thesis, University of Queensland.

Fogarty, G., Cretchley, P., Harman, C., Ellerton, N., & Konki, N. (2001). Validation of a questionnaire to measure mathematics confidence, computer confidence, and attitudes towards the use of technology for learning mathematics. *Mathematics Education Research Journal*, 13(2), 154-160.



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