Mathematics support at university

Janet Harris[1]
University of Waikato
New Zealand

Abstract

This paper examines why mathematics support is necessary at universities and who should provide this support. The paper discusses the types of students who have difficulty with mathematics and provides a reflection of the author's own work in the field of mathematics support. The thesis of the paper is that mathematics support is required and that trained learning developers can offer this support in a friendly and supportive environment that is unaffiliated to other departments.

Introduction

Educators from different countries find that many students do not have sufficient initial learning to support the mathematics used at university (Croft, 2001; Engineering Council, 2000; James, Montelle, & Williams 2008). Hearne Scientific Software (2002) reported in a newsletter that 52% of Australian lecturers they had surveyed believed that there was a decline in the mathematical skills of undergraduates taking engineering courses. The apparent decline in students' mathematics abilities is just one part of the problem in Australia. Hood (2010) refers to a review carried out by eight Australian universities that suggests that children are losing interest in mathematics and science at school, which is leading to fewer students taking courses with mathematical content at university. Walker (2000) believes that Britain is also suffering from a decline in mathematical standards at school level. Lawson (2004) cites a series of reports by professional bodies that raise concern about the mathematical competence of new undergraduates in Britain. He provides some objective evidence of this decline in the form of a summary of changes observed in the results of diagnostic testing in mathematics, using the same test, amongst new undergraduate students with the same mathematics entry qualification, at one university during the period 1991 to 2001. Scores in the test dropped considerably during this period. Lawson describes the use of mathematics support centres at a number of universities to address the problem. In his report on a joint conference held by The Institute of Mathematics and its Applications (IMA) and The European Society of Engineering Education (SEFI), Barry (2008) notes that one of the themes was the decline in mathematical preparedness, not just in Britain but throughout Europe and other parts of the world.

[1] Harris, J. (2010). Mathematics support at university. In V. van der Ham, L. Sevillano, & L. George (Eds.), *Shifting sands, firm foundations: Proceedings of the 2009 Annual International Conference of the Association of Tertiary Learning Advisors of Aotearoa/New Zealand (ATLAANZ)* (pp. 106-114). Auckland: ATLAANZ.

To counter this apparent decline in students' mathematical abilities many higher education institutions in countries such as Ireland, Britain and Australia have instigated large-scale drives to introduce mathematics support centres within institutions themselves (Barry, 2008; Croft 2000; Mac an Bhaird & O'Shea, 2009; MacGillivray, 2008). There is not a great deal of literature on mathematics support in New Zealand universities; however, there does appear to be a recognised need for mathematics support as some universities do have support centres. There also appears to be limited New Zealand representation at conferences. In 2007, a representative of Lincoln University attended a symposium on Learning Support for Mathematics and Statistics at the Queensland University of Technology (Australian Network in Learning Support in Mathematics and Statistics, 2007). In 2009, the University of Waikato had a representative at the ATLAANZ conference 'Shifting sands, firm foundations' in which a session was given on a new type of workshop that had been trialled by the staff of mathematics learning support at the University of Waikato. Although there is considerable literature on the decline of students' mathematical abilities and the causes for this decline in Europe and Australia over the last 10 to 15 years, there has not been the same flow of literature in New Zealand.

This paper discusses the types of students who may need mathematics support at university and includes a list of some of the more common types of mathematical errors students make, which raises the issue of who should try to help students to correct these errors. The paper offers an insight into the work of the author and the types of mathematics support offered at the author's university and recommends that appropriately trained staff carry out mathematics learning support in a supportive and friendly environment.

Mathematics learning support

There appear to be two particular groups of students that are a cause for concern in universities. The first group involves students considered as non-specialist (students whose courses contain components of mathematics). The main problems these students encounter stem from an inability to transfer the mathematical skills they have learnt to their chosen subjects, and as Croft (2002, p. 147) points out:

> The mathematical education of non-specialist undergrads has long been a bone of contention. … The debate about the ownership of the mathematical education of these students may often be reduced to the level of a playground brawl. Decisions about ownership are not made on sound pedagogical grounds, but are often more to do with financial and political considerations, and sometimes to do with failure-rate control.

In the author's own university, the mathematics department offers support to mathematics students only, which until recently left non-specialist undergraduates

seeking help wherever they could, until Student Learning began offering mathematics learning support.

The second group of students needing support are those who have weak mathematical backgrounds. The need for mathematical learning support as a separate entity is identified by Croft (2002, p. 146) citing Hunt and Lawson (1997), who believe "it would be arrogant and unrealistic of lecturers – many of whom have no formal teaching qualification – to assume that they have the expertise to put right the cumulative failures of school education." They pose the question: "Who are the best people to teach mathematics at this level in universities given the nature of the problem?"

The level of mathematics that staff are required to teach to weak students is well below university standards. Schechter (2001) gives a list of some of the more common errors in undergraduate mathematics, which include the following:

- sign errors
- confusion about the square root symbol
- unconventional order of operations
- ambiguously writing fractions
- everything is undistributed cancellations.

Comments by Professor Stephen Joe (personal communication, 2009, June 22) on errors by first year undergraduates taking mathematics included:

- difficulty in dealing with negative numbers
- incorrect expansion of algebraic equations
- incorrect manipulation of indices and logarithms.

The above examples are simple errors caused by incorrect application or little knowledge of basic mathematics and can be corrected with a small amount of tuition. However, if these errors are left uncorrected they can cause enormous problems for students doing mathematics that is more advanced.

In considering how to deal with the above types of errors, Croft (2002, p. 146) cites Sutherland and Dewhurst (1999) who believe "The teaching needs are more akin to school teaching and university lecturers are not the best people to be carrying out this kind of work." Croft further cites Larcombe (1998) who writes: "mathematicians have no appetite for what they see as unrewarding and often thankless work" (p. 146) which strengthens the argument that mathematics support would be better undertaken by a separate entity.

With the perceived decline in students' mathematical abilities, it is imperative to take steps to retain students and help them complete their chosen courses. The literature on retention and completion rates for mathematics and mathematics related subjects

around the world is particularly gloomy at present (Cuthbert & MacGillivray, 2007; Engineering Council, 2000), as is the drop in numbers of the students entering tertiary education to follow mathematics and mathematics related courses such as engineering and accountancy. In New Zealand, Scott (2009) reports on the decline of domestic, undergraduate enrolments in specific subjects since 2002. These include enrolments in Manufacturing, Engineering and Technology (declined by 41%); Accountancy (declined by 20%); Mathematical Sciences (declined by 22%); and Teacher Education (declined by 15%).

In 2009, Student Learning Support at the author's university began offering limited mathematics support to all students in the university to facilitate retention of students and completion of courses and the author of this paper, as a mathematics learning developer, began to offer one-to-one consultations, online resources and trialled two specialised workshops in Semester B, 2009. The nature of the consultation process is considered in detail below, but first a brief outline of the workshops and the online resources is provided.

Student Learning Support mathematics workshops

The two workshops trialled in Semester B 2009 were designed for students who have difficulties with mathematical word problems. The author chose this topic as the reading of mathematical problems can cause difficulties for students at levels of ability, but especially for those students who have English as a second language (Neville-Barton, 2005). However, second language students are not the only ones who have difficulties. Clement (1982) describes how "science-orientated college students" (p. 16) were unable to do basic algebra word problems.

The workshops trialled in Semester B ran in a slightly different format from the standard mathematics workshops in that they were co-taught by the author, a mathematics learning developer and an English learning developer. The workshops were considered successful, based on attendance and evaluations carried out by the university's Appraisals Office. The evaluation indicated that 100% of those who attended were satisfied with the overall content included in the workshops.

In Semester A, 2010, a total of ten mathematics workshops will be run, including the two word-based workshops run in Semester B, 2009. The ten workshops will be based on various mathematical topics, and include small amounts of theory. Examples given in the workshop are drawn from different content areas, such as economics and engineering. The workshops are designed to introduce students to the terminology of mathematics and to the terminology, as it is used, in other subjects so that students can see the connections between mathematics and the courses they are taking.

Online mathematics support

To enhance the support offered to students with a mathematics component in their courses, Student Learning Support has produced its own online resources that students can access. Students are able to read about a topic, take tests and ask questions

through forums. An example of such a topic is 'Using Decimals' which includes lessons and quizzes such as 'Manipulating Numbers in Standard Form'. The on-line resource is still in its infancy and requires a great deal more added to it, especially in terms of interactive material. However, funding and staff are limited, as is the software capable of dealing with mathematics.

Reflections

Over the years, in my role as a learning developer, I have seen many students requiring mathematics support. They vary in background, culture, age and the subjects they take. Some of these students have had poor mathematical abilities, while others have been more advanced. However, whatever their abilities they all have one thing in common: when they perceive they have a problem, they exhibit some degree of anxiety. Research shows that anxiety can inhibit learning (Metje, Frank, & Croft, 2007; Steen, 1999), and our first task, which is pastoral in nature, is to ensure that the students feel comfortable and confident within themselves (Wood, 2001). The problems students bring to consultations are not necessarily confined to mathematical problems. They can include problems associated with how they perceive their lecturers or tutors, personal problems, time management, and language problems, all of which can all impact a student's ability to learn. If the problem is not mathematical then I can refer students to counsellors or to their lecturers.

However, usually the problem is mathematical, so, our second task is diagnostic in nature. By discussing the problem with the student, we can usually unravel the reason why the student cannot understand what is required of them. This may be something as simple as misreading the question or copying down incorrect lecture notes, (a very common problem for second language students) or it may be a case of previous misconceptions coming to the surface as they advance in mathematics. In my experience the majority of students have problems because they have missed 'chunks' of basic mathematics such as fractions, or they are unable to connect what they did in school mathematics to the subject they are now taking. This appears particularly true where differentiation is concerned.

The first type of problem, missing 'chunks' of basic mathematics, can be addressed in several ways, but the overriding concern is to make sure the student does not feel 'stupid' or 'backward' because they do not understand a basic concept. The second type of problem is more difficult to counter. Many students seem to be unable to transfer their mathematical knowledge to other subjects (MacGillivray, 2008). Again, this may be due to some insufficiency in their mathematics but for many it is the 'jargon' associated with mathematics and the 'jargon' associated with the subject they are taking, they very often have nothing in common. Students can fail to make a connection between the different terms used and often become confused and unsure of their abilities. The inability of students to transfer their mathematics to other subjects can come as something of a shock to them. Students may feel that they have mastered mathematics when actually all they have done is use rote, formulaic methods of

answering questions. When they come to apply this knowledge to other subjects, they have very little idea what the mathematics they learnt has to do with their new subjects and for some it can mean a premature end to their university study.

Once the diagnostic episode has taken place, the third task can begin which is to look at what skills the students need to tackle the problem and to make sure they do not face the same problem again.

This 'three task' programme may seem rather mundane and repetitive, but it is not. Each student is entirely different in their learning needs, so even when students present with the same problem, the skills required to overcome the problem can vary greatly. It is therefore necessary to be able to understand where a student is 'coming from', that is, how they perceive the problem, and how capable they are of dealing with any new skills introduced. Overtaxing the student can add to the problem so careful thought is given to how to interact with each person.

The 'three task' method of offering mathematics support may also seem heuristic in nature but politics and economics dictate what resources are available for offering support to students in New Zealand universities. In the author's university there are no resources other than the author as a 0.5 EFT mathematics learning developer. There are no funds for computers or books to support learning and the programme is forced to rely on a few books provided by the author. Countries such as Britain and Australia have acknowledged that there is concern about the decline in students' mathematical abilities and have invested money, from governments and universities, into countering this decline.

Summary

There is strong evidence from the literature that there is a decline in students' mathematical abilities in many parts of the world. Several countries have taken up the challenge to counter this decline by providing extra support for non-specialist students and students who have weak mathematical abilities. The author's own unit has begun to offer limited mathematical support for all students with the intention of helping to raise retention and completion rates. However, raising retention and completion rates is a long-term project and the benefits are not immediately apparent. Politics and money dictate resourcing and support centres are seen as a low priority because they do not generate an income. This is sufficient 'ammunition' for different departments, and even whole institutions to continue arguments over who teaches non-specialist undergraduates and undergraduates with weak mathematical backgrounds. Pedagogy and offering students as much mathematical support as possible are issues that appear to be of small concern and cutting costs by using staff unsuited to this level of teaching appears to be fairly common practice . However, if New Zealand is to maintain its integrity within the fields of research and manufacturing, intervention is required now to ensure the country has a sufficient graduate force to keep pace with the rest of the world.

The question of whether university is the right place to counter the perceived decline in students' mathematical abilities is outside the scope of this paper. However, while there is a problem, government and universities must explore all avenues and make resources available so that students have the best chance possible to graduate.

References

Australian Network in Learning Support in Mathematics and Statistics. (2007). *Carrick Project: Report from the 2007 Symposium on Learning Support in Mathematics and Statistics in Higher Education.* Retrieved November 9, 2009, from http://sky.scitech.qut.edu.au/~macgilli/carrick//symposium.html#presentation

Barry, M. (2008). Conference report. *IMI 6th Mathematical Education of Engineers and SEFI Mathematics Working Group 14th European Seminar 2008.* Retrieved June 17, 2009, from http://www.ima.org.uk/mathematics/mt_june_08_conference_report.html

Clement, J. (1982). Algebra word problem solutions: Thought processes underlying a common misconception. *Journal for Research in Mathematics Education, 13*(1), 16-30. Retrieved April 7, 2010 from http://www.jstor.org/stable/748434

Croft, A.(2000). A guide to the establishment of a successful mathematics learning support centre. *The International Journal of Mathematics Education in Science and Technology, 31* (3), 431-446. Retrieved from http://pdfserve.informaworld.com/ 848491_751316537_713816333.pdf

Croft, A. (2001). *A holistic view of mathematics support in Higher Education*. Retrieved from http://mathstore.ac.uk/workshops/maths-support/croft.pdf

Croft, A. (2002). Mathematics: The teaching, learning and support of non-specialists. In P. Kahn & J. Kyle (Eds.), *Effective learning & teaching in mathematics & its applications* (pp. 144-158). London: Kogan Page.

Cuthbert, R. H., & MacGillivray, H. L. (2007, November). Investigation of completion rates of Engineering students [Electronic version]. In *Proceedings of the 6th Southern Hemisphere Conference on Mathematics and Statistics Teaching and Learning (El Calafate DELTA' 07*) (pp. 35-41), El Calafate, Argentina. Retrieved February 11, 2010, from http://eprints.qut.edu.au/13163/

Engineering Council. (2000). *Measuring the mathematics problem.* Retrieved from http://www.engc.org.uk/ecukdocuments/internet/document%20library/Measuring%20the%20Mathematic%20Problems.pdf

Hearne Scientific Software. (2002, March 30). *Poor maths skills failing Engineering students.* Retrieved April 7, 2010, from http://www.hearne.com.au/news/24/

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33-46. Retrieved June 8, 2010, from http://www.jstor.org/stable/749455

Hood, L. (2010, March 10). *Group of Eight Review's sum of all fears: Maths is in serious decline* . Retrieved April 7, 2010, from news.com.au: http://www.news.com.au/ national/group-of-eight-reviews-sum-of-all-fears-maths-is-in-serious-decline/story-e6frfkvr-1225838924327

James, A., Montelle, C., & Williams, P. (2008). From lessons to lectures: NCEA mathematics results and first-year mathematics performance. *International Journal of Mathematical Education in Science and Technology, 39*(8), 1037-1050. Retrieved from http://www.math.canterbury.ac.nz/ ~a.james/files/papers/ncea.pdf

Lawson, D. (2004). Supporting the transition from school mathematics to university mathematics. In M. Demlova & D. Lawson (Eds.), *Proceedings of the 12th SEFI Maths Working Group Seminar* (pp. 95-100). Retrieved June 18, 2010, from http://sefi.htw-aalen.de/Seminars/sefi2004.pdf

Mac an Bhaird, C., & O'Shea, A. (2009). *Is mathematics support worthwhile? An overview of the 3rd Irish workshop on mathematics learning and support centres in MSOR connections, 9*(2), 52-55. Retrieved from http://www.mathstore.ac.uk/ headocs/9252_bhaird_c_and_oshea_a_mathssupport.pdf

MacGillivray, H. (2008). *Learning support in mathematics and statistics in Australian universities: A guide for the university sector.* Retrieved from http://pandora.nla.gov.au/pan/88626/20080918-1313/www.altc.edu.au/carrick/ webdav/users/siteadmin/public/grants_project_learningsupport_maths_guide_aug08.pdf

Metje, N. Frank, H. L., & Croft, P. (2007). Can't do maths – understanding students' maths anxiety. *Teaching Mathematics and its Applications, 26*(2), 79-88. doi: 10.1093/teamat/hrl023

Neville-Barton, P. & Barton, B. (2005*). The relationship between English language and mathematics learning for non-native speakers.* Retrieved from http://www.tlri.org.nz/assets/pdf/9211_summaryreport.pdf

Schechter, E. (2001). *The most common errors in under graduate mathematics*. Retrieved June 9, 2010, from http://www.math.vanderbilt.edu/ ~schectex/commerrs/

Scott, D. (2009, April). *Trends in fields of study of bachelors degree graduates in New Zealand*. Retrieved April 14, 2010, from http://www.educationcounts.govt.nz/publications/tertiary_education/41801/3

Steen, L.A. (1999.) Twenty questions about mathematical reasoning. In L. Stiff (Ed.), *NCTM'S 1999 Yearbook: Developing Mathematical Reasoning in Grades K-12* (pp. 270-285). Retrieved February 6, 2010, from http://www.stolaf.edu/people/steen/Papers/reason.html

Walker, J. (2000). *Additional work for universities as students arrive minus maths skills.* Retrieved April 7, 2010, from http://www.highbeam.com/doc/1G1-63396126.html

Wood, L. (2001). The secondary-tertiary interface. In D. Holton (Ed.). *The teaching and learning of mathematics at university level: An ICMI study* (p. 94). Hingham, MA, Kluwer Academic Publishers.