

# Mathematics Support: promoting student learning and some factors that may work against student learning

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## Abstract

In Australia, learning support in mathematics has been a part of the university landscape for many years. In 1973, a 'counsellor in mathematics' was appointed to the Communication and Study Skills Unit at the Australian National University, and in 1984 the first dedicated 'mathematics learning centres' were established in two Australian universities.

The Mathematics Learning Centre at the University of Sydney was established in 1984 and offers mathematics support to students who enrol at the University without the appropriate level of mathematics for their degree programs. Western Sydney University has provided some mathematics support for students for roughly 20 years. Since 2011, all mathematics support at Western Sydney University has been coordinated through the Mathematics Education Support Hub. The Mathematics Education Support Hub offers mathematics support to all students both on-campus and off-campus.

In this paper, we will discuss the ways we endeavour to ensure that mathematics support at our universities promotes independent learning. We will also discuss the pressures on mathematics support that may have an adverse impact on student learning. These pressures may come from the institution and include cost cutting measures, pressures on staff teaching in mathematics support and pressures on the students themselves.

## 1. Introduction

In Australia, mathematics learning support has been a part of the university landscape since 1973, when a 'counsellor in mathematics' was appointed to the Communication and Study Skills Unit at the Australian National University, and in 1984 the first dedicated 'mathematics learning centres' were established at the University of Sydney and Queensland Institute of Technology (Capricornia) (MacGillivray 2009, p. 459). By 2007, some form of learning support in mathematics was offered in 32 out of 39 Australian universities with Drop-in assistance being 'the most commonly offered assistance' (MacGillivray 2009 p. 459-460).

The University of Sydney was founded in 1850 and is a large research-intensive metropolitan university with over 54,000 students. About 82% of its students study on the main campus and mathematics learning support is offered through the Mathematics Learning Centre (MLC), which was established in 1984.

By contrast, Western Sydney University (WSU) was founded in 1989 and is a multi-campus university situated in the greater western Sydney area. It has over 42,000 students in ten schools. The majority of Schools offer degree programs where some quantitative skills are needed. Most degree programs are offered on more than one of the five main WSU campuses. The Mathematics Education Support Hub (MESH) was established in 2011 and offers mathematics support to students both on-campus and off-campus.

The term *mathematics support* should be interpreted to include support in both mathematics and statistics.

## 2. Best practice

The aim of all those teaching mathematics and statistics at university level should be to develop and enhance a student's understanding. Teaching students to blindly and unthinkingly use formulas or apply tests without understanding the underlying concepts, when they apply and how to modify them for different circumstances is doing all of society a disservice. As university teachers we want students to understand, to think, to problem solve, to know when and how to use what they have learnt. Mathematics and statistics learning support must work to support this.

### 2.1. Mathematics Teaching and Learning

The premise that underpins mathematics support at WSU and the University of Sydney is that mathematical capacity is acquired and mathematical thinking is developed through **doing** mathematics.

This idea is self-evident to mathematicians and is not new. It was elegantly expressed by the famous mathematician Paul Halmos:

'For a student of mathematics to hear someone talk about mathematics does hardly any more good than for a student of swimming to hear someone talk about swimming.'

Halmos, Moise and Piranian (1975, p. 466)

Teaching mathematics to mathematically under-prepared university students is complex and nuanced as each student must be individually assessed to determine his or her mathematical skills, conceptual understanding of key ideas and ways of thinking mathematically.

Some of our students can lack even the sense of the value of a fraction, while others may be missing just some of the more subtle concepts from calculus. Careful assessment of each student's knowledge and understanding is necessary to provide appropriate targeted assistance. Face-to-face contact with students is essential for such assessment. In this area, one size definitely does not fit all.

### 2.2. Mathematics Support at Western Sydney University and the University of Sydney

There are many common aspects with the way that mathematics support is delivered at our universities including our emphasis on student learning by doing mathematics. We organise our practice to take account of the diversity of our students so that each student's needs are assessed. However, there are some significant differences due to the structure of the universities.

WSU has provided some mathematics support for students for roughly 20 years. Since the inception of MESH in 2011 a more coordinated approach to mathematics and statistics support has evolved with the services offered to students increased in type and capacity. MESH services to assist students with numeracy, mathematics and statistics now include bridging workshops before the start of the academic year, a drop-in service, an online answer service, targeted workshops, online materials and assistance to academics to help them to help their students. MESH contract and permanent staff all have relevant postgraduate qualifications.

The drop-in service runs on six campuses in a campus library, from just two hours a week to roughly 16 hours a week, depending on student demand. Students can approach a MESH tutor for assistance with any quantitative aspect of their studies; they can work nearby getting assistance as needed, work in groups or alone.

The workshops are run for specific subjects, usually just before a test, quiz or exam, as this is when demand for assistance peaks. MESH provides students with questions covering the content to be examined, and students are expected to work in groups, discussing and solv-

ing the problems, with the MESH staff facilitating this process. For almost all subjects, the MESH support staff are not involved in the teaching of the subject.

An online answer service and online resources enable students to access assistance from anywhere, anytime. However, there is much less interest in these online services than in the drop-in service or workshops. MESH staff also curate, create and modify resources.

Feedback from students who have used MESH services is very positive, for example, 'MESH library roving [drop-in service] will save you in this unit.' and 'MESH workshops are the kickstart to getting serious about exam prep study for this subject. Hugely helpful'.

At the University of Sydney, the MLC provides a range of mathematics support including bridging courses held in February, a drop-in centre and targeted revision workshops held throughout the academic year (March to November), and unrestricted access to a range of electronic resources – MathsCasts – and other paper based mathematics resources.

The MLC Drop-in Centre is the primary means of providing mathematics support at the University of Sydney and accounts for about 86% of student attendance.

A dedicated drop-in centre was originally established to provide a simple, flexible and non-threatening way for students with similar difficulties to study together at their own pace and seek assistance when necessary, enabling students 'to engage with mathematics or statistics in an environment with no formal expectations of them other than that they are there to try' (MacGillivray & Croft 2011, p. 196). We expect our students to adopt this ethos and we work hard to promote a mathematics learning community – a place where students come together to learn and help each other learn.

Research has established the success of this model for students at risk in learning mathematics. In their study of two mathematics support centres similar to the MLC, Solomon, Croft & Lawson (2010, p. 423) argued that:

'while their greatest benefit is the availability of focused one-to-one support as an immediate response to specific problems, students also comment on the importance of atmosphere and the learning environment, an increase in student control and lack of time pressure, and the informality and psychological security of centres'.

Many students perceive tutorials as 'risky spaces' and feel too exposed to ask questions in them (Solomon et al. 2010, p. 427). The MLC Drop-in Centre, however, gives students a safe environment to ask questions away from their tutorials. As one student put it: 'I often come in confused, upset and distressed [and] leave with clarity' (Student feedback).

The revision workshops in the major mathematics subjects are held each week to revise a particular mathematical concept and closely follow the subject outlines. The workshop format varies and may include group discussions as well as students working individually during the workshops. As at WSU, there is a predictable spike in interest just before the assessments.

The MLC, along with many other mathematics support centres, has produced MathsCasts or short videos on mathematical topics; 89 in total attracting about 11,000 views in 2016. The MathsCasts are freely available on the MLC website.

However, video is essentially a passive medium, and by itself, passively listening or watching others do mathematics 'is in actuality no learning' (MacGillivray 2009, p. 470).

For this reason, the MathsCasts were designed to compliment rather than replace the face-to-face programs. All MathsCasts are linked to either our face-to-face mathematics bridging courses or to a specific university mathematics subject. Some MathsCasts incorporate exercises for students to 'pause and try this for yourself' with additional exercises provided in print form, while other MathCasts are linked to particular questions in the subject tutorial problem sheets.

### **3. Pressures on the provision of mathematics support**

The non-core nature of mathematics learning support makes it vulnerable in times of cuts to university funding. MacGillivray and Croft (2011, p. 191) report that one of the themes that emerged in audits of mathematics support centres carried out in the Australia, Ireland and the UK is the lack of security of those centres. Perkin, Lawson and Croft (2013, p. 171) found that mathematics support had decreased or ceased in some UK universities and 'this seems, in the main, to relate to the lack of available funds or insufficient strategic lead' and not because mathematics support was no longer needed.

#### **3.1. Economic Pressures at Institutional Level**

One of the ways that universities have attempted to make economies in mathematics support in Australia is to employ professional staff, that is non-academic staff, in mathematics learning support roles. At WSU, one academic staff position was replaced by a professional staff position when the academic staff member retired. In 2013, at a Group of Eight university in Australia, there was an unsuccessful attempt to convert the academic positions of the mathematics support centre to professional staff positions.

The savings here are twofold and may reduce the quality of mathematics support offered to students. Firstly, classifying a position as professional removes the requirement of the staff member to do research or even to keep up with the research in mathematics learning support. However, over time, this may have a detrimental effect on student learning as teaching becomes 'research uninformed and research uninforming' (B. James, personal communication, Nov 2016).

Secondly, professional staff are denied a well-defined career path available to academic staff – that of promotion. Hence a staff member in a professional position will be cheaper in the long run by preventing any salary increases due to promotion. However, advertising a mathematics support role as non-academic reduces the pool of qualified applicants by potentially excluding those applicants interested in an academic career. Such applicants may see a professional position as a 'dead end'. At one university, filling a mathematics support position with professional staff proved to be much more difficult than filling a similar position with academic staff.

The casualisation of teaching and the increasing number of staff on fixed-term contracts in Australian universities can also have a detrimental effect on providing mathematics support. As support staff are often in contact with students from many different subjects (more than 30 subjects in at least 10 disciplines in one semester at WSU), it takes considerable knowledge and experience to be able to give a high level of appropriate support for all relevant subjects. Knowledge of subject content, expectations of teaching academics, terminology used and level of mastery expected, all enable support staff to better assist students. Consequently, it can take a full year before support staff are able to perform at optimal level.

Furthermore, at times of budget pressure, a regular occurrence at many universities, casual staff are easy targets for budget cuts with contract staff also at great risk when their contracts end. Cutting staff, even if more staff are hired in better times, means that institutional knowledge and staff expertise is lost and has to be redeveloped.

#### **3.2. Strategic Leadership at Institutional Level**

Strategic leadership is also of critical importance in establishing and maintaining mathematics support and 'buy-in from a senior management "champion" is needed' (Croft, Groves and Lawson 2016, p. 4).

Unfortunately, there is a real risk to mathematics support when senior management changes especially if a champion is lost. A change in leadership at the highest levels may be accompanied with changes to university governance, or changes to university funding models. These changes may have unintended consequences impacting on the provision of mathematics support. In the mid 1990s at the University of Sydney, a change to the university funding model saw the MLC effectively defunded and operating on budget deficits for several years. More recently, the University Economic Model has resulted in charges for dedicated space devolving to each department or unit. In 2014, this threatened the existence of the MLC Drop-in Centre and hence the way mathematics support was offered at the University of Sydney.

Moreover, even without major structural changes, a new senior manager may not understand the cumulative nature of mathematics or how it is learned. He or she may even believe that one can pick up missing skills easily and quickly. This can result in a senior manager pushing particular models of mathematics support or teaching that are not best suited or even pedagogically sound.

### **3.3. Face-to-face or not?**

There has been pressure, perhaps seen as a way to provide mathematics support more economically, to either substitute online mathematics support for more traditional face-to-face support or to 'tweak the mix' towards providing more online support at the expense of face-to-face support.

However, communicating mathematics effectively to an under-prepared student is a difficult task involving a continual assessment of the student's understanding. This is best accomplished in the student's presence.

Goodyear (2007, p. 95) argues that co-presence (face-to-face) interaction 'is "thick" with information, for example body language, gesture and silence'. He goes on to argue that face-to-face allows for 'fluent timing of turn taking' and the 'efficiency and flexibility of "loose talk" allows rapid topic identification and shifting between topics' — 'good for arriving at outcomes for which there is no script'.

Without face-to-face interactions one loses the opportunity to push students to write, to take charge of a problem and to move from being a spectator to being an active participant in their mathematics or statistics. Frequently, one needs to read the very subtle signals that indicate when a student does not understand what is being done. At such times much gentle probing may be needed to determine the missing knowledge or misunderstandings that need to be addressed before progress is possible.

Even student/staff interactions via video links do not have these advantages, and we support Goodyear (2007, p. 95) when he says 'we have to have very good reasons for denying learners the chance to capitalize on the affordances of co-presence'. We believe this is true especially for students in mathematics support.

### **3.4. Pressures on Staff**

Those of us who work in mathematics support usually do so out of a desire to improve the learning outcomes for students who are 'at risk' of failing or withdrawing from their mathematics subjects.

In recent years, there has been an increasing use of metrics to measure not only research quantity and quality, and grant success of academic staff in universities, but also teaching quality and success (Teelken, 2012). These metrics may be used in promotions and for assessing acceptable academic performance at yearly evaluations, and, as such, they must be taken seriously by staff.

At the University of Sydney, at the time of writing, academic staff in standard teaching and research positions, including mathematics support staff, have workloads weighted according to a 40:40:20 model in research, teaching and administration. There are also expectations that each academic meets a 'minimum standard' for research, and consequences can be severe for staff who fail to do so. In 2011/12, academic staff who failed to meet the University's criteria for research active staff were targeted for redundancy. The metric used considered only research performance – teaching was deemed irrelevant to this exercise.

The pressure to publish, arguably the most important criterion for promotion, puts the mathematics support academic in a quandary. Should staff continue to spend the time and 'go the extra mile' for their students and in doing so, put their teaching and their students' learning before their research, or do they attend to the requirement for more research and increasing research quality? Failing to do the latter, leaves staff who support student learning in the firing line.

There has also been more emphasis in recent years on student evaluation of teaching (SET) by means of student surveys. However, the findings of Uttl, White and Gonzales (2017, p. 22) suggest that there are 'no significant correlations between SET ratings and learning', and paradoxically, using such metrics may have the effect of depreciating the teaching quality due to 'increased workloads and administrative processes' (Teelken 2012, p. 286). Evidence of 'good teaching' from SET surveys may measure whether students like the lecturer (Teelken 2012, p. 285), student satisfaction, student perceptions of their course experience or student interest and not teaching effectiveness (Uttl et al. 2017).

Uttl et al. (2017, p. 40) suggest that academic staff 'face a stark dilemma' of teaching to obtain good student ratings 'and be promoted' or teaching to promote student learning, 'and be terminated'. It has already been noted that to learn mathematics students must do mathematics. So insisting that students to do mathematics, rather than watch someone else do the mathematics is better for student learning, but it is harder for students and so may not lead to good student evaluations.

In the era of performance management, an academic staff member has the unenviable task of balancing their students' needs against their own survival as an academic.

### **3.5. Pressures on Students**

University students are increasingly under economic pressure and time pressure; from increased tuition fees and increased work commitments.

University education in Australia is not free. An Australian student who is studying science or engineering full-time will pay, or if they access the government loan scheme owe, tuition fees of \$9,050 in 2017. Over the past 20 years, tuition fees have increased in real terms and are expected to increase by an additional 7.5% by 2021 with graduates being required to repay their debt sooner and faster.

In 2014, an estimated 53% of first year university students were in paid work with 33% of full-time students and 42% of part-time students reporting that part-time or casual work was their only source of income. (Baik, Naylor & Arkoudis 2015, p. 54-56).

In their survey of first year students across eight Australian universities, Baik et al. (2015, p. 57) found that 77% of younger students ( $\leq 19$  years old) work 'to afford extras (such as travel, [or] entertainment)' or 'to be more financially independent of their families' (72%), but 51% of this group also work 'to meet basic needs' including rent, food and transport. The percentage of students who work to meet basic needs increases for older students: 75% for students aged 20-24, and 79% for students over 25 years old (Baik et al. 2015, p. 57). Interestingly, 37% of the 19 and under age group reported that they undertake paid work to save in order to repay their government debt (Baik et al. 2015, p. 57).

Financial pressures on students are increasing as a higher percentage of the costs of a university education are now borne by the students themselves. Consequently, the number of hours that students spend in paid work has been increasing for the last 20 years with students earning money for an estimated average of 14.5 hours per week in 2014 (Baik et al. 2015, p. 58).

It is, therefore, not surprising that 66% of working students report 'that their financial situation is a source of worry' or that for 55% of working students 'work interferes with study' with 24% of students reporting that they miss class to work (Baik et al. 2015, p. 59).

An example of a negative consequence of paid work is that at WSU recently, of 21 students who registered for a mathematics bridging course but did not attend, 28.6% said the reason for their non-attendance was that they had to work.

The time devoted to using mathematics support, such as drop-in sessions or special workshops, is in addition to timetabled activities, and thus may prove difficult for students to schedule along with paid work. Students who need to, or feel the need to work have less time to make use of mathematics support and may be reluctant to engage with mathematics support. We have observed that, in recent years, students are more likely to attend review classes before assessments and not weekly classes that systematically build up mathematical knowledge and capabilities, and we have been forced to accommodate this attendance pattern. However, the time poor student looking only for a quick fix, often just before an exam or an assessment task, is unlikely to learn much of value in these classes.

#### **4. Conclusion**

In this paper we have endeavoured to articulate some of the principles that promote student learning and the pressures that can act against it. Some things are beyond our control, but we believe that we need to resist the casualisation of our work and the classification of our roles as non-academic as both may have a detrimental effect on the short and long term provision of high quality mathematics support.

Employing support staff on a continuing basis or long-term contracts provides more stability for staffing than casual or short-term contracts and so ensures that institutional knowledge and expertise is retained.

Employing academic staff in mathematics support roles ensures that vital research in this area continues. This research plays an important role in pushing back against uninformed management decisions that may seek to pressurise us into inappropriate and less effective forms of mathematics support, including online support instead of quality face-to-face support. Research in the discipline was instrumental in successfully arguing for the maintenance of a dedicated space for the MLC Drop-in Centre at the University of Sydney in 2014.

Many of the pressures and tensions felt by staff and students result in a loss of time devoted to mathematics support. Time is needed to provide good support, whether this is time spent with students or time used to develop quality resources. Staff time for mathematics support is lost when arguing against inappropriate models of support, justifying the need for support staff and protecting their career. On the other side, time is needed by students to take advantage of support and to practice mathematics, especially for those who need to recover from poor secondary school mathematics choices. However, the average number of hours students spend in paid work has been increasing and this trend is predicted to continue as the burden of the costs of university education shifts to the students (Baik et al. 2015, p. 93). This results in students having less time for learning.

Working in a mathematics support role is hard but very rewarding. Staff who work in the area are often passionate about their task of developing student capabilities and understandings in mathematics, but as academic staff we must be mindful of the need to achieve

a balance between our students' needs and the demands of our academic careers. We must also advocate for our colleagues who do not have the advantages of our academic status to ensure that they have employment certainty and can progress in their mathematics support role.

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