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Obtaining learning independence and academic success through self-assessment and referral to a Mathematics Learning Centre

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Abstract

Globally, universities are striving to increase enrolment rates, especially for low socioeconomic status and mature-aged students. In order to meet these targets, universities are accepting a broader range of students, often resulting in a widening mathematical knowledge gap between secondary school and university (Hoyles, Newman & Noss, 2001). Therefore, even amid the growing trend of scaling back services, there exists a need for extra learning support in mathematics. Mathematics support services are recognised as vital in assisting students to both bridge the knowledge gap and become independent learners. Through a survey of students using the Mathematics Learning Centre at Central Queensland University Australia, it was found that the implementation of scaffolding, adult learning principles and the embedding of mathematics support provides students with not only fundamental mathematical knowledge but also the skills required to become self-directed learners.

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Introduction

The demographic of university students is changing. Increasing enrolment rates and broadening participation, especially low socioeconomic status and mature-aged students, has become a focus for many universities including Australia, New Zealand and the United Kingdom (UK) (Australian Technology Network of Universities [ATNU], 2010; Curtin University of Technology [CUT], 2010; Hoyles et al., 2001; MacGillivray, 2008). Within Australia, changes have resulted from the Review of Higher Education (Bradley Report) recommending "that the Australian Government set a national target of at least 40 per cent of 25 to 34 year-olds having attained a qualification at bachelor level or above by 2020" (Bradley, Noonan, Nugent & Scales, 2008, p. xviii). The global trend to increase enrolments and accept a broader range of students is resulting in a "much greater diversity of numeracy, mathematical skills and knowledge backgrounds across tertiary cohorts" (MacGillivray, p. 15). The mathematics deficit exhibited by students entering university is "symptomatic of a general denial of mathematics for more than a decade, the consequences of which must now be acknowledged and faced by all types of universities" (p. 27).

With the removal of compulsory mathematics subject in years eleven and twelve in Australian schools, an increasing number of Australian students choose not to study mathematics beyond Year 10 resulting in under preparedness of students entering higher education (Varsavsky, 2010). Wilson and MacGillivray (2007) found that even when students had completed senior high school algebra and calculus, they still required assistance with basic mathematic at a tertiary level. "The increasingly weaker mathematics background of university entrants and its consequences have been reported around the world (Varsavsky). As the mathematical knowledge gap between secondary school and university broadens (Hoyles et al., 2001), mathematics learning centres in universities are becoming increasingly important. These independent units, which are typically separate from the faculties, are in an ideal position to foster independent learning practices which are vital for academic achievement. The facilities offered by these centres are providing "lifelines for students in areas with the greatest problems and inner conflicts in perceptions of the roles of mathematics both directly and indirectly in their disciplines" (MacGillivray, 2008, p. 24).

The Mathematics Learning Centre

The Mathematics Learning Centre (MLC) at Central Queensland University Australia (CQU) was established in 1984 as an academic support centre. The MLC provides assistance to students who are experiencing difficulty with the mathematics or quantitative component of their course. Undergraduate students wishing to utilise the service do so either by self-referral or by referral from their lecturer or tutor. Students are able to access the MLC for both individual and group tuition, according to their needs, regardless of school or faculty. In 2010, approximately 2,500[1][2] enquires came

[1] In 2010 there were approximately 4,800 students enrolled in first level courses with a mathematics component.

[2] This number also includes repeat visits by individual students.

through the MLC. This number includes inquiries from individual students either on-campus, by telephone or by email and group sessions and class room visits. Many of the students utilising the MLC choose to do so anonymously. The MLC also offers a range of preparatory courses for students seeking university entry through alternate pathways and bridging courses in mathematics for enrolled students undertaking course work with a mathematical component.

Two of the most important student characteristics, which influence the teaching and learning process used by the MLC, pertain to the students' prior skills and knowledge and their personal learning requirements. Many students who use the MLC have had limited mathematical opportunities throughout their schooling, leading to a deficiency in the required fundamentals of mathematics. This of course results in difficulties understanding the abstract and complex concepts often encountered in university mathematics. Additionally, negative mathematical experiences often result in apprehension and anxiety when solving mathematical problems.

In contrast, some students who access the MLC have sound mathematical skills and knowledge but require assistance with extending their mathematical understanding of more complex concepts and technological competencies. These students require minimal assistance and often have the confidence to continue on their learning journey with basic tips and occasional support.

On campuses with a dedicated MLC room, students are encouraged to utilise the space and the resources to study independently. This, coupled with the knowledge that help is nearby, enables students with low mathematical confidence to work more assuredly on their own and to ask for assistance only as required.

MLC resources – Scaffolding and adult learning

Scaffolding was initially conceptualised from a socio-cultural perspective as "a form of assistance that enables the child or the novice to solve a problem, carry out a task, or achieve a goal that would be beyond his or her unassisted efforts" (Wood, Bruner & Ross, 1976, p. 90). However, this approach to learning is true for all (Wood & Wood, 1996).

The original notion of scaffolding has been extended and challenged as information and communication technologies (ICT) based learning support has emerged (Azevedo & Hadwin, 2005; Lajoie, 2005). Within contemporary higher education, learning can be situated on a continuum from face-to-face, through a blended approach to one that is completely ICT-based. In mathematics learning support utilising ICT, the human interaction varies from reduced interaction to no interaction and teachers tend to be less responsive to learner feedback. Wood and Wood (1996) suggest that if interaction with computers can mirror even a small part of the effectiveness of class instruction, then progress towards more effective teaching is being made.

A number of guiding principles have informed the design and development of study materials for scaffolding students using the MLC. These principles are essentially based on the adult learning literature of Knowles, Holton and Swanson (1998) and Entwistle and Ramsden (1983)

and the principles in the use of computer-based materials (Alessi & Trollip, 1991). These aspects are briefly considered:

- Adult learners accessing the MLC are considered experiential learners who need programs that are meaningful and relevant to them. Adult learners like to be involved in a learning process facilitated in a climate of respect. A mathematics skills audit test is used to determine learners' background knowledge and understanding of mathematics.

- Adult learners see education as a process of developing increased competence to achieve their full potential in life. They want to be able to apply whatever knowledge and skills they gain today to living and working more effectively tomorrow. Accordingly, learning experiences should be organised around competency-development categories.

- It is a normal aspect of maturation for a person to move from dependence towards increasing self-direction. The rate of change to self-directed learning varies between people, depending on their backgrounds. Thus it is important to provide independent learning materials appropriate to a range of individual needs and levels of ability. Materials should, as far as possible, be self-instructional and self-paced and contain self-assessment opportunities.

- As individuals grow and develop, they accumulate a reservoir of experience that becomes an increasingly rich resource for learning. Accordingly, study materials should be activity-based and promote experiential learning within a supportive learning context.

- Individuals become ready to learn something when they experience a need to know in order to satisfy real-life tasks or problems. Thus materials should be relevant to the adult learner's own needs and encourage the learner to discover the need to know.

The model currently used by the MLC includes:

- Use of mathematics skills audit testing. Such testing is used to establish whether the student has any knowledge gaps in their basic mathematics or the prerequisite knowledge required for a particular course. In some cases these tests have been embedded into undergraduate courses.

- Provision of mathematics resources. These resources, designed to assist students in overcoming gaps in existing mathematics knowledge, are available online and from MLC centres on CQU campuses. In some instances, the resources have been embedded into undergraduate courses. Through collaboration between faculty and MLC staff, a web site has been especially prepared to enable students to refresh or bridge the background mathematics content and concepts needed for a range of programs. The content is presented in such a way that the students are able to work through it at their own pace.

- Provision of individual assistance with studies in mathematics. This service is provided through a drop-in service on the Bundaberg, Rockhampton, Gladstone and Mackay campuses. Many students use this service and in some cases there can be over 10 students in attendance on a single campus at one time.

- Assistance for students studying in distance mode. The MLC can be accessed in person at four of the CQU regional campuses, by telephone or via email. MLC staff use Tablet PCs to assist in providing a personalised online service to students. "A Tablet PC is a laptop computer that is equipped with a touch screen and stylus (pen) enabling the user to annotate (write on) the screen" (Adams, Elliott & Dekkers, 2010, p. 4). These Tablets allow MLC staff to easily and quickly respond to student enquiries, providing hand written solutions to problems or even videos if required.

- Delivery of workshops. The MLC provides workshops, on topics where students experience difficulties, at the request of course coordinators and in cooperation with faculty. Workshops are held during orientation week to highlight the mathematics the students may encounter in their undergraduate degree, give a brief introduction and advise students of resources and services available. Students are then encouraged to use the online resources provided via the MLC website.

This model ensures that the services provided by the MLC are scalable and provide an efficient service adjusted to meeting the different levels of scaffolding support required by students. The practices of the MLC are directed to supporting students in taking responsibility for their own learning and skills development.

Study overview

In 2010-2011, undergraduate students accessing the MLC services were invited to complete an MLC survey. Surveys were available within each of the MLCs with dedicated rooms or available from staff members where there were no dedicated study rooms. Completion of the surveys by on-campus students depended on the student's willingness to complete the survey when anonymity was not guaranteed. Distance students who had contacted the MLC via email were posted a paper-based survey. No follow up was conducted to encourage students to respond. While the primary aims of the survey were to gain a snapshot of MLC students and determine if dedicated MLC spaces for students were supported and, if so, how they contributed to independent learning practises, another aim was to evaluate the resources provided by the MLC staff to assist with student queries. Anecdotal evidence from student comments had supported the beliefs that dedicated spaces were more conducive to independent learning (over appointment-based tutorials in staff members' offices) and that distance students appreciated the type of support that can be afforded them through the use of the Tablet PC.

Forty-four students participated in the study, comprising 14 males and 30 females ranging in age from 19 to 62. The study was conducted across four CQU campuses and included students studying internally or by distance as well as those studying part- or full-time. Of the students surveyed, 75% (33/44) attended the MLC on a campus. The survey questions are presented in Table 1.

Table 1: ***MLS survey questions***

Date:	Course(s):		Program:	Study Mode:	FT	PT	Internal	Flex
Gender:	M	F				Age:		

I learnt about the MLC through:

Lecturer/Tutor	Moodle/CQU website	Email	Class visit by MLC staff or orientation session	Fellow Student

What was your main reason for visiting/contacting the MLC? (pick only one)

A	Recommend by Lecturer/Tutor	E	Previously failed assessment item or course
B	Recommended by a fellow student	F	Didn't want to ask the lecturer
C	Needed help with an assignment question(s)	G	Low confidence in my mathematics ability
D	Didn't understand a concept/topic/problem in a lecture/tute/text and needed help		

How did you seek assistance from the MLC?	Which campus did you visit
Did you find sharing the room with other students helpful or inconvenient?	In your opinion, how conducive to ***independent learning/self-study*** was the MLC study room?
In your opinion, ***overall*** how conducive to study/learning was the MLC room?	The handouts provided were effective and readily available
The MLC website was useful	By contacting/visiting the MLC, I have found that my mathematics has improved

Following a study on Mathematics Learning Centres within Australia, MacGillivray (2008) recommended that MLCs should have dedicated study spaces. In view of this recommendation, we wanted to determine if students felt that dedicated MLC spaces were conducive to independent learning/study and if these spaces were preferable to assistance provided in staff offices. We were also interested in reasons why individual students accessed the service and if they attended by self-referral. Due to the increasing prevalence of mathematics deficits exhibited by students entering university, we wanted to know if students felt that the assistance provide through the MLCs increased their mathematical knowledge.

Dedicated MLC rooms

The Australia Learning and Teaching Council (ALTC) study conducted by MacGillivray (2008) recommends that MLC spaces should be a dedicated place where students can work and access at least paper-based resources and assistance from a duty tutor during specified hours. Its value is lessened if it is only available when a tutor is on duty or if there is no staffing

assistance at all. The atmosphere of the space should be conducive to collaborative work provided others are not disturbed.

CQU presently has dedicated MLC rooms on two of the four campuses. On the other two campuses, the student either obtains on-campus assistance in the staff member's office or a tutorial room is booked for the session.

The dedicated MLC rooms on both Rockhampton and Mackay campuses are located near staff offices. A timetable of staff availability is displayed on the MLC door and even though staff are only available at rostered times, the space is available to use within normal office hours. Thirty-four of the 39 (87.2%) participants having access to a dedicated MLC space found it conducive to overall study/learning. Of these, 64.7% (22/34) thought the service was excellent at achieving this. Student comments on the use of the dedicated MLC spaces included *I like the convenience of being able to study anytime in the room* and *It is a quiet and conducive place* [sic] *to study.*

On campuses with dedicated MLC spaces, there are often multiple students utilising the service at any particular time. Sometimes students will attend in a study group and sometimes they will form an impromptu study group with other students already in the room. As can be observed from Figure 1, when asked if students found it helpful or inconvenient to have other students in the room at the same time, only 7% (2/28) of students found it inconvenient whilst many found it helpful.

Self-assessment

Self-assessment is an important part of becoming a successful student. The acquisition of self-assessment skills not only improves learning in a particular course but also establishes the foundation for lifelong learning (McDonald & Boud, 2003). In a study examining self-assessment in school children, Blatchford (1997) found that social factors affected children's ability to accurately self-assess. Dunning, Heath and Suls (2004) conclude that accurate self-assessment is especially

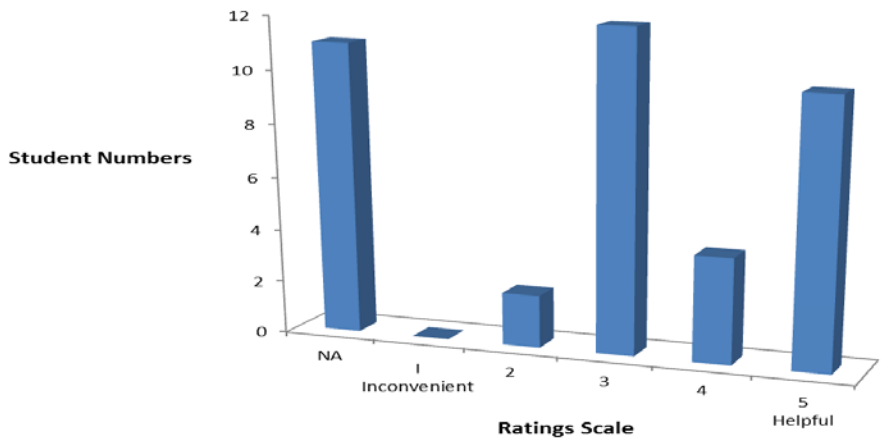

Figure 1: **Students views on sharing MLC space**

crucial in higher education though several factors limit the student's ability to accurately self-assess. These factors are:

- Information deficits—the lack of knowledge or expertise to accurately assess competence. Five of the students surveyed were referred to the MLC for assistance by their lecturer or tutor indicating their inability to correctly self-assess. When faculties and MLCs work closely together, students with information deficits can reap the benefits of the MLC and work toward gaining a closer alignment between their predicted and actual abilities. MacGillivray (2008*)* also highlighted the importance of a symbiotic relationship between mathematics support and faculties.

- Unknown errors of omission—the inability to recognise knowledge gaps. To assist in highlighting the knowledge gaps that a student may have, the MLC has developed course-specific mathematics skills audit tests. Some of these tests are still administered by MLC staff but the majority have been embedded into courses, often being offered as an on-line quiz that students can attempt repeatedly in order to reassess their knowledge.

- Information neglect—the failure to take into account information that is at hand. Some students either never seek mathematical support when required or wait until they have failed an assessment or subject, sometimes more than once, before attending the MLC. Two of the study participants fell into this category.

Even though McDonald and Boud (2003) found that self-assessment training should be incorporated as part of the curriculum, through the use of diagnostic testing and reciprocal relationships between the MLC and the faculties, students are better able to self-assess their need for mathematical support and self-refer to the service for assistance. In fact 52% (23/44) of participating students attended the MLC because they recognised their failure to comprehend a concept, topic or problem in a lecture, tutorial or in their textbook. Nine needed help with assignment questions and even though the MLC does not assist students with their assignments, staff will help students gain the mathematical knowledge required for their assignment. Furthermore, distance students that contact the MLC are supplied with resources, including videos and handwritten solutions created with the Tablet PC, to bridge their knowledge gap.

Independent learning and study

The MLC encourages students to develop independent learning habits by providing assistance on an as needed basis. Small group tutorials are encouraged to entice students to interact and work together to improve their own learning. The MLC does not provide an editorial service or check student assignments. On campuses with dedicated MLC spaces, students can work independently and seek assistance from the duty tutor when required. Knowing that assistance is nearby increases the students' confidence to work independently. As can be observed from Figure 2, of the students surveyed that attended MLCs with dedicated study spaces, 82% (7/39) found the space to be conducive to independent learning and study, with the remaining 18% being neutral. Additionally, of the students who

thought the space was beneficial, 66% (21/32) rated it as excellent.

Under the direction of the Head of the MLC, specialised MLC staff skills are utilised to create an array of resources that can be incorporated into enabling programs or used by university students to bridge any gaps in their knowledge. These resources are available for students to use and keep when accessing the MLC service on campus. Of the 30 students that used the handouts 80% (24/30) found them at least satisfactory with 79% (19/24) of these students finding them to be an excellent resource.

The majority of these resources are also available via the MLC website. This allows students to access resources at their own convenience, further enhancing independent study habits. Providing materials via the Web reflects mathematics as a dynamic discipline with a range of intertwining concepts as opposed to the linear approach provided by text-based materials. The Web affords opportunities to present the material in a more fluent manner, similar to the nature of mathematics itself. Through this structure "students can select and access material and content according to their needs" (Webster & Hackley, 1997, p. 1289). Twenty-two of the students surveyed had used the MLC website. Of these, nearly three-quarters (16/22; 72.7%) stated that they found the site to be very useful.

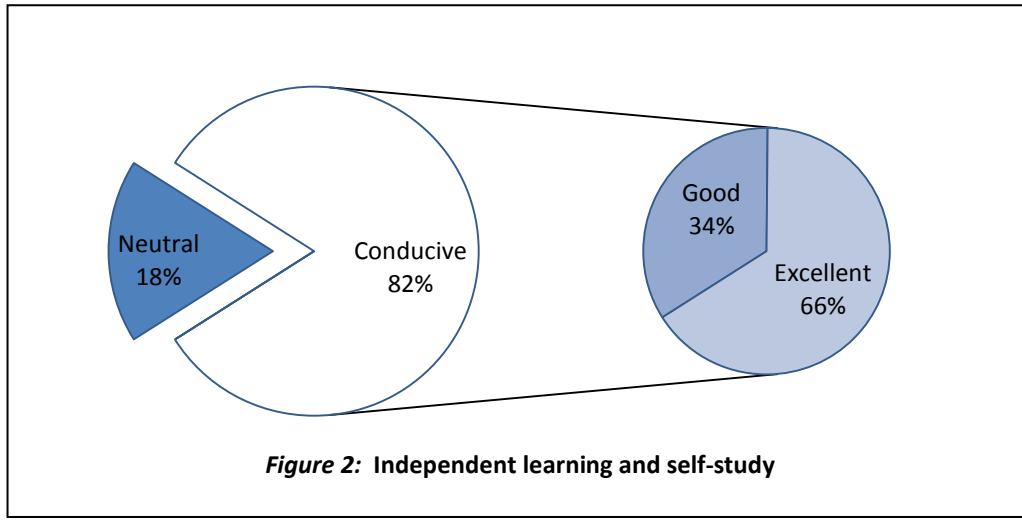

Figure 2: **Independent learning and self-study**

Embedding in undergraduate courses

Where students have omissions in the mathematical knowledge required to succeed in a course or fail to understand the mathematical concepts being taught, support is required to prevent attrition. All of the students surveyed found the MLC service useful and would recommend it to other students. When asked if they had discovered an improvement in their mathematics, 98% (39/40) of the students found that there was at least some improvement with 48% (19/40) attesting to a vast improvement in mathematical performance.

To address the growing mathematical knowledge deficit in students entering university, many universities are attempting to embed mathematics learning support within the content of their undergraduate courses. Within CQU, an increasing number of mathematics and statistics courses[3] are embedding learning support. Though the embedded material is not as extensive and sophisticated as other universities, especially some within the UK (Golden & Lee, 2007), it does assist students in self-assessment of their mathematical knowledge and encourages either self-directed study or self-referral for further assistance.

Within the UK, government funded projects and collaboration between universities has resulted in Web- and text-based mathematics learning support resources being made available (Golden & Lee, 2007). These resources are then able to be embedded into individual university courses. Unfortunately within Australia, the varying intellectual property policies across universities make the sharing of teaching materials difficult (Porter, 2011).

> Despite the turf wars, however, it remained the case that, addressing the need for learning support arising from students' poor mathematical skills required and still requires, collaborative effort and a coherent framework in which the provision of learning support can be aligned with the subjects/disciplines that are generating the need. While through this project, a sustainable infrastructure has been created for hosting a resource collection, there remains a need for universities to encourage staff to fully populate the repository with good quality peer reviewed resources. (p. 11)

[3] A semester-long teaching activity with synonyms of "subject" or "unit."

Conclusion

The importance of mathematics to modern society cannot be understated. Globally, policy makers are promoting participation in Science, Technology, Engineering and Mathematics (STEM) education and training as a means of constructing a skilled workforce (Department of Education, Training and the Arts [DETA], 2007). Within Australia, STEM education and training is nationally recognised as underpinning economic growth (DETA). Yet, a shortfall in mathematical knowledge is prevalent globally.

In the present academic climate of widening participation and increasing gaps in mathematical knowledge, mathematics support centres are becoming increasingly important. Providing students with dedicated study spaces and assistance when required has been shown to increase independent learning and study. Combining this with the ability of students to self-assess through the provision of embedding of skills audit tests in undergraduate degrees enables students to bridge mathematics knowledge gaps.

Through the provision of mathematics support units as individual entities working closely with faculties, mathematical knowledge gaps are better able to be bridged. Furthermore students need ready access to such services.

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