Tertiary Numeracy Enquiry

Final Report

April 2010

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EXECUTIVE SUMMARY

The development of numeracy skills at all levels of education and their application in all areas of life is attracting interest in Australia and overseas. With numeracy demands of society increasing, it is becoming critical to provide all students with an opportunity to develop an appropriate level skill in this area.

This report focuses on numeracy at the tertiary level and comes as a response to numeracy concerns expressed by both staff and students at the University of Tasmania (UTAS). This work maps the numeracy demands of UTAS courses, identifies numeracy concerns and contributes to future work on addressing those issues and improving students’ overall learning experience.

The enquiry involved a series of semi-structured interviews with academic staff representing thirty-three different schools and centres at UTAS. The interviews were designed to help determine numeracy demands of UTAS courses and assess academics’ perceptions of the students’ numeracy capabilities. The project also scanned existing forms of numeracy support.

According to the results of the study, numeracy demands of some courses are more explicit than others, but essentially numeracy is required in every area of study. The enquiry provides a number of examples of how this looks in particular disciplines. Notwithstanding these varied requirements, there appears to be a mismatch between the numeracy requirements of UTAS courses and the students’ ability to meet those demands. The level of numeracy skills necessary to study different subjects, however, varies across all courses, from the most basic understanding of data presented in tables or graphs, to the most advanced Formal Mathematical Concepts.

Acknowledging the widespread requirement for numeracy across UTAS and the gaps that currently exist in students’ numeracy capabilities, the following recommendations are made:

1. Numeracy be included as a graduate attribute by explicit incorporation within one of the existing UTAS graduate attributes or academic standards. This would bring implicit numeracy demands more to the fore for both staff and students.

2. That avenues for supporting staff to develop students’ numeracy as it relates to the requirements of their discipline are implemented, through for example:
   - Professional learning for staff in embedding teaching of Developed Numeracy Concepts and Supporting Capabilities within units and courses;
   - Input from professionals in the teaching of numeracy; and
   - Online resources for staff and students.

3. Prepare a business plan for the provision of support for students in developing the numeracy necessary for successful study.
4. Conduct a review of the UTAS preparatory and bridging programs for mathematics, including UPP090 (Bridging Mathematics), KMA003 (Foundation Mathematics), and BEA109 (Introduction to Quantitative Methods) in light of the findings of this study.
The Research Team

Dr Jane Skalicky
Dr Skalicky is a Lecturer, Learning and Teaching, in the Centre for the Advancement of Learning and Teaching (CALT) at UTAS. Dr Skalicky’s dissertation was in the area of mathematics education, investigating numeracy within reform-based learning environments. She has taught both in primary and tertiary educational settings, following a career in the banking and finance industry. Before joining CALT, she coordinated the Primary and Middle Mathematics Education courses for pre-service teachers within the Faculty of Education. Dr Skalicky is an active member of the Mathematical Association of Tasmania and the Australian Association of Mathematics Teachers, in addition to serving on the editorial boards of the Australian Primary Mathematics Classroom journal and the Mathematics Research Group of Australasia. Dr Skalicky currently coordinates an institution-wide peer learning program that has received national awards, and a UTAS Citation for Outstanding Contributions to Student Learning. She has published widely in the area of numeracy.

Dr Skalicky and Dr Brown form part of the leadership team on an Australian Learning and Teaching Council (ALTC) project investigating professional development for tertiary teachers in the mathematical sciences.

Dr Natalie Brown
Dr Natalie Brown is Co-Head of CALT, with leadership responsibility for Academic Development and Scholarship of Teaching and Learning at UTAS. Dr Brown obtained her PhD in the discipline of Plant Science. Prior to joining CALT, she worked for six years as a Lecturer in Science Education, including three years as Director of the Bachelor of Teaching program. As a former teacher of secondary mathematics and science, Natalie has extensive experience working with teachers to provide professional learning in these areas. Most recently this has been through an ARC linkage project ‘Mathematics in Australian Reform Based Learning Environments’, membership of Science, Information and Communication Technology and Mathematics Education for Rural and Regional Australia Tasmania and as a critical friend in two Australian School Innovation in Science, Technology and Mathematics projects. Dr Brown is also working with the Australian Bureau of Statistics to develop resources for journalism students in the area of statistical literacy.

Dr Andrea Adam
Dr Adam is a Lecturer, Learning and Teaching in CALT. She obtained her PhD in the area of cognitive psychophysiology. Dr Adam has experience teaching statistics and research methodology and coordinating undergraduate units in quantitative methods for Psychology. Currently, she coordinates student learning support in the area of academic and literacy skills on the Hobart campus.
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The research team would like to acknowledge the contributions of Dr Annaliese Caney and Ms Alexandra Lejda, who provided research assistance and shared their expertise throughout the project.
1. Background

Numeracy has been generating lively discussion within the educational community for the best part of 50 years. Periodically it is bared on the political and media stages, ensuring a continuing and captive audience. Attention to numeracy, particularly in the last decade, has been driven by the demands of society in relation to the contexts of everyday life, community life, education, and employment.

The recent National Numeracy Review Report (Department of Education, Employment and Workplace Relations, 2008) sets its scene as being “against a background of increasing globalisation, rapidly changing technology, an increasing sense of insecurity on almost every front, and media-fuelled debates about how well our educational system is preparing Australian students for these current and future challenges” (p. 1). The alignment of the numeracy needs of students with the learning opportunities provided for students has created an ongoing challenge across all levels of the education system.

Although there are variations in how numeracy is conceptualised, notably numeracy has forged an identity of its own having been overshadowed in education practice by literacy definitions and interventions (Luke, Elkins, Weir, Land, Carrington, Dole et al., 2003). How numeracy is conceptualised affects not only the mathematics curriculum but also the relationship between mathematical content knowledge and pedagogy. At the pre-tertiary level, concerns regarding the numeracy capabilities of students have been driving curriculum reform efforts both nationally and internationally for a number of decades. At the tertiary level, universities are recognising the need to foster numeracy and consider the learning outcomes of students as they embark on their professional lives. Research on numeracy in the workplace indicates that the workforce is becoming increasingly ‘demathematized’ with numeracy becoming more embedded and hidden in work tasks (Galligian & Taylor, 2008). Both literacy and numeracy are emerging as important issues in the context of the increasing association of quality undergraduate education with the development of generic and transferable skills (University of Western Australia Careers Advisory Board, 1996).

1.1 UTAS Context

1.1.1 Our students

In 2008, UTAS provided undergraduate education to 16,487 students, primarily through 33 Schools and Centres across 7 major Faculties and Institutes: Arts; the Australian Maritime College; Business; Education; Health Science; Law; and Science, Engineering & Technology. UTAS operates three Tasmanian campuses, in Hobart, Launceston and Burnie, and also has campuses in Sydney and overseas. In the last five years, student enrolments (22,600 in 2008) have increased by over 40%.

The majority of the UTAS student cohort are enrolled domestically (78%). Full fee-paying overseas students currently comprise 22% of the university’s total enrolments, which represents an increase of 134% on the number of international students enrolled in 2003.
Approximately 24% of the university’s total student enrolments are under 20 years of age, with the remaining students split relatively equally between students 20 to 24 years of age (37%) and students 25 years and over (39%). The entry of mature-age students (25 years and over) into UTAS has remained relatively stable since 2003 (38%).

1.1.2 Preparatory courses and support for mathematics

Currently, 7 out of 33 Schools/Centres at UTAS have a mathematics prerequisite for course entry: Agricultural Science; Economics & Finance; Engineering; Maritime Conservation & Resource Sustainability; Mathematics & Physics; Marine Engineering & Hydrodynamics; and Pharmacy. Students who do not meet the entry conditions are required to complete a Mathematics Foundation Unit (KMA003), which is delivered by the School of Mathematics & Physics. Additionally, a number of Schools recommend, but do not require, a certain level of mathematics proficiency for course entry. These include the Schools of Human Life Sciences, Medicine, and Psychology.

A Bridging Maths Unit (UPP090) is also available to students through the University Preparation Program. The purpose of this unit is to “develop basic skills and confidence in learning mathematics ... to prepare students for non-Science course areas such as Humanities, Nursing, Commerce and Primary and Early Childhood Education” (University of Tasmania, 2009).

Support for literacy and general academic skills development is available for UTAS students. This support is provided to domestically-enrolled students through the Centre for the Advancement of Learning and Teaching (CALT), funded through the teaching activities of the unit, and to overseas students by EnglishAssist, with funding provided by International Services. In contrast, no central support is provided at UTAS for numeracy or generic mathematics issues.

1.1.3 Numeracy at UTAS

Concerns regarding students’ numeracy capabilities have been voiced by academic staff from a range of disciplines at UTAS, particularly in the sciences, over the last two years. At a meeting of First-year Coordinators in 2008, concerns were raised regarding numeracy problems within more than one School. This concern with students’ level of mathematical and numeracy skill is mirrored in other higher education institutions in Australia (e.g., Chapman, 1998, Galligan & Taylor, 2008; Kemp, 1995) and internationally (e.g., Gill & O’Donoghue, 2006), as well as at the pre-tertiary level (Tasmanian Qualifications Authority, 2008).

1.2 Objectives of the Enquiry

With the increasing diversity of students enrolling to study at Australian universities, it is expected that the level of academic preparedness of those students will continue to vary. Numeracy is increasingly recognised as an academic literacy and graduate attribute alongside literacy. It is important, therefore, to recognise the numeracy demands of
university courses and identify any mismatch between those requirements and students’ numeracy capabilities, to develop appropriate forms of support that will allow students to not only succeed within their chosen field, but also become active members of society. In the context of ongoing curriculum reform at both pre-tertiary and tertiary levels and the increasing diversity of student populations, this enquiry has produced the following outcomes for UTAS:

- A UTAS tertiary numeracy ‘situation’ report, mapping the current numeracy demands of Schools and discipline areas and documenting sources of numeracy support for students;
- Recommendations regarding a strategic and coordinated approach to numeracy support; and
- Recommendations regarding the incorporation of numeracy understanding as a graduate attribute of UTAS students.
2. Literature Review

Numeracy is both personal and societal and involves the understanding and use of mathematics in everyday life. Numeracy is neither the same as, nor an alternative to, mathematics. It is however, equally as important in helping students to learn to cope with the quantitative demands of society (Steen, 2001). Furthermore, the relationship between the two constructs is not necessarily understood or held in the same regard by everyone. The terms numeracy and mathematics often appear to be used interchangeably (Groves, Mousley, & Forgasz, 2006), however, there are a number of views regarding the relationship between the two constructs. These views largely debate whether numeracy is a subset of mathematics, more than mathematics, or if they are synonymous with each other. For example, Zevenbergen (2005) represented the interaction between school mathematics and numeracy as a “dynamic model” of two overlapping circles (p. 5). Zevenbergen argued that in primary school the overlap between numeracy and mathematics is almost synonymous and as students move through to senior secondary school the distinctions between the two constructs become more evident as increasingly complex and abstract mathematical content is introduced.

2.1 Definitions and Interpretations of Numeracy

The term numeracy first surfaced in the Crowther Report (1959), a report commissioned in the United Kingdom. Crowther imparted a sophisticated view of numeracy that encompassed both “understanding of the scientific approach to the study of phenomena – observation, hypothesis, experiment, verification” and the need “to think quantitatively” (quoted in Cockcroft, 1982). Importantly, numeracy is introduced to mirror literacy. Over two decades later, the term reappeared in the Cockcroft Report (1982) representing a “culture of utility” (Noss, 1998). Cockcroft emphasised the practicalities of mathematics education in relation to the workplace and adult life, specifically including “appreciation and understanding of information which is presented in mathematical terms” (p. 11). Australia and New Zealand have essentially inherited the term numeracy from the United Kingdom.

Across the different education systems within Australia – both public and private – a widely accepted definition of numeracy is provided by the Australian Association of Mathematics Teachers (AAMT, 1998):

To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life. In school education, numeracy is a fundamental component of learning, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:

- Underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical, and algebraic);
- Mathematical thinking and strategies;
- General thinking skills; and
- Grounded appreciation of context. (p. 2)
This definition links the common strands of the mathematics curriculum (number, measurement, space, pattern and algebra, and chance and data) with the demands of everyday life. In relation to context the reference to “all areas of the curriculum” is acknowledged. Certainly there is a growing recognition that while the discipline of mathematics offers the foundations from which students develop numeracy, a cross-curricula focus is now advocated given that quantitative information is rarely restricted to mathematics classes.

In recent times several other terms have surfaced in relation to understanding quantitative information and are often used interchangeably with numeracy. On the international scene mathematical literacy is used as the term numeracy does not necessarily translate into some languages (National Numeracy Review, 2008). As defined by the Organisation for Economic Co-operation and Development (OECD, 2006) in Europe, mathematical literacy involves:

An individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned and reflective citizen. (OECD, 2006, p. 72)

Following the lead of the United States, quantitative literacy has also caught the attention of educators, particularly in relation to the emphasis on multiple literacies and also for its emphasis on context. Steen (2001) advocates this definition of quantitative literacy as used in the International Life Skills Survey:

An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work. (p. 7)

Other terms include statistical literacy (Watson, 2006) and critical numeracy (Johnston, 1994) with references to financial literacy, for example, circulating in relation to specific contexts for mathematics. In this review, numeracy is discussed in relation to being able to understand and use quantitative information.

2.2 The Practice of Numeracy

Ongoing discussions regarding interpretations of numeracy, including its relationship to mathematics, are in part due to the different ways numeracy is practiced in learning activities being undertaken by schools. These generally include:

- Numeracy as ‘the basics;’
- Numeracy as mathematics in real-life; and
- Numeracy across the curriculum.

Numeracy as ‘the basics’ concerns the development of core mathematical skills such as a focus on number and associated computation skills or familiar strands of the curriculum such as measurement. Learning is structured within the mathematics classroom.
Numeracy as mathematics grounded in real life, however, attempts to align mathematical skills with context emphasising the effective use of mathematics in everyday life. In this sense learning opportunities are incorporated in real life contexts within the mathematics learning area.

Essentially, a cross-curricular view of numeracy implies that the development of numeracy is the responsibility of teachers more generally, with opportunities to use mathematics emphasised across all aspects of the curriculum. In the National Numeracy Review Report, (Department of Education, Employment and Workplace Relations [DEEWR], 2008) it was identified that numeracy requires an across-the-school commitment. Although this was largely discussed in the context of the compulsory levels of schooling, it is argued that it has equal relevance within the tertiary sector. Chapman, Kemp, and Kissane (1990) write “If students have not learned how to use mathematics across the curriculum unless explicitly asked to do so, it is unlikely that they will use mathematics beyond the mathematics classroom” (p. 117). Importantly, there is recognition of the importance of numeracy not only as an element for the teaching and learning of mathematics, but also as a capability more generally. It is this view that is perhaps of relevance to the tertiary environment.

Despite its many conceptions, numeracy today has not only emerged as an integral element of the teaching and learning of mathematics but has also been identified as being an important capability that should be developed within other curriculum areas (National Curriculum Board, 2008).

Numeracy includes capacities that enhance the lives of individuals by enabling them to interact with the world in quantitative terms, communicate mathematically, and analyse and interpret everyday information that is represented mathematically. It incorporates aspects such as number sense, measurement, estimating quantities, bearings, map reading, networks, properties of shapes, and personal finance and budgeting. Numeracy also includes the mathematics used by professionals such as economists, psychologists, architects and engineers, the mathematics that is useful in learning disciplines such as geography, chemistry, physics and electronics, and the everyday vocational mathematics used in fields such as building, sports, health and catering. It involves aspects of accurate measurement, ratio, rates, percentages, using and manipulating formulas, the mathematics of finance, modelling and representing relationships especially graphically, and representing and interpreting sophisticated data. (NCB, 2008, p. 4)

2.3 Numeracy in the Tertiary Context

Numeracy at the tertiary level places emphasis on the application of numeracy and mathematical concepts in the context of various disciplines and courses of study. The term academic numeracy was used by Galligan and Taylor (2005) to clarify the skills necessary for success in the university context as:
a critical awareness which allows the student to situate, interpret, critique, use and perhaps even create mathematics in context, in this case the academic context. It is more than being able to manipulate numbers or being able to succeed at mathematics. (p. 87)

Chapman (1998, 1999) also referred to academic numeracy when considering numeracy “in relation to the learning objectives and outcomes of a particular unit, the subject discipline to which the unit belongs, and the broader social and workplace contexts outside tertiary study” (1999, p. 364). Identification of the mathematics embedded in tasks, application of mathematics required to complete the tasks and arrive at a solution, along with interpretation of the results and the use of formal and informal language were the focus of the framework for academic numeracy developed by Chapman (1998) when investigating the numeracy demands of three units within a teacher education course.

In a tertiary environment, numeracy capabilities are essential for developing learning potential within different courses. When considering the relationship between mathematics and numeracy, Johnston (1994) argues that:

Numeracy is a critical awareness which builds bridges between mathematics and the real world, with all its diversity. ... In this sense ... there is no particular ‘level’ of mathematics associated with [numeracy]: it is as important for an engineer to be numerate as it is for a primary school child, a parent, a car driver or a gardener. The different contexts will require different mathematics to be activated and engaged in. (p. 34)

Moreover, numeracy requirements in the tertiary environment evolve with the changing needs of the workforce, economic, technological and social changes, and the increasing diversity of student population. The increase in the cultural and academic diversity of commencing tertiary students has been discussed in the literature by Taylor and Galligan (2009) and Anthony, Hubbard, and Swedosh (2000).

While it may be evident that students need a certain level of numeracy to study Engineering or Physics, numeracy requirements are not as explicit in other disciplines, such as Nursing, Arts or Business (Galligan, 2004). Numeracy requirements in the tertiary setting are often more embedded in the actual coursework, rather than explicitly stated and used in their pure form.

Although research in the fields of numeracy and mathematics education is vast, work that has been conducted in the tertiary sector is limited, with most studies concentrating on tertiary mathematics. Relevant research includes the work of Galligan and Taylor (2005, 2008), who conducted a survey of academic staff regarding the mathematical skills and concepts needed by students enrolling in first year courses and the academics’ perceptions of the students’ skill level. They found a mismatch between expectations of the skills of commencing students and stated prerequisites and in addition, they were concerned about the critical thinking and problem solving abilities of students. It is noted that the majority of research that has been conducted in the tertiary sector has focused on students and not on the teaching practices they experience (Galligan & Taylor, 2008). Kemp (2005) found that improved learning could be supported, although the research was restricted to the impact of a one-hour intervention workshop aimed at improving the
numeracy, specifically the reading and interpretation of tables of data, in a non-mathematical context for students enrolled in the social sciences. Additionally, a recent Australian Learning and Teaching Council (ALTC) grant investigated learning support in mathematics and statistics in Australian universities (MacGillivray, 2008). After completing an extensive enquiry into Mathematics and Statistics Learning Support (MSLS) facilities within Australian universities, the project provided recommendations regarding the level of support needed as well as the nature of support that should be provided, in terms of both staffing and resourcing, as part of core university business.
3. Conceptual Framework – Model for Developing Numeracy

For the purpose of this enquiry, a model for developing numeracy has been adopted and used as a framework for data collection and analysis (refer to Figure 1). The model was originally conceived as a response to a current Australian Research Council project as a means for linking mathematics (through quantitative literacy) to the Tasmanian reform-based curriculum (Watson, Beswick, & Brown, 2004). The model has since been expanded to include a number of supporting capabilities for a more complete picture of numerate behaviour (Skalicky, 2007).

The model is consistent with current ideas in the United States, where the importance of quantitative literacy (numeracy) within society (Steen, 1997) and for democracy itself (Steen, 2001) has been strongly acknowledged. An important feature of the model is that it distinguishes between all students (representing equity and democracy) and selected students who may go on to contribute to society by means of innovation in areas that specifically require knowledge and understanding of the formal mathematical concepts, for example, science and technology, and in this respect is suitable for considering numeracy at the tertiary level.

The model is presented in Figure 1. Detailed descriptions and definitions of the individual concepts are presented in Appendix A.
Figure 1. Model for Developing Numeracy (Watson, Beswick, & Brown, 2004; and Skalicky, 2007)
4. Research Design

4.1 School Participation

Thirty-three Schools and Centres (hereafter referred to as Schools) at UTAS participated in the enquiry; Schools are listed in Appendix B. Initially, Heads of Schools were notified of the enquiry via an email invitation. The invitation asked Heads of Schools to either nominate a staff member to represent the School or approve the participation of a staff member as suggested by the research team (the investigators are in regular contact with staff across the University in relation to students’ literacy and numeracy needs).

Following approval from the Head of School, participants were contacted via email or phoned by a member of the research team and asked to confirm their willingness to participate. If the Head of School did not respond in any form to the invitation after one week, the research team contacted the suggested participant directly.

During the interviews, several additional staff members were identified. Consequently, a total of 35 interviews were conducted.

4.2 Interview Process

A semi-structured interview (Creswell, 2003; Tashakkori & Teddlie, 1998) was the main instrument used to collect data. The interview was constructed in three sections (Table 1); interview questions are presented in Appendix C.

Table 1: Design of the Interview

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<td><strong>Section A - Introductory Section</strong></td>
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<tr>
<td><strong>Section B – Numeracy Requirements</strong></td>
<td>Designed to explore the numeracy demands of courses across UTAS.</td>
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<td><strong>Section C - Numeracy Support</strong></td>
<td>Designed to explore the numeracy support for students already in place across UTAS.</td>
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The design of the semi-structured interview ensured consistency in the line of inquiry while allowing the interviewer to pursue other avenues of interest, and if appropriate, encouraging the participants to freely express their views. It was intended that the enquiry focussed on first year students.

Given that Section B included a discussion of a model for numeracy, the role of the interviewer involved facilitating the discussion and was both interactive and encouraging. All participants were presented with an opportunity to review the model and to seek input from colleagues prior to the interview.
4.3 Procedure

All data were collected during the second semester of the 2008 academic year and the first semester of 2009. Interview questions were forwarded to the participants prior to the interview. As each participant was representing a School, it was important for the participants to have the opportunity to seek relevant information pertaining to the needs of their Schools.

The interviews were organised individually at a time and place nominated by each participant. Members of the research team conducted interview sessions that were approximately 30 minutes in duration and recorded with consent.

The first interview conducted involved all three members of the research team as part of a moderating process to ensure that a consistent approach to interviewing was adopted throughout the project. One member led the interview while the others observed and contributed to discussion or questioning as appropriate. All other interviews were generally conducted by a single interviewer.

At the beginning of each interview, participants were asked to verify their details on a cover sheet as part of the consent process. The cover sheet included name, position, School/Faculty and relevant contact details.

The project received ethical approval from the Southern Tasmanian Social Sciences Human Research Ethics Committee at UTAS in September 2008. Ethical considerations included obtaining approval to proceed from each School and informed consent of each participant. Heads of Schools and participants were provided with both the interview schedule and a project information sheet. The information sheet included an overview of the project objectives, contact details of appropriate members of the research team, and statements on the treatment of data and confidentiality.

4.4 Data Analysis and Presentation

Each interview session was recorded, stored in a database and transcribed. The model for developing numeracy (Figure 1) was used as a framework for data coding and qualitative analysis. First, examples of the numeracy demands of courses were collated to illustrate the broad application of numeracy concepts across UTAS. Second, responses were analysed using a clustering procedure to extrapolate the main themes (Miles & Huberman, 1994); these are presented as sub headings in the results with frequency of responses reported. Coding was checked by at least two members of the research team.

To enhance the accuracy of the data, other sources of information, such as course and unit outlines, and additional information provided by some of the Schools, were used where appropriate. Although the focus of the enquiry was first year students, some data relating to second and third year students has been incorporated into the findings, with occasional references to post graduate students.
5. Findings

5.1 Numeracy Demands at UTAS

This section outlines the numeracy concepts embedded across courses at UTAS and illustrates the prevalence of numeracy across all academic disciplines.

5.1.1 Foundation Numeracy Concepts

The foundation numeracy concepts are addressed individually and collectively throughout pre-tertiary mathematics. Examples of the foundation numeracy concepts in the context of tertiary education are presented in Table 2. Out of the thirty-three Schools interviewed, only one School – Philosophy – did not mention any specific demand for the foundation numeracy concepts. Numeracy demands for the School of Philosophy are, however, identified in relation to developed and formal numeracy concepts.

Just over two thirds of the Schools reported four or more of the concepts as being relevant to their courses. Although the majority were traditionally science-based, the number also included: Accounting & Corporate Governance; Architecture & Design; Education; English, Journalism & European Studies; Nursing & Midwifery; Sociology & Social Work; and Visual & Performing Arts.

Nearly every School reported that data representation, analysis, and interpretation were specifically required for their courses. Similarly the same number of Schools indicated fractions, decimals, and percents were a key numeracy demand. Percent was the most common rational number discussed and often in conjunction with data representation, analysis, and interpretation.

A degree of computation was reported by 27 Schools and this was followed by 24 reports that units of measurement were required. Estimation and averages were reported by over half of the Schools.
### Table 2: Foundation Numeracy Concepts Demands at UTAS

<table>
<thead>
<tr>
<th>Foundation Numeracy Concepts</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Data Representation, Analysis and Interpretation (n = 30) | ▪ Reading graphs, tables, maps and considering population data (Geography & Environmental Studies);  
▪ Reading company financial reports and balance sheets (Management);  
▪ Discussing the Industrial Revolution and its impacts; demographic data; and convict history (History & Classics);  
▪ Interpreting ABS Aboriginal Community population data and comparing it with the mainstream population (Riawunna). |
| Fractions, Decimals and Percents (n = 30) | ▪ Calculating concentrations and dilutions (Medicine);  
▪ Calculating volumes of compounds (Marine Conservation & Resource Sustainability);  
▪ Understanding the concept of rhythm (Music). |
| Computation (n = 27) | ▪ Calculating total value of losses (Law - Contract);  
▪ Calculating ratios based on the information provided in balance sheets and company reports, e.g. current liabilities to total shareholder equity ratio (Accounting & Corporate Governance). |
| Estimation (n = 21) | ▪ Determining the volume of material needed for specific projects (Art);  
▪ Conducting experiments (Psychology);  
▪ Confirming the accuracy of calculations (Accounting & Corporate Governance). |
| Units of Measure (n = 18) | ▪ Cutting different lengths, measuring canvas and ordering materials (Visual & Performing Arts);  
▪ Doing conversions, particularly in medication management for registered nurses (Nursing & Midwifery);  
▪ Discussing Aboriginal art, indigenous land and justice issues (Riawunna);  
▪ Making solutions, calculating dilutions and working out metabolic rates (Human Life Sciences). |

### 5.1.2 Developed Numeracy Concepts

Developed numeracy concepts represent both a level of sophistication of the foundation numeracy concepts and a convergence of some of the concepts. Examples of the developed numeracy concepts in the context of tertiary education are presented in Table 3.

Number sense, proportional reasoning, measurement, and relationships were all reported by approximately half of the Schools. Uncertainty was reported by a third of the Schools.
Table 3: Developed Numeracy Concepts demands at UTAS

<table>
<thead>
<tr>
<th>Developed Numeracy Concepts</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number Sense (n = 18)</strong></td>
<td>▪ Looking at financial data, understanding cash position, turnover, etc. (Accounting &amp; Corporate Governance);</td>
</tr>
<tr>
<td></td>
<td>▪ Developing a marketing plan (Management - Marketing);</td>
</tr>
<tr>
<td></td>
<td>▪ Project and business planning and evaluation (Management - Entrepreneurship);</td>
</tr>
<tr>
<td></td>
<td>▪ Understanding the marginal tax system, how it can be manipulated to achieve the best commercial outcomes (Law);</td>
</tr>
<tr>
<td></td>
<td>▪ Assessing the accuracy of calculations (Psychology).</td>
</tr>
<tr>
<td>**Proportional Reasoning</td>
<td>▪ Understanding concepts of density, scale, and weight (Art);</td>
</tr>
<tr>
<td>(n = 18)</td>
<td>▪ Understanding scale and proportion; shapes and dimensions (Architecture);</td>
</tr>
<tr>
<td></td>
<td>▪ Dealing with resolution (Art - Digital Design);</td>
</tr>
<tr>
<td></td>
<td>▪ Calculating fertilisation rates, and chemical treatment rates (Marine Conservation &amp; Resource Sustainability).</td>
</tr>
<tr>
<td><strong>Relationships (n = 16)</strong></td>
<td>▪ Understanding the concept of probability (Philosophy);</td>
</tr>
<tr>
<td></td>
<td>▪ Understanding the difference between negative and positive relationships as a basis for learning statistics (Psychology);</td>
</tr>
<tr>
<td></td>
<td>▪ Reading financial statements and company reports (Accounting &amp; Corporate Governance);</td>
</tr>
<tr>
<td></td>
<td>▪ Breaking common patterns or rules (Music).</td>
</tr>
<tr>
<td><strong>Measurement (n = 15)</strong></td>
<td>▪ Understanding concepts of density, scale, and weight (Art);</td>
</tr>
<tr>
<td></td>
<td>▪ Understanding scale and proportion; shapes and dimensions (Architecture).</td>
</tr>
<tr>
<td><strong>Uncertainty (n=11)</strong></td>
<td>▪ When making therapeutic decisions, knowing what a 50% chance means and recommending an appropriate treatment (Psychology);</td>
</tr>
<tr>
<td></td>
<td>▪ Understanding the value and assessing the accuracy of research (Psychology).</td>
</tr>
</tbody>
</table>

5.1.3 Formal Mathematical Concepts

Examples of the formal mathematical concepts in the context of tertiary education are presented in Table 4. The formal mathematical concepts included in the numeracy model were Algebra, Geometry, Statistics and Probability; however some additional advanced mathematical concepts relevant to the tertiary environment were discussed by Schools and are presented as a fifth category - Other.
### Table 4: Formal Mathematical Concepts Demands at UTAS

<table>
<thead>
<tr>
<th>Formal Mathematical Concepts</th>
<th>Examples</th>
</tr>
</thead>
</table>
| **Statistics (n = 20)** and **Probability (n = 8)** [note these categories are combined here in the examples given] | - As a basis for learning evidence based medicine (Medicine);  
- Concepts of cumulative frequency, normal distribution, averages and distributions, interpreting diagrams and quoting errors, mostly in relation to population data (Earth Sciences);  
- Basic data interpretation and familiarity with regression analysis (Education);  
- In Biogeography and in modelling (Geography & Environmental Studies);  
- Undertaking research projects that involve determining sample size, running various tests and interpreting results (Management);  
- Conducting research, analysing, evaluating and manipulating data (Agricultural Science);  
- Interpretation of statistical data (Sociology & Social Work);  
- Looking at demographical spatial data in Classical Archaeology (History & Classics);  
- Applying statistical concepts of the Fourier series; confidence limits; hypothesis; standard, binominal, Poission, continuous, and discrete distributions, in the engineering context, e.g. in concrete testing and in relation to reliability of electrical equipment (Engineering);  
- Data handling (Aquaculture in Marine Conservation);  
- Interpretation of basic statistical data (Asian Languages & Studies). |
| **Algebra (n = 14)** | - Manipulating equations and solving simultaneous equations (Economics and Engineering);  
- Geometric progression in Macroeconomics, differential calculus, and exponents (Economics);  
- Looking at architectural science and force in Building Technology and Construction units (Architecture & Design);  
- In climatology, particularly in modelling; also in atmospheric, and oceanic units (Geography & Environmental Studies);  
- To introduce the notion of functions (Computing & Information Systems);  
- Applying formulas to calculate dilutions and concentrations; rearranging formulas (Chemistry);  
- Resistance calculations of the flow of water in certain diameter pipes (Marine Conservation);  
- Modelling populations (Aquaculture/Marine Conservation);  
- Applying and manipulating formulas, calculating ratios, e.g. determining a selling price per unit depending on the required level of profit (Accounting & Corporate Governance). |
| **Geometry** | - Drawing and construction; looking at relationships and |
Across the Schools, statistics was reported as the most common formal mathematical concept. Responses included basic statistical concepts such as sampling, central tendency and tests of significance to more sophisticated concepts such as regression analysis. For a small number of Schools this was the only formal concept discussed. Although probability underpins statistics, it was reported less frequently than statistics as a formal concept. The difference is likely to reflect the familiarity of the term statistics by staff and therefore its use as incorporating all things statistical in nature.

Algebra was the second most common formal concept and, like statistics, responses included reference to basic algebraic equations as well as high level algebraic functions. A third of the Schools indicated that geometry concepts were required for their courses.

### 5.1.4 Supporting Capabilities

The Supporting Capabilities represent the aspects of numeracy that contribute to a high level of numerate behaviour that extends beyond mathematical skill. Although acknowledged by most Schools as an important aspect of students’ success with numeracy concepts, the supporting capabilities were not discussed as comprehensively as the numeracy and mathematical concepts. Approximately a third of the Schools explicitly reported that confidence, critical thinking and decision making, and context were capabilities needed to support the mathematical concepts. Reasoning was explicitly reported by just less than a quarter of the Schools. Examples included:

| (n = 11) | proportions in Gothic windows in the History and Theory unit (Architecture & Design);  
|          | Surveying (Geography);  
|          | Analytical geometry (Economics);  
|          | Geographical and visual interpretations, e.g. using a diagram to describe a bending moment in a beam (Engineering);  
|          | In fishing gear technologies unit (Marine Conservation);  
|          | Looking at drug decomposition rates and calculating an area under a curve (Pharmacy). |

| Other (n = 8) | Logarithms and exponentials (Human Life Sciences);  
|              | Logic is required to learn programming (Visual and Performing Arts);  
|              | Logarithms, exponential operators, sets, quotients and reminders (Computing and Information Systems);  
|              | Chaos and space theories; Golden mean and Fibonacci series (Masters in Architecture and Design);  
|              | Logic, model theory, set theory and computability theory (Philosophy);  
|              | Algebraic manipulations, geometric concepts, components of vectors, vectors and vector products, complex numbers, calculus, differential integral, and differential equations. Using linear functions to create models (Engineering). |
The other side of this [mathematical concepts] is that we also think that interpreting the results is important – we go through the two step process, decision making and reasoning. We don’t do it as an explicit course, we do it as part of the project at that particular time. (School of Plant Science)

Much more common in our units is attention to critical thinking, argument analysis issues. One of the things philosophers do is collect argument types – skilling up on the norms required for a good inference as to the best explanation as opposed to deduction and induction. (School of Philosophy)

Confidence with mathematics - definitely in pretty well all areas of pharmacy ... I guess because it’s a science based profession, you’re dealing with quantities and doses and blood concentrations and whether it’s recommending for a 15kg child ... there will be a maximum recommended daily dose based on the child’s weight ... pharmacists are often dealing with that. (School of Pharmacy)

Discussing concepts of inequality and wealth distribution, understanding what a dollar a day means for a person’s lifestyle. (School of Asian Languages & Studies)

The Supporting Capabilities was also an area that participants discussed when sharing their concerns about numeracy (refer Section 5.2.3). Examples of specific applications of numeracy where Supporting Capabilities were identified by staff as particularly relevant are provided in Table 5.
### Table 5: Supporting Capabilities demands of UTAS courses

<table>
<thead>
<tr>
<th>Supporting Capabilities</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Confidence with mathematics | ▪ Contract, property and company law (Law);  
▪ Teaching mathematics (Education – Human Movement);  
▪ Working out a crushing strength of concrete cylinders (Engineering). |
| Critical thinking and Decision Making | ▪ Understanding the difference between significant and non significant comparisons in terms of errors and standard deviations (Plant Science);  
▪ In programming, multimedia, graphic design and manufacturing, breaking things down into a series of steps, assessing every step and putting it all together (Art);  
▪ Applying mathematical formulas to solve a problem in fish farming, including collection of required information, doing the calculations and determining appropriate treatment and application rates (Marine Conservation & Resource Sustainability);  
▪ Determining the use for statistical data in news stories (Journalism);  
▪ Determining whether the market will tolerate a suggested price per unit and if necessary, adjusting the cost per unit to maintain the required level of profit (Accounting & Corporate Governance). |
| Appreciation of context | ▪ Calculating concentrations in Chemistry (Education);  
▪ Designing a layout of an art gallery by applying a mathematical formula (Visual & Performing Arts);  
▪ Applying mathematical theories to solve problems (Maritime Engineering & Hydrodynamics);  
▪ Evaluating projects and developing business strategies (Management);  
▪ Programming (Computing & Information Systems);  
▪ Evaluating accuracy of medical charts (Nursing & Midwifery);  
▪ Understanding of patterns and sequences (Music);  
▪ Discussing concepts of inequality and wealth distribution, understanding what a dollar a day means for a person’s lifestyle (Asian Languages & Studies);  
▪ How to use information from an accounting system to make decisions, e.g., analysis of company reports (Accounting & Corporate Governance);  
▪ Developing business skills, knowing how to do BASS and GST (Art);  
▪ Understanding IQ points (Psychology). |
5.2 Numeracy Concerns

Approximately half of the Schools reported that numeracy was a concern for their School and had been raised as such in various forums, for example, School meetings, staff meetings and course reviews. These Schools were:

- Chemistry
- Computing & Information Systems
- Earth Science
- Economics & Finance
- Education
- Engineering
- Geography & Environmental Studies
- Human Life Sciences
- Marine Conservation & Resource Sustainability
- Maritime Engineering & Hydrodynamics
- Mathematics & Physics
- Nursing & Midwifery
- Pharmacy
- Philosophy
- Plant Science
- Sociology
- Zoology

Additionally, the majority of Schools acknowledged various numeracy related concerns more broadly but indicated numeracy was not a current priority. Using all comments, four themes were identified from the discussions with staff: preparedness of students, accommodating student diversity, supporting capabilities, and student attitude. The themes are presented in order of prominence.

5.2.1 Preparedness of students

Twenty-two Schools expressed concern in relation to the numeracy capabilities of students. This was expressed broadly as a decline in the capabilities of students commencing their tertiary education, that many students do not meet expectations and also in terms of “shaky foundations” in relation to basic mathematics. Comments included:

Even ten years ago we used to be able to...get students to actually do some algebra, solve a two equation system, simultaneous equations and we’ve had to drop that from the syllabus because they just cannot...are not equipped to do it. (School of Economics & Finance)

So basically there is a heavy maths component and of the students we have who come in who struggle, the majority struggle because of poor mathematics skills. That is the biggest problem – we lose the most students through not being able to cope with the level of mathematics that is required....The number of poorly prepared students has increased. (School of Mathematics & Physics)

Comments were also related to specific concepts that Schools identified as lacking in students, for example: solving and manipulating equations was a common concern. Other examples included:

The main thing I see is that students are completely [at a loss] understanding statistics – data representations, averages, all of that sort of thing – they are really lacking in skills to really understand how statistics work. This is not really an issue in first year, but it is in later years. For example I teach in the unit Volunteering in Asia and one of the things we look at is inequality. Is there greater or lesser inequality in the world than there was 40
years ago? They don’t know how to measure that, they really don’t know where to start. It is not even that they don’t know the data, they really have no idea where to start – they do it by ‘feel’ – they ‘feel’ that things are worse but they can’t really give you any evidence...They wouldn’t know, they wouldn’t be even be able to begin to assess whether an argument using statistics is well supported or not. How is it measured? (School of Asian Languages & Studies)

When I look at this [numeracy model] I can see how it’s true that some of our students for instance do find it difficult, with percentages...even in terms of when they’re trying to work out their time allocation. (Conservatorium of Music)

5.2.2 Accommodating student diversity

The diversity of students coming through courses was a numeracy related concern reported by 15 Schools. This theme included a combination of the increasing numbers of mature age and international students as well the “spectrum” or “spread of ability” of students coming through the education system. For the international students several Schools indicated that the students’ mathematical skills were often quite advanced, however, numeracy appeared to be confounded by more general issues with literacy. Several Schools also indicated that in a culture of combined degrees, accommodating the numeracy backgrounds of students from other Schools within their courses was challenging.

5.2.3 Supporting Capabilities

The supporting capabilities of students in relation to numeracy included both the confidence of students and also the application of quantitative information within the context of their discipline. Individually and in combination the capabilities were reported by just over a third of the Schools.

Schools reported that the students lack confidence in dealing with numerical information. For example:

I think they generally do [meet expectations] but we are aware that, I know for example that students will avoid tracing [tracking funds] because they don’t like numbers that sort of thing. It doesn’t mean they can’t do it, it’s just means that under pressure they’d prefer not to and that’s a confidence thing. (School of Law)

Some of them have no confidence that they can do probability and proportions. Some have serious problems with basic algebra, e.g. moving numbers around in equations, that if you multiply one side by something, you need to multiply the other side. Students lack the confidence, e.g. when they see a sigma or a square root sign, or a power of 2, they ‘freak out’. Their confidence in mathematics really affects their ability to apply it in their work. (School of Psychology)

Schools also reported that the students struggle with the application of mathematical concepts within their disciplines, and that students fail to see the relevance of the mathematics in relation to solving problems. For example:
Students don’t skill transfer so even if they did this formula manipulation in maths that was something they did in maths, accounting is different. (School of Accounting & Corporate Governance)

In relation using statistical data:

I think ... only a small percentage of students really understand how they can translate that data into an academic essay. And it’s the application I think, some students probably don’t fully grasp the data but most students I think don’t maximise the possibility of applying it. (Riawunna)

5.2.4 Student Attitude

Alongside the issue of confidence in particular, approximately a third of Schools described the students’ general dislike of working with quantitative information using terms such as “uncomfortable,” “resistance,” and “fearful.” Comments included:

There is a lot of resistance toward maths amongst students. (School of Geography & Environmental Studies)

They are often fearful of the sight of numbers, it is depressing. (School of Philosophy)

Calculating a basic percentage change and a variable, there’s enough students in the class that struggle with that. I think in many cases it’s just that you start saying something about a ratio and they just switch off. I think it’s just a real fear and apprehension. (School of Economics & Finance)

With a lot of students I’d say that I think it seems to be just being absolutely petrified of numbers and they come in and look at a page of numbers and equations and turn off and I mean supporting the way that we ask those questions perhaps, finding a way to break that down to confidence with mathematics is the biggest issue, that they’ll actually sit down and try and nut it out a lot of them will turn off immediately and walk away from subjects because its maths. (Maritime Engineering & Hydrodynamics)

Furthermore, several Schools reported that students appear to make specific choices to ‘avoid’ mathematics during the course of their studies. For example:

Some students do Zoology because they don’t like maths, even at Honours levels. They are shocked when they have to interpret data. They begin to recognise the value of data when they have to collect it in third year. (School of Zoology)

Some students choose the course because they think there is no maths involved. (School of Marine Conservation & Resource Sustainability).
5.3 Explicit Teaching of Numeracy Concepts across UTAS Courses

Schools were asked if explicit teaching of numeracy concepts occurred within courses to ascertain what types of concepts Schools were incorporating into their planned course material.

Over half of the Schools reported that explicit teaching of numeracy concepts routinely occurred in lectures and tutorials or in additional workshops put on to support students (discussed in more detail in Section 5.4). A number of other Schools acknowledged that numeracy concepts were likely to be addressed informally on an ‘as needed’ basis with comments indicating this was often at the level of the foundation numeracy concepts in conjunction with ‘reteaching’. Table 6 shows the types of concepts being taught in Schools.

Table 6: Examples of explicit teaching of numeracy and mathematical concepts across UTAS Schools.

<table>
<thead>
<tr>
<th>School</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Science</td>
<td>Data handling and statistics unit in first year (in conjunction with Maths &amp; Physics) and a research and development unit in fourth year that involves statistics, e.g., ANOVA.</td>
</tr>
<tr>
<td>Architecture &amp; Design</td>
<td>Algebra and geometry, e.g., Construction and Building Technology Unit.</td>
</tr>
<tr>
<td>Chemistry</td>
<td>In context, such as physical chemistry.</td>
</tr>
<tr>
<td>Computing &amp; Information Systems</td>
<td>Some aspects of arithmetic in computation, average, logarithms sets, boundedness, conversion between different data representations.</td>
</tr>
<tr>
<td>Economics</td>
<td>Introductory statistics (first year); Quantitative Economic Analysis Unit (Bachelor of Economics)Maths.</td>
</tr>
<tr>
<td>Education</td>
<td>Teaching covers range of numeracy concepts (foundation to formal) in Bachelor of Education. Tutorials on a range of statistical concepts: means, percentages, percentiles, graphs, t-tests (Bachelor of Human Movement).</td>
</tr>
<tr>
<td>Engineering</td>
<td>Mathematics is taught throughout the course in context. In its pure form in the KNE152 Unit.</td>
</tr>
<tr>
<td>Geography &amp; Environmental Studies</td>
<td>Scale (graphs and maps), basic trigonometry and data analysis.</td>
</tr>
<tr>
<td>Human Life Sciences</td>
<td>Basic statistics (e.g., mean, chi square) and some of the Foundation and Developed Numeracy Concepts; Logarithms, Exponentials, and the use of software packages.</td>
</tr>
<tr>
<td>Marine Conservation &amp; Resource Sustainability</td>
<td>Population modelling, application of formulae, calculus, algebra, and some of the developed numeracy concepts required for the quantitative methods unit.</td>
</tr>
<tr>
<td>Maritime Engineering &amp; Hydrodynamics</td>
<td>Differentiation, integration, differential equations.</td>
</tr>
<tr>
<td>Mathematics &amp;Physics</td>
<td>Calculus with its extensions, pure algebra and statistics.</td>
</tr>
<tr>
<td>Medicine</td>
<td>Data handling and basic statistics (Medical Research), e.g., t-tests, standard deviations, standard errors.</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Nursing &amp; Midwifery</td>
<td>Calculations, e.g., conversions and formulae in the context of interpreting charts.</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>Calculations, including percentage calculations, conversions between different units in the context of concentrations and dilutions; statistics.</td>
</tr>
<tr>
<td>Philosophy</td>
<td>Probability (axioms and simple proofs) and statistics.</td>
</tr>
<tr>
<td>Sociology &amp; Social Work</td>
<td>Percentages, cross-tabulations, statistics, statistical packages and their application in research.</td>
</tr>
<tr>
<td>Psychology</td>
<td>Basic data interpretation and representation, statistics and probability throughout degree.</td>
</tr>
<tr>
<td>Zoology</td>
<td>Statistics and probability (linear regression, correlation, analysis of variance, regression analysis, chi-square), geometric progression, logarithms.</td>
</tr>
</tbody>
</table>

Explicit teaching was reported mainly in relation to the formal mathematical concepts, such as algebra and statistics, the latter being the most common area that students receive tuition; this was generally aligned with units such as quantitative research methods.

In relation to the question of explicit teaching, a number of Schools commented that although mathematical concepts were important they were not taught specifically in a numerical form but rather ‘discussed,’ or ‘addressed’ for example:

- Concepts [geometry and space] are addressed but not taught necessarily, well certainly not taught from a mathematical perspective. (School of Art)

- The maths part of this [advanced logic for third year students] is very much around the logic end of maths, not anything to do with number theory, not anything involving analysis and algebra. (School of Philosophy)

### 5.4 Support for Numeracy

Schools were asked to report the avenues through which students are directed to for numeracy support. Overall, there were few examples of formal pathways for supporting students with numeracy concerns; however, examples of some of the mechanisms used by Schools are reported, first, in relation to the assessment of numeracy, second in relation to the use of services that are available University-wide, and then by the type of support offered by Schools. Finally, those Schools which identified that numeracy support initiatives were being discussed are reported.
5.4.1 Assessment of Numeracy

Approximately a quarter of the Schools described mechanisms for assessing students’ level of numeracy. The use of self assessment tests was reported by three Schools and included:

- The School of Education has a self-assessment test in the course orientation booklet, which is followed by a pre-assessment numeracy test in week 1 or 2 of the mainstream course. Students who struggle with the self-assessment test are then encouraged to seek extra support.

- A self assessment module is used by the School of Economics & Finance. Students are encouraged to identify their own short comings in relation to basic numeracy skills with follow up resources provided to students. Ongoing concerns may be further addressed through a workshop early in the semester.

- The School of Chemistry run a maths skills quiz (self-assessed) throughout the first semester. The quiz covers all concepts required during the first year and allows the students to identify their own needs.

Two assessments (calculation based) are mandatory for the Nursing and Midwifery students as part of the medication management unit. Students have to get 100% in order to progress to the practical (clinical) component of the program.

Pharmacy students are subject to an ongoing numeracy assessment through a system of assignments available throughout the mainstream program. Early assessment of students was considered crucial by both the Schools of Engineering and Maritime Engineering & Hydrodynamics. Maritime Engineering & Hydrodynamics have introduced an informal but mandatory series of assessments for commencing students. In the School of Engineering students are also identified early in their studies although assessment is in line with their backgrounds:

Until recently they haven’t really had any formal mechanism; for the first year now we have KNE101. Since ... we need to accept students with a TER below 70, this was really the impetus for setting up this tutorial support unit. We run this as four hours, one of maths (taken by someone from maths), one of computing and so on. This is a supplementary way of getting some assistance. This is only mandated for those who we make it a condition of enrolment that they do this course – those with low TER scores, coming through the bridging course, mature age, the ones who have been away from study for a while... there will be probably others that will be advised to go into the tutorial unit [after first Statics test].

5.4.2 Support for Numeracy: University-wide

Bridging Units

UTAS offers several ‘enabling programs’ for commencing students, designed to bring students up to an expected academic level and enhance their learning experience
(outlined in Section 1.1.2). Three Schools reported that students might be directed to the Bridging Maths Unit UPP090 for assistance. Ten Schools reported that students might be coming through or directed to complete the Mathematics Foundation Unit KMA003 (generally all Schools with pre-requisites).

**Student Support Services**
A small number of Schools suggested that students with severe numeracy issues might be advised to seek help through some of the central student support services. These included:
- Student Counselling Services – Two Schools; and
- Centre for the Advancement of Learning and Teaching (CALT) – Four Schools.

### 5.4.3 School Support for Numeracy

The majority of the Schools reported that numeracy support is generally built in to the content of lectures and tutorials. Individual numeracy support is usually taken up one on one with teaching staff with students encouraged to approach their tutors, lecturers and course coordinators after class or during consultations times. Other mechanisms are reported in Table 7.

#### Table 7: Examples of support provided for numeracy across UTAS Schools.

<table>
<thead>
<tr>
<th>Numeracy Support</th>
<th>Description</th>
<th>Number of Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbooks and Use of On-Line</td>
<td>Students directed to web based resources, additional texts or software support</td>
<td>8</td>
</tr>
<tr>
<td>Resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshops/tutorials</td>
<td>Additional workshops or tutorials scheduled to meet demand</td>
<td>9</td>
</tr>
<tr>
<td>Use of expertise</td>
<td>Expertise sought from other Schools for students requiring mathematical or statistical support (usually postgraduate level). Can be recommended to hire tutor</td>
<td>4</td>
</tr>
<tr>
<td>Introductory Units</td>
<td>Formal support tutorials or bridging units</td>
<td>2</td>
</tr>
<tr>
<td>Peer Assisted Study Sessions (PASS)</td>
<td>School participation in the UTAS PASS program</td>
<td>2</td>
</tr>
</tbody>
</table>

### 5.4.4 Other avenues for numeracy support

Other avenues for numeracy support, identified by Schools included involvement in isolated initiatives. At the School of Engineering, for example, staff have met with senior secondary mathematics and physics teachers to discuss mathematics and numeracy issues. Similarly, the School of Maritime Engineering & Hydrodynamics has been involved in a research initiative with the University of Wollongong linking high school mathematics and students’ numeracy skills when they enter a University. Undergraduate students at Riawunna can have two hours per week per subject with an appointed tutor to address issues, which is a government-funded opportunity.
Three other initiatives noted were:

- Redesigning programs to give students maximum opportunity to gain confidence in the types of mathematical concepts dealing with later in their studies (Schools of Economics & Finance, Chemistry, and Marine Conservation & Resource Sustainability).

- Changing the delivery of the content to emphasise context and relevance of concepts, e.g. some concepts at the School of Computing & Information Systems are now taught by using analogy as opposed to abstract mathematics, and by introducing relevant examples.

- Incorporating more interactive resources in units to assist students at the School of Marine Conservation & Resource Sustainability.

### 5.4.5 Future Plans for Numeracy Support

Although no specific formal initiatives were identified by the Schools, several comments are relevant.

- Appointing an officer to provide numeracy and literacy support has been discussed at the School of Human Life Sciences.

- The School of Nursing & Midwifery expressed interest in diagnostic testing as means for early identification of those students who may need numeracy support.

- The School of Agricultural Science is planning to redesign their first year programs. In the future mathematics is likely to be incorporated into the first year coursework to enable the students to learn mathematics in context.

- The School of Economics & Finance has discussed designing a more comprehensive module (self assessed) for relevant skills.

- As part of the new four year program, the School of Education has discussed a numeracy test for students, which would be followed by an elective for students who pass and a compulsory unit for those that fail.

- The School of Marine Conservation & Resource Sustainability indicated the need for staff professional development in relation to students’ numeracy.

In relation to the University more generally, the following summary comment was noted:

“Would like to see university resources directed at numeracy, and clear messages to staff and students on the importance of numeracy, e.g. case studies of personal experiences, peer messages.” (School of Geography)
“At university the numeracy levels of all students should be higher and that’s not necessarily the students that we get through. This is a concern for everyone.”
(School of Mathematics & Physics)
6. Discussion

This enquiry provides the university with a comprehensive picture of the numeracy demands across the institution. The numeracy model adopted proved to be a useful tool for illustrating the numeracy demands of courses at UTAS and helping staff to identify the numeracy requirements of their courses. By separating out Foundation Numeracy Concepts, Developed Numeracy Concepts, and Supporting Capabilities staff across the disciplines were able to consider numeracy in the context of their own courses and separate from the Formal Mathematical Concepts more prominent in the science-based disciplines. For example:

It just didn’t seem as apparent when we first started talking about numeracy how emerged and integral and that it is a part of all this. I guess because it all becomes systematic and very tacit knowledge in the end that it’s hard sometimes to recognise it as much. (School of Architecture)

The findings of the enquiry indicate that there is a need across all disciplines for students to be proficient with the Foundation Numeracy Concepts. The most commonly mentioned of these were fractions, decimals, and percents; and data representation, analysis, and interpretation. The Developed Numeracy Concepts were not as prevalent but nevertheless mentioned by over half of the Schools. Although not focus of this study, Formal Mathematical Concepts were identified by over one-third of the Schools and these extended beyond Schools in the scientific disciplines.

Statistics as a foundation or developed concept or in a formal sense in relation to probability was identified by almost every School as a component of competency in their discipline. This highlights the importance of statistical understanding across all disciplines and lends support to the growing emphasis on statistical literacy (Watson, 2006).

The Supporting Capabilities were seen by many interviewees as being important to students’ success with both explicated and embedded numeracy within learning tasks. Confidence and the capacity to apply numeracy within a context were seen to be relevant particularly for developed numeracy. Similarly, critical thinking and decision making based upon sound understandings of numeracy were highlighted by a number of Schools.

Acknowledging that numeracy is an important part, either explicitly or implicitly, of tertiary curricula, Schools’ concerns regarding numeracy are therefore a university-wide issue. Four themes identified from interviews were: preparedness of students, accommodating student diversity, developing supporting capabilities, and student attitude. Interestingly, these themes emerged from Schools regardless of whether or not they had a mathematics prerequisite. In Schools that do have a prerequisite, however, these concerns were more related to application of skills in context and confidence in the Formal Mathematical Concepts.

Generally, Schools did have not a clear pathway for numeracy support. Although a number of Schools indicated using various university-wide services and a range of formal
and informal avenues, such as diagnostic or self-assessment, support is largely ad hoc and uncoordinated. The results of the enquiry suggest that whilst there are some examples of emerging best-practice in relation to numeracy, many Schools and staff operate in a reactive fashion most of the time. It also appears that Schools are dealing with similar problems but often in isolation, particularly in relation to statistics and quantitative methods.

Anecdotally, the enquiry appears to have generated interest in numeracy at the tertiary level and has left a positive impression on some staff, for example:

They [the students] don’t need to use the statistics and data in their work. But since you contacted me last year, I did think that we should be able to embed this into our units – how are we going to help them develop this if we don’t teach and assess them on this. They have to have the skill in finding out what are the relevant bits of information for their assignments, they do need to use tables and pie charts and assess their accuracy but we assume they know it – but then you find they don’t. (School of Asian Languages & Studies)

I think it’s quite useful to actually think about this [numeracy model], I don’t really think very much about the numeracy skills. I think so much about the literacy skills, the basic research skills for literature and I try to make my statistics in practice as simple as possible so I guess I’ve thought about it at this level. (School of Psychology)
7. Recommendations

Acknowledging the widespread requirement for numeracy across UTAS and the gaps that currently exist in students’ numeracy capabilities, the following recommendations are made:

1. Numeracy be included as a graduate attribute by explicit incorporation within one of the existing UTAS graduate attributes or academic standards. This would bring implicit numeracy demands more to the fore for both staff and students.

   *Dealing with numbers and attaching some significance to them – I’d probably say should be generic attribute of all exiting graduate students, to be able to say read the newspaper, see some numbers quoted and be able to ascertain whether they mean anything or not...it [numeracy] would enhance their ability to function outside the university and also give them a set of useful ways of thinking about the world.* (School of Art)

2. That avenues for supporting staff to develop students’ numeracy as it relates to the requirements of their discipline are implemented, through for example:
   - Professional learning for staff to support them in embedding teaching of Developed Numeracy Concepts and Supporting Capabilities within units and courses;
   - Input from professionals in the teaching of numeracy; and
   - Online resources for staff and students.

3. Prepare a business plan for the provision of support for students in developing the numeracy necessary for successful study.

4. Conduct a review of the UTAS preparatory and bridging programs for mathematics, including UPP090 (Bridging Mathematics), KMA003 (Foundation Mathematics), and BEA109 (Introduction to Quantitative Methods) in light of the findings of this study.
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University of Western Australia Careers Advisory Board. (1996). *Generic skills survey report*. Perth, WA: University of Western Australia.


NOTE: University of Tasmania statistics used in Section 1.1 have been obtained from the Management Information and Reporting Unit, University Statistics: [http://www.utas.edu.au/docs/statistics/index.html](http://www.utas.edu.au/docs/statistics/index.html)
Appendix A – Model for Developing Numeracy: Definitions

Foundation numeracy concepts

The foundation numeracy concepts are largely those areas associated with students’ early mathematical experiences. Over the school years they are collectively addressed through the mathematics curricula and include:

Computation

Facility with the four operations (addition, subtraction, multiplication, and division) through written, mental, and calculator methods of computation.

Fractions, decimals, and percents

Includes the links between the concepts as all three areas share a multiplicative foundation even though each has a different notational system.

Estimation

Understanding of approximation, including the ability to compare numbers.

Average

Understanding what an average value represents, e.g. a majority, typifies a set of unequal numbers, a way of reducing a set of numbers and approximating a statistical norm, e.g., average annual rainfall, average annual income.

Units of measure

Includes being able to compare and order objects, choose appropriate unit of measurement for task at hand, use and understand the multiplicative relationships between units and also place value:

- Units of length (e.g., mm, cm, m, km);
- Units of area (e.g., cm², m², km²);
- Units of liquid volume (e.g., ml, litres);
- Units of volume (e.g., cm³, m³); and
- Units of mass (e.g., mg, g, kg).

Data representation, analysis and interpretation

Early experiences with data should include two areas:

- Pose questions, gather data, and use data to answer questions; and
- Looks for patterns and trends in existing data sets and generate questions to be answered.

Developed numeracy concepts

Developed numeracy concepts represent both a level of sophistication of the foundation concepts and also a convergence of some of the concepts. For example, number sense includes both understanding whole numbers and part-whole number concepts (fractions, decimals, and percent) and manipulation of each through computation and estimation.

These concepts include:
Number sense

...refers to a person’s general understanding of number and operations along with the ability and inclination to use this understanding in flexible ways to make mathematical judgements and to develop useful strategies for handling numbers and operations. It reflects an inclination and ability to use numbers and quantitative methods as a means of communication, processing and interpreting information (p. 3).¹

- Recognition of unreasonable results of calculations, judging the reasonableness of answers produced on a calculator and also the reasonableness of totals and change provided when shopping.

Proportional reasoning

...being able to understand the multiplicative relationships inherent in situations of comparison. Situations of comparisons include: fractions, percentages, ratio, decimals, scale, algebra, probability.²

- Related to concepts of density, speed, acceleration, force, machines.


Measurement (Shape and Space)

Shapes can be regarded as patterns: houses, office buildings, bridges, starfish, snowflakes, town plans, cloverleaves, crystals, and shadows. Geometric patterns can serve as relatively simple models of many kinds of phenomena. In the study of shapes and constructions, we look for similarities and differences as we analyse the components of form and recognize shapes in different representations and different dimensions. The study of shapes is closely connected to the concept of “grasping space”... we must be able to understand the properties of objects and the relative positions of objects; we must be aware of how we see things and why we see them as we do; and we must learn to navigate through space and through constructions and shapes. They require understanding the relationship between shapes and images (or visual representations) such as that between a real city and photographs and maps of the same city. It also includes understanding how three-dimensional objects can be represented in two dimensions, how shadows are formed and interpreted, and what perspective is and how it functions (p. 79).³

Uncertainty

Our information-driven society offer an abundance of data, often presented as accurate and scientific and with a degree of certainty. But in daily life we are confronted with uncertain election results, collapsing bridges, stock market crashes, unreliable weather forecasts, poor predictions of population growth, economic models that do not align, and many other demonstrations of the uncertainly of our world. Uncertainty is intended to suggest two related topics: data and chance (p. 79).

Relationships

Every natural phenomena is a manifestation of change, and in the world around us a multitude of temporary and permanent relationship among phenomena are observed: organisms changing as they grow, the cycle of seasons, the ebb and flow of tides, cycles of unemployment, weather changes, stock exchange fluctuation. Some of these change processes can be modelled by straightforward mathematical functions: linear, exponential, periodic or logistic, discrete or continuous. However many relationships fall into different categories, and data analysis is often essential to determine the kind of relationship present. Mathematical relationships often take the shape of equations or inequalities, but relations of a more general nature (e.g., equivalence, divisibility) may appear as well. Functional thinking – that is, thinking in terms of and about relationships – is one of the fundamental disciplinary aims of teaching mathematics. Relationships can take a variety of different representations, including symbolic, algebraic, graphic, tabular, and geometric. As a result, translation between representations if often of key importance in dealing with mathematical situations (p. 79).

Supporting capabilities

The supporting capabilities represent the many of aspects of numeracy that contribute to a high level of numerate behaviour, beyond mathematical skill.

These capabilities include:

Confidence

Includes both choosing to use mathematics wherever required and a willingness to take risks and persevere in approaching new mathematics and new contexts.4

Critical Thinking and Decision Making

Awareness that mathematics can be used inappropriately, can be represented to promote bias, and can therefore promote inequities in society. The ability to question assumptions and use mathematics in an analytical and critical manner to make decisions and resolve problems and investigations.4

**Appreciation of Context**

The ability to select and apply the appropriate mathematical tools for sense-making in a given context and understanding how the context impacts on the mathematics. Contexts related to school and everyday life, public and social issues, and an awareness of mathematics connected to history and culture. 

**Reasoning**

Show a methodical, logical, and thorough plan for solving the problem. The approach and answers are explicitly detailed and reasonable throughout (whether or not the knowledge used is always sophisticated or accurate). The student justifies all claims with thorough argument: counterarguments, questionable data, and implicit premises are fully explicated.
### Appendix B – List of participating Schools/Centres

<table>
<thead>
<tr>
<th>Name of School</th>
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<tbody>
<tr>
<td>Accounting and Corporate Governance</td>
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<tr>
<td>Agricultural Science</td>
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<tr>
<td>Architecture and Design</td>
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<tr>
<td>Art</td>
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<tr>
<td>Asian Languages and Studies</td>
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<tr>
<td>Chemistry</td>
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<tr>
<td>Computing and Information Systems</td>
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<tr>
<td>Earth Sciences</td>
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<td>Economics and Finance</td>
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<tr>
<td>Education</td>
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<tr>
<td>Engineering</td>
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<tr>
<td>English, Journalism and European Languages</td>
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<tr>
<td>Geography and Environmental Studies</td>
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<tr>
<td>Government</td>
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<tr>
<td>History and Classics</td>
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<tr>
<td>Human Life Sciences</td>
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<tr>
<td>Law</td>
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<tr>
<td>Management</td>
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<tr>
<td>Marine Conservation and Resource Sustainability (inc Aquaculture)</td>
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<td>Maritime Engineering and Hydrodynamics</td>
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<td>Mathematics and Physics</td>
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<td>Medicine</td>
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<td>Music (Conservatorium of)</td>
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<td>Nursing and Midwifery</td>
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<td>Pharmacy</td>
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<td>Philosophy</td>
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<td>Plant Science</td>
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<td>Psychology</td>
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<tr>
<td>Riawunna</td>
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<tr>
<td>Sociology and Social Work</td>
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<tr>
<td>Visual and Performing Arts</td>
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<tr>
<td>Zoology</td>
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</table>
Appendix C - Interview Schedule

SECTION 1
INTRODUCTION

Q1 Recently, students’ capabilities in terms of numeracy have become an area of concern nationally, not only at primary and secondary levels, but also in the tertiary sector. In your School, have any issues been raised in relation to numeracy, and if so have they been discussed at any type of forum?

Suggestions include:
- school or faculty meetings;
- inter-faculty meetings; or
- forums external to the University (e.g., conference, professional associations, with stakeholders)?

SECTION 2
NUMERACY REQUIREMENTS

Q2 What are the key numeracy demands of students in your School?

We are interested in the types of quantitative information that students in your school will encounter during their studies – this is regardless of whether your School offers formal units of mathematics.

The model for learning both numeracy and mathematics that is being used in this project is outlined in Figure 1 (overleaf). In particular, the model identifies specific foundation and developed numeracy concepts that are relevant to all students, as well as the supporting capabilities students need to be able to apply appropriate mathematics in different contexts. You might find the framework useful as a guide to identify the key numeracy demands of students in your school. Examples of the contexts in which students will encounter these concepts can be discussed with the interviewer.

SECTION 3
NUMERACY BACKGROUND AND SUPPORT

Q3 Is there explicit teaching of numeracy concepts within your courses?

Q4 a) Is there mathematical knowledge that you assume the students have coming into your courses?

b) On the whole, do the students meet these expectations?

Q5 In your School, where are students directed to for support for numeracy? Consider both formal and informal sources of support.

Q6 Does your school have, or are planning, any programs, resources, or course and curriculum developments to address students’ numeracy?

Q7 Any final comments?
Appendix D - Feedback

Following a 6 week review period during which Schools were able to comment on the draft report, feedback was received from ten individuals. Overall comments were positive and generally affirmed the contents of the report and the importance of the issues covered.

The feedback from three Schools in particular is noted in this section.

- Additional information was provided by the School of Chemistry in relation to the prior knowledge and assumed background for mathematics. This information will be used to inform a review of the foundation/bridging programs.

- The School of Engineering reiterated support for numeracy as a graduate attribute.

- Both the School of Engineering and the School of Mathematics & Physics pointed to a need to engage in consultation with the secondary education sector particularly in relation to prerequisites and formal mathematical concepts, for example, geometry.

Acknowledgement

It is acknowledged by the authors that at the time of data collection, two representative members of the Australian Maritime College (AMC) were interviewed. In the report, however, the representatives’ separate Centres (Marine Conservation & Resource Sustainability and Maritime Engineering & Hydrodynamics) have been reported individually as are individual Schools. It was perhaps an oversight that Ports & Shipping was not interviewed as the third Centre that makes up AMC. In light of this, Ports & Shipping accepted an invitation to participate in the review of the draft report and the following comment from the Director is noted:

“We do have numeracy issues in our National Centre but believe that the report content, recommendations and scope sufficiently addresses our issues.”