Perceived Mathematical Proficiencies Required for First Year Study at The University of Southern Queensland.

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March 1998

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Executive Summary

In 1997 a survey of all academic staff teaching first year units was conducted to review the mathematical skills and concepts needed by students enrolling in first year units; to assess academics' perceptions of the skill level possessed by students and to ascertain whether concerns about numeracy at USQ were widespread or isolated. It was clear from the results of the survey that there are some mismatches between expectation of mathematical skills present in commencing students and stated prerequisites. Further, academics were concerned about the mathematical abilities of entering students generally in the areas of critical thinking and problem solving and specifically in areas particular to their units. The authors make 2 recommendations that would address these issues.

Recommendations

- Academics require access to more information about commencing students' mathematical and general skills and knowledge and details of set prerequisites.

- OPACS should develop closer links with Faculties and faculty staff so that they can work collaboratively to improve academic numeracy levels, in the first instance, and then develop strategies to address the problems of academic numeracy and academic literacy in a systematic way.

1.0 Introduction

The changing nature of Australian universities means that today student populations are more diverse than ever before. This is especially true at USQ where the majority of students are not recent school leavers (67% in 1997). The unpreparedness of universities for the repercussions of this diversity can result in academic difficulties for universities and students. McInnes and James (1995) in the CAUT funded study of the first year on campus, declare that "a major problem for many staff teaching in the first year, in addition to the increasing spread of student abilities, is the uneven preparedness within a student population. This uneven preparedness, perhaps in terms of specific topics or techniques, means that selecting a suitable starting point is problematic for first year subjects". These concerns are prevalent in a range of subject areas but mentioned particularly are students' abilities to write (in Humanities, Social Science and Arts) and perform mathematics. Presently mathematical preparedness of students is determined using topics and levels of mathematics achieved in secondary school (mathematics prerequisites). There are three problems with the implementation of the prerequisites:

1. many staff are not familiar with recent changes to the secondary school mathematics syllabi;
2. the category of "no mathematics prerequisites" is interpreted differently by different students and academics;
3. even though students have achieved the mathematics prerequisite many still appear to have difficulties.

These problems are reflected in concerns across this university and others about the numeracy levels of all our students. The University of Adelaide report (Cousins and Roberts, 1995) a similar concern with their students and it is upon their report that the following study is based.

This initiative aimed to:

1. review the mathematical skills and concepts needed by students enrolling in first year units;
2. assess academics' perceptions of the skill level possessed by students;
3. ascertain whether concerns about numeracy at USQ are widespread or isolated;
4. make recommendations to the university, faculties, OPACS and individual unit team leaders on the results of the above.

2.0 Survey content and procedures

The Queensland Junior and Senior Mathematics Syllabi for Maths A, B and C were used to develop questionnaires detailing mathematics topics studied in Years 10, Year 11 and 12 Queensland Secondary Schools. Questionnaires were designed to ascertain academics' perceptions of mathematics topics expected for study in their respective units and their perceptions of on and off-campus students' performance in these topics. An open ended question allowed academics to make personalised comments. Little to no diagnostic testing takes place within most units so quantitative data were not requested. See Appendices for copies of the questionnaires and accompanying letter.

All unit team leaders responsible for the management of first level units, offered in either semester 1 or semester 2, were sent two copies of the questionnaire and asked to pass copies onto other lecturers/tutors within the unit. If lecturers did not respond to the questionnaire within 4 weeks a reminder letter was forwarded encouraging participation.

Analysis of the questionnaire was completed from the whole university population of responding first year units and by faculty. Any analysis that was completed in reference to faculty was always linked with the faculty of offer even though many students in particular units were not enrolled in a course offered through that faculty. For example Data Analysis is a Faculty of Science unit but forms a component of degree courses in a number of other faculties. It is linked only with the Faculty of Science.

A small number of informal interviews were conducted with staff as requested. These are not reported here.

This report is only concerned with first level units. The authors acknowledge that mathematics skills are also required in other units studied at higher levels, but at this stage considered these outside the scope of this report.

3.0 Results and Summaries

A total of 136 questionnaires were sent to six faculties. The numbers for each faculty are shown in Table 1. The response rate ranged from 83% from the Faculty of Education to 20% from the Faculty of Business. There were five units where more than one lecturer responded to the questionnaire.

The following results and summaries relate to the responses and are divided into two categories:

- academics' perceptions of mathematical topics and skills needed by commencing students;

- academics' perceptions of mathematical abilities in these topics and skills.

The questionnaire also allowed for comments. There were a total of 46 lecturers who commented on various aspects of students' mathematics skills. These comments will be used, where appropriate, throughout the report.

While the initial questionnaire separated on and off campus students, most lecturers found it impossible to differentiate. As one lecturer commented:

> *....my judgement for the external students is not as easy. I see only the final product of a few assignments. I don't see how much they struggle to get to this final product...*

Hence the following results show perceptions of the general population of USQ students.

Table 1: Number of Surveys returned by Faculty

Faculty	Surveys	Total
Commerce	Sent	4
	Returned	3
Business	Sent	10
	Returned	2
Science	Sent	43
	Returned	28
Engineering	Sent	25
	Returned	10
Education	Sent	6
	Returned	5
Arts	Sent	48
	Returned	29
Total Sent		136
Total Returned		77 (57%)

3.1 Mathematical proficiencies required by commencing students

Table 2 lists the topics and skills used in the questionnaire, which was derived from the Queensland Mathematics Syllabi for Year 10, Years 11 and 12 Mathematics B and C. Mathematics A (Year 11 and 12) was not listed and detailed in the questionnaire as many of the skills listed in Mathematics A are found in the Year 10 Syllabus. Lecturers were asked to tick their perceptions of the skills needed for their unit. Of the 77 respondents, 16 ticked none of the topics, a typical comment being "*no relevance to these units*".

Lecturers were asked to indicate the expected mathematics background of students in their unit by circling one or more of: None, Year 10, Maths A, Maths B, Maths C.

Tables 3 and 4 below summarise the expected mathematical background of students at the commencement of a unit. As it was academics' perceptions of this, there was some disagreement between lecturers. In four units there was either a Maths A/Year 10 or None/Year 10 mismatch. There were also 15 lecturers who indicated Year 10 or 12 maths was not required, but then ticked a number of skills from Year 10 and 12 that were needed for the unit. As one lecturer commented:

> *Although maths is not stated as a pre-requisite or even as desired for entry into... we still expect (or rather assume) that students have a certain level of senior maths..*

Table 2: List of topics and skills detailed in the Queensland Mathematics Syllabi for Years 10, 11 and 12.

GENERAL TOPICS AND SKILLS
Communicate mathematical ideas and reasoning
Use mathematical language and terms accurately and appropriately
Use mathematical skills to analyse and solve unfamiliar problems
Make judgements as to the validity of mathematical reasoning
Demonstrate an ability to use instruments eg. calculator, computer, measuring instruments.
Estimate results and answers within a degree of accuracy
Ability to perform simple pencil and paper calculations when necessary
YEAR 10 TOPICS AND SKILLS
1 : WORKING MATHEMATICALLY
Select and organise key information
Generalise from one problem to another
Clarify mathematical questions to guide the investigation of the situation
Produce mathematical arguments to prove a proposition
Use standard mathematical techniques to solve a problem
2 : SPACE
Draw and name angles
Draw and name 2D and 3D shapes using basic tools
Understanding terms - eg ray, plane, point
Use properties of perpendicular and parallel lines
Use trigonometric ratios
Understand symmetry in plane shapes and solids
Use coordinates in four quadrants
Understand bearings and construct maps including using scales
Interpret congruence and similarity of shapes
Visualise, produce and describe translations, reflections, rotations and enlargements
3 : NUMBER
Use fractions, decimals, percentages, ratios
Perform basic operations on +ve and -ve numbers
Recognise patterns in numbers
Use powers, roots, scientific notation
4 : MEASUREMENT
Recall and apply suitable units of measurements
Apply basic operations to time situations
Use time lines and timetables
Calculate monetary items (eg. budgets)
Calculate perimeter, area, volume for simple 2D and 3D shapes
Use Pythagoras's theorem
5 : CHANCE AND DATA
Collect data for a simple survey or experiment
Assemble, present and interpret data in tabular and graphical form
Use mean, median and mode
Draw conclusions from surveys and experiments
Use and interpret measures of simple probability
6 : ALGEBRA
Translate from words to symbols
Perform simple algebraic operations eg expand brackets, collect like terms

Use indices
Manipulate algebraic fractions
Use formulas
Draw linear graphs from a table of values
Use slope and intercept in straight lines
Recognise and represent linear, quadratic, reciprocal and exponential functions
Solve simultaneous equations
Use and solve simple equations and inequations
Communicate solutions to problems in appropriate language
YEAR 11/12 TOPICS AND SKILLS
MATHEMATICS B
Interpretation and drawing of scale drawings and plans
Application of trigonometry including sine and cosine rules
Practical applications of volumes, surface area and circle geometry
Concepts of relation, function, domain and range
Practical applications of linear, quadratic, absolute value and reciprocal functions
Investigate the shapes of polynomials
Concept of an inverse function
Solve two simultaneous equations using graphs
Calculate and interpret average and instantaneous rate of change
Interpret derivative as instantaneous rate of change including concept of a limit
Derivative theorems for x", sums, product and chain rules
Practical applications of derivatives eg stationary points, increasing and decreasing functions and optimisation
Find derivatives of sin$x$, cos$x$, e^x, ln$x$
Draw and interpret graphs of trig functions
Solve simple trig equations
Use Pythagorean identities
Use definitions of a^x and $\log_a x$
Use index laws
Use logarithmic laws
Draw and interpret exponential and logarithmic graphs
Use logs to solve index equations
Applications of exponential and logarithmic functions
An understanding of networks and linear programming
Perform interest calculations
Use arithmetic and geometric progressions interest calculations
Definitions of definite and indefinite integrals
Calculate integrals for polynomial, exponential, sine and cosine functions
Practical applications of the integral
Use integration to find an area
Numerical integration eg trapezoidal rule
Interpretation of graphical displays of data
Identification and use of 5-number summaries
Calculations and interpretation of measures of central tendency and dispersion
Calculation and use of probability and probability distributions
Use random sampling
Formulations and testing of statistical hypothesis
Define and use the normal distribution

MATHEMATICS C
Definition and properties of a group
Structure of the real number system
Structure, representation and operations on complex numbers
De Moivre's Theorem
Mathematical applications of complex numbers
Definition, properties and operations on matrices
Determinants and inverse matrices
Solutions of systems of linear equations using matrices
Applications of matrices
Definition of vectors and relationship with matrices
Operations with vectors including scalar and vector products
Applications of vectors
Curve sketching
Integration of functions involving products and quotients
Integration by parts
Simpson's Rule
Solution and application of simple linear first order differential equations
General sequences and series, including arithmetic and geometric progressions
Application of AP and GP
Permutations and Combinations and their application
Applications of patterns and use of finite differences

Table 3: Mathematics background expected by responding academics within each Faculty (Figures indicate number of surveys).

Faculty	**None**	**Year 10**	**A**	**B**	**C**	**Grand Total**
Commerce	2	0	1	0	0	3
Business	1	0	0	1	0	2
Science	10	8	3	7	0	28
Engineering	3	0	4	2	1	10
Education	2	0	3	0	0	5
Arts	13	4	12	0	0	29
Grand Total (%)	31 40%	12 16%	23 30%	10 13%	1 1%	77

Table 4: Mathematics background expected by responding units within each Faculty

Faculty	None	Year 10	Maths A	Maths B	Maths C
Commerce	Introduction To Law		Intro To Accounting		
	Financial Markets				
Business	Aust Political Institution			Economics	
Science	Data Analysis	Foundation Psychology	Organic Chemistry	Foundation Chemistry	
	Intro Profess'l Computing	Climates - Past & Present	Introductory Computing	Inorganic & Physical Chemistry	
	Nursing Foundations 2	Astronomy	Biophys. Science Foundations	Discrete Maths	
	Social Sciences Nursing	Medication Calculations 1		Algebra And Calculus I	
	Behav Science Foundations	Anatomy And Physiology		Operations Research I	
	Biological Bases Behaviour	Social Process Behaviour		Physics & Instrumentation	
	Physiological Psychology			Physics For Surveyors	
Engineering	Electronic W'shop & Prod		Engineering Communications And Practices	Civil Engineering Materials	Electrical Technology
	Telecommunication Principl		Engineering Materials	Fluid Mechanics	
	Telecommunications Systems		Aerodynamics		
			Surveying A		
Education	Foundations Of Language		Soc-Cult Phys Ed & Sport		
	Health For Teachers		Computing And Design		
			Learn Through Comp Program		
Arts	Communication & Scholarship	Intro To Studio Practice	Voice And Movement 1		
	Performance 1	Technology And Design	Sound And Lighting 1		
	Music Craft 1	Radio Production 1	Intro To Public Relations		
	Found Stud In Hist Of Art	Public Relations In Australian History	Environmental Systems		
	Visual Cultures		Writing Public Relations		
	Introductory Mandarin		PR Practice And Techniques		
	World Civilisation 1500 AD		PR Project		
	Intro Australian History		Issues Management And Strategic Planning		
	Arts In Asian Civilisation		Corporate Communication		
	Communication Cultural Form		Professional Communication		
	Narrating Australia		Advanced PR Strategies		
	Introductory German A		Crisis Management		
	German 1				
Total Units (n=72)	28	10	23	10	1

From Table 4 it can be seen that while 38 out of 72 (53%) of units surveyed expected no maths background or Year 10 mathematics, 34 out of 72 (47%) expected Mathematics A, B and/or C. However, while many individual units expect a certain mathematical background, degree programs do not always specify mathematics A, B, or C as prerequisites or even state them as desired for entry into their degree. Table 5 summarises the prerequisites required for USQ degrees (Queensland Tertiary Courses, QTAC, 1998). This can lead to some confusions as occurred in the 3 following examples. Economics is a core unit in the Bachelors of Business and Commerce where academics expected Maths B topics to have been completed (Table 4), yet mathematics is not stated as a prerequisite in Bachelor of Business and is mentioned as desirable only in Bachelor of Commerce. In the Faculties of Education and Arts, 15 units expected students to have a background in Mathematics A, yet no mathematics is stated as a prerequisite or desired. In the Faculty of Engineering and Surveying, Mathematics B is stated as a prerequisite, yet students enrolled in Electrical Technology are expected to have a Mathematics C background to undertake this unit. However, Algebra and Calculus 1 is listed as a corequisite in the course structure.

Table 5: Prerequisites into degree units offered by Faculties (from Queensland Tertiary Course, QTAC, 1998)

Faculty	Prerequisite(subject, no. units, exit asst)
B.Commerce All, Banking, Finance & G. Commerce	English and Maths desirable
B.Business (inc Info. Tech., Bus Comp. and End-user Comp.)	English (4 SA)
B.Science Biology/Science Applied Maths, Applied Computer Science, Industrial Computing Psychology Nursing	 English (4 SA), Maths B (4 SA), one of Biology, Chemistry or Physics is desirable English (4 SA), Maths B (4 SA) English (4 SA), Maths A or B (4 -) English (4 SA), Maths A or B (4 -), one of Biology, Chemistry, Physics, or Multi-Strand Science desirable
B.Engineering, B.Surveying **B.Technology** (Civil, Electrical, Electronic, or Mechanical Engineering; Surveying)	English (4 SA), Maths B (4 SA), Physics desirable English (4 SA), Maths B desirable
B.Education	English (4 SA)
B.Arts	English (4 SA) [some interview/other]

Table 6: Numbers of responding units requiring specific mathematical skills.

	No Maths	Year 10	Maths A	Maths B	Maths C	Total	(%)
Year 10							
General skills	10	10	21	8	1	50	65
Working Mathematically	9	8	9	8	0	34	44
Space	4	6	7	7	1	25	32
Number	13	12	21	8	1	55	71
Measurement	11	8	8	7	1	35	45
Chance and Data	8	7	15	5	1	36	47
Algebra	9	5	9	8	1	32	42
Year 11 and 12							
Topics in Maths B	7	3	2	6	1	19	25
Topics in Maths C	2	0	2	4	1	9	12

Table 6 principally separates the skills assumed from the Year 10 list and indicates where lecturers ticked **at least one** topic/skill from each section. Note that while no Year 10 maths was required by 31 respondents there were a number of skills and topics within Year 10 which were assumed. For example 11 lecturers assumed some knowledge of measurement, and 9 assumed skills in algebra.

The most important topic considered by lecturers was a skill in number work, with 71% of total respondants indicating at least one of the skills within this section. Moreover, 65% of respondents indicated general mathematical skills were needed in their unit. This was reflected in the comments made by the lecturers.

> *In this unit they don't have to do any calculations but they have to be able to read psychology journal articles and draw conclusions about research...*
>
> *This unit is not at all mathematical and just assumes general numeracy knowledge and ability to do simple calculations.....*
>
> *...much of the questionnaire not applicable. My major concern, even in music, is the perceived inability of many students to think logically, and to apply routine thought processes to a given (musical) problem...*

3.2 Academics' perceptions of mathematical abilities of commencing students

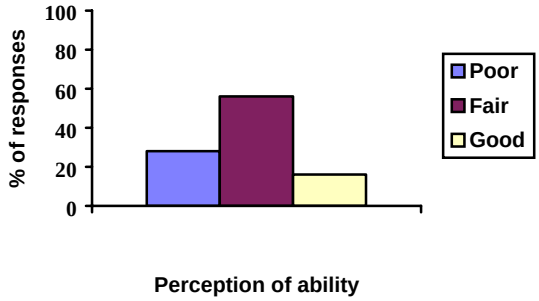
The perceptions of academics regarding the mathematical abilities of commencing students were varied with the added complication that many academics found it difficult to rank large groups of students as either good, fair or poor because of the variation of abilities within any one class. Only one academic felt able to differentiate between the ability of on and off campus students, so this variable was deleted from the analysis. Also although percentages were used to allow for comparisons between different groupings, these percentages were in some cases based on small numbers and caution should be used in their interpretation.

Despite these shortcomings, general perceptions can be gleaned from the data. Overall, students' mathematical skills and abilities were thought to be fair with 682 out of 1210 (56%) of topics being marked this way (Table 7). However, the distribution of rankings between good, fair and poor was not balanced with 341 (28%) responses being ranked as poor and 187 (16%) responses as good (Fig. 1). This indicates that there is some concern about students' numeracy levels.

Table 7: Responding academics' perceptions of student mathematical ability.

		Poor		Fair		Good		
	No. of Units	No. of responses	% of Faculty	No. of responses	% of Faculty	No. of responses	% of Faculty	Total
Arts	29	42	24	70	39	66	37	178
Business	2	17	50	17	50	0	0	34
Commerce	3	14	24	45	76	0	0	59
Education	5	3	15	16	80	1	5	20
Engineering	10	55	21	143	54	65	25	263
Science	28	210	32	391	60	55	8	656
Total		341		682		187		1210

Fig. 1: Perceptions of students' ability by all responding academics.



These general perceptions were confirmed by the written comments included by some academics with their survey. Of these, 22% indicated in their comments that they had concerns with students' numeracy levels. For example:

> *...students had great difficulty with pen and paper calculations...*
>
> *Numeracy, in the sense of a feeling for the accuracy or not of an answer is generally missing...*
>
> *Overall, I think the maths skills of students entering these units are significantly worse than they should be...*
>
> *The current primary and secondary school system has failed dismally in teaching students basic arithmetic techniques*

However, caution should be taken, in the view of one academic,

> *Judging student proficiency is very difficult because we are predominantly exposed to students with difficulties. Hence I suspect our perceptions are biased downwards....*

Figures 2 to 4 detail academic perceptions of students' abilities by topic. By far the most responses are associated with the grouping of General and Year 10 topics. Few units (10 and 1 respectively) required the senior topics of Maths B and C, so responses for these topics are much smaller (Fig. 3 and 4). However, they did indicate that many academics were concerned about the abilities of commencing students in these topics with 21 out of 37 topics in Maths B and 9 out of 17 in Maths C containing over 50% of responses with a rank of poor.

It was apparent that overall, academics were concerned mostly about the general numeracy skills necessary for university study (academic numeracy). In particular the topics (topics in brackets are the abbreviations used on the figures) of

- use fractions, decimals, percentages and ratios (fractions),
- ability to perform pencil and paper calculations (pencil and paper),
- demonstrate an ability to use instruments, eg calculator, computer, measuring instruments (use of instrument),
- assemble, present and interpret data in tabular and graphical form (interpret data),
- communicate mathematical ideas and reasoning (communicate ideas),
- use mathematical language and terms accurately and appropriately (use language);

were mentioned in over 50% of responses, with fractions being mentioned most frequently and use of language least. According to the academics' perceptions, units using these topics contained students with a balance of good, fair and poor abilities except in the use of language and communicating ideas where good students were few.

On the other hand within other topics over 50% of responses indicated that students were perceived to perform poorly. These topics included

- General skills
    - making judgements as to the validity of mathematical reasoning (make judgements)
    - using mathematical skills to analyse and solve unfamiliar problems (use skills)
    - generalise from one problem to another (generalise)

- Specific mathematical skills
    - solve simultaneous equations
    - recognise and represent linear, quadratic function, reciprocal and exponential function (use linear and quadratic)
    - visualise, produce and describe translations, reflections, rotations and enlargements (translate)
    - produce mathematical arguments to prove a proposition (prove a proposition)

The lack of general skills, in particular, was reinforced by 13% of academics who commented on the essential nature of critical reasoning and logical thinking for commencing students. For example

Of course the logical thinking and problem solving skills one learns in Maths are important.

...perceived inability of many students to think logically, and to apply routine thought processes to a given problem....

Analysis of responses for different topics by Faculty resulted in some differences between faculties (Fig. 5). Working mathematically and algebra were perceived to be a problem across all faculties with working mathematically especially being a concern within the Faculty of Education and algebra being a concern within the Faculty of Arts, although the number of units requiring these were small. It should be noted that the response rate of surveys within the Faculty of Business was very small so the results included may not be indicative of the Faculty's perception of commencing students' mathematical abilities. Within the other faculties although the number of units represented were often small they were representative of the majority of academics' perceptions of commencing students' mathematical abilities (see Table 1 for response rates). When the faculties were analysed individually the following observations were made.

Fig 2: Academics' Perceptions of Mathematical Abilities (General, Year 10)

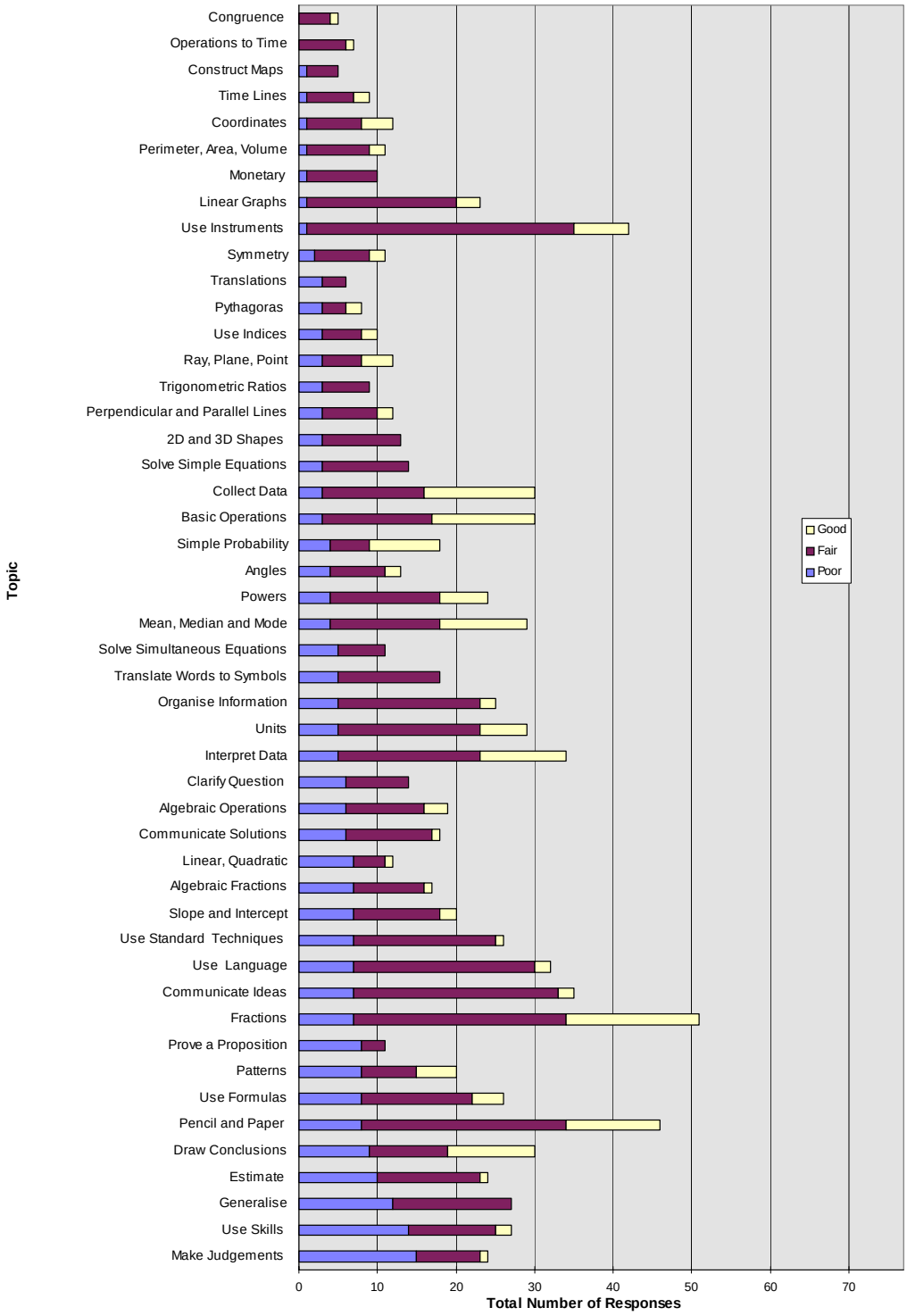


Fig 3: Academics Perceptions of Mathematical Abilities - Maths B

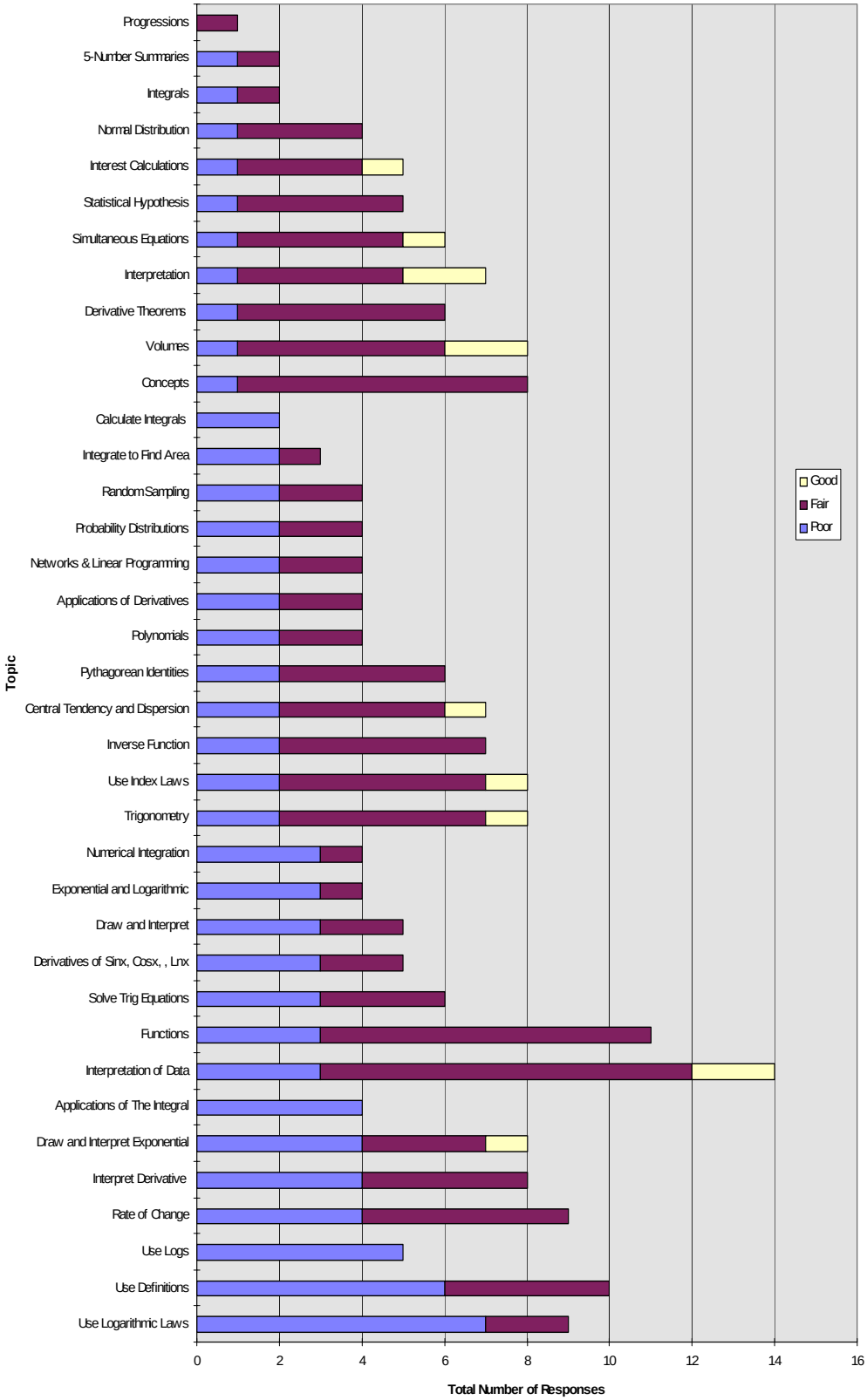


Fig 4: Academics Perceptions of Mathematical Abilities - Maths C

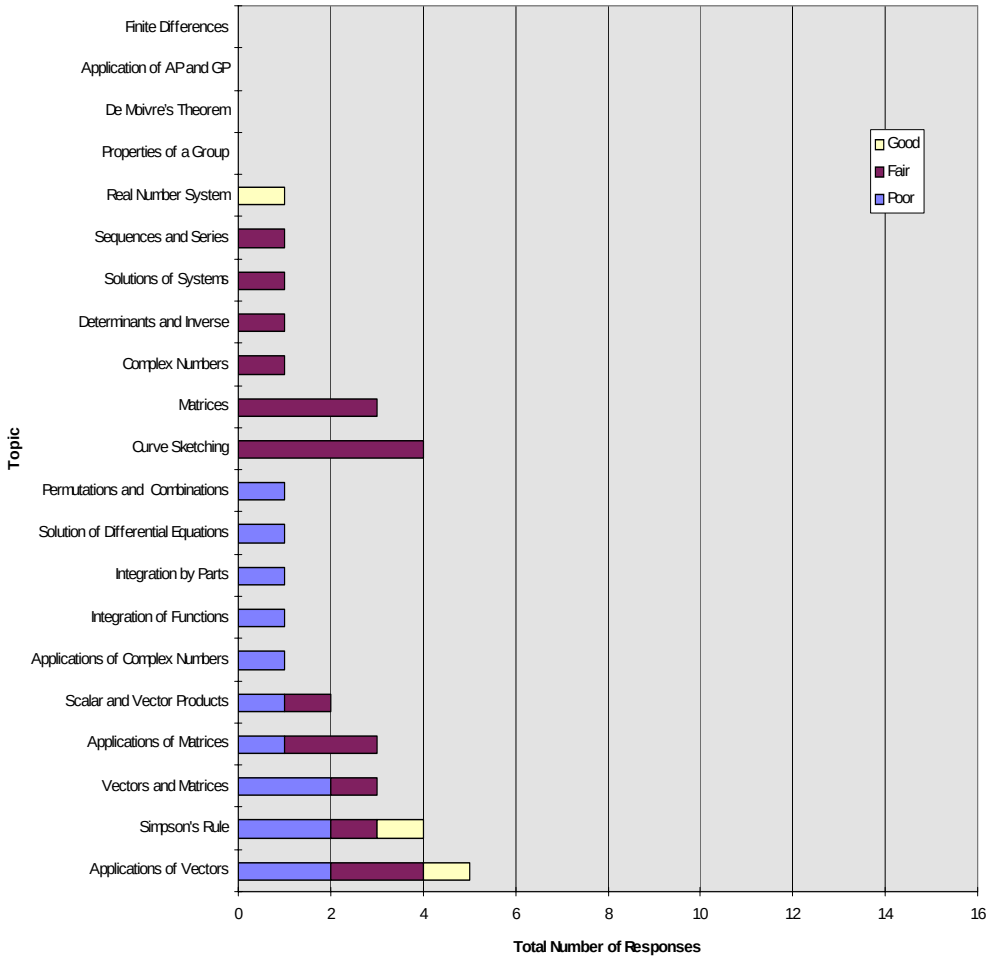
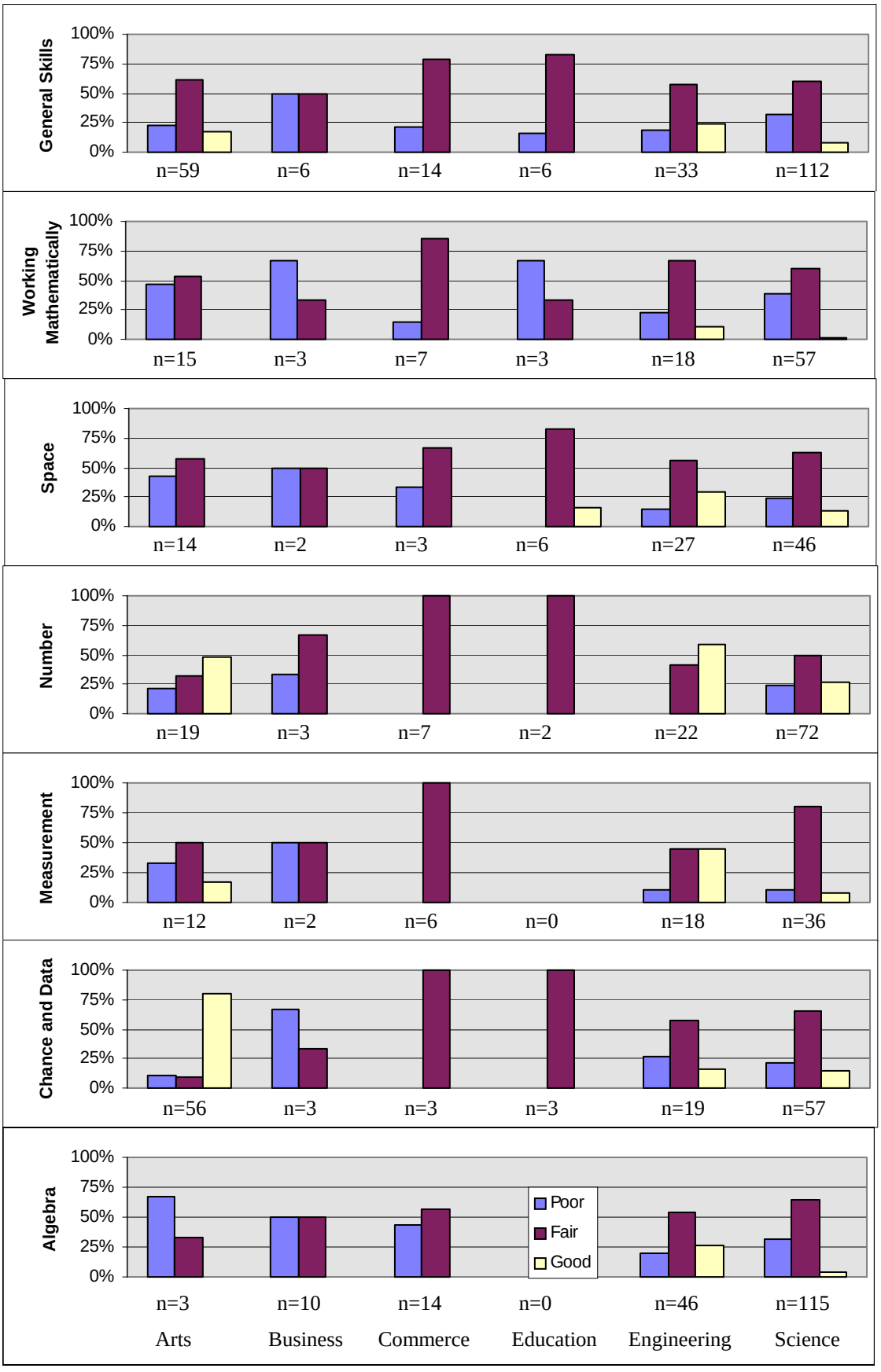


Fig. 5: Perceptions of mathematical abilities for General and Year 10 topics between faculties (number of surveys returned Arts =29, Commerce = 3, Business = 2, Engineering = 10, Science = 28, n refers to total number of responses in each skill).



Faculty of Arts

Twenty nine responses were received from 48 units. When General and Year 10 topics were assessed as a group (Fig. 5), academics perceived that commencing students had good abilities in chance and data and number, with poor abilities in working mathematically, space and algebra. When these skills were examined topic by topic (Fig. 6), the following topics occurred most frequently.

- use fractions, decimals, percentages and ratios (fractions)
- ability to perform pencil and paper calculations (pencil and paper)
- demonstrate an ability to use instruments, eg calculator, computer, measuring instruments (use of instrument)
- assemble, present and interpret data in tabular and graphical form (interpret data)
- draw conclusions from surveys and experiments (draw conclusions)
- use mean, median and mode (mean, median and mode)
- communicate mathematical ideas and reasoning (communicate ideas)

Within the majority of these topics academics mainly ranked students as fair or good, with few believing students had poor abilities. The exception was use of instruments where few units were ranked as containing good students. In the small number of Arts units that required particular mathematical skills students were believed to perform poorly. These included the topics of

- use formula
- recognise patterns in number (patterns)
- use mathematical skills to analyse and solve unfamiliar problems (use skills)
- make judgements as to validity of mathematical reasoning (make judgments)
- use standard mathematical techniques to solve a problem (use standard techniques)

and account for the concern in some units about the algebra skills of students.

Faculty of Business

Two responses were received from 10 units, with only one of these indicating a need for mathematical skills. Consequently a detailed analysis of this faculty is not included. Fifteen out of 48 topics assessed were perceived to contain students with poor skills (Fig. 7).

Faculty of Commerce

Three responses were received from a total of 4 units, with only two of these indicating a need for mathematical skills. Commerce staff had few concerns about the mathematical abilities of students, except perhaps in the area of Algebra (Fig. 5). When examined topic by topic 10 out of 48 General and Year 10 topics were thought to contain units in which students mainly had a rank of poor (Fig. 8).

Faculty of Education

Five responses were received from 6 units, with only two of these indicating a need for mathematical skills. Education staff expressed few concerns about the ability of students except in the area of working mathematically (Fig. 5). In a topic by topic analysis only in the topics of clarify questions(clarify mathematical questions to guide the investigation of the situation), generalise (generalise form one problem to another) and use skills (use mathematical skills to analyse and solve unfamiliar problems) did academics perceive students to perform poorly (Fig. 9).

Faculty of Engineering and Surveying

Ten responses were received from 25 units. When General and Year 10 topics were assessed as a group and compared with other faculties (Fig. 5) academics perceived students to be mostly fair with a balance between good and poor students in all skills, except number where perceptions were that unit leaders ranked students as either fair or good only.

When these skills were examined topic by topic, the following topics occurred most frequently (Fig. 10).

- perform basic operations on +ve and -ve numbers (basic operations)
- demonstrate an ability to use instruments, eg calculator, computer, measuring instruments (use of instrument)
- use fractions, decimals, percentages and ratios (fractions)
- recall and apply suitable units of measurement (units)
- use powers, roots, scientific notation (powers)
- draw linear graph from table of values (linear graphs)
- use formula
- assemble, present and interpret data in tabular and graphical form (interpret data)
- ability to perform pencil and paper calculations (pencil and paper),
- estimate results and answers within a degree of accuracy (estimate)
- use slope and intercepts in straight lines (slope and intercepts)

The distribution of good, fair and poor ranks within these topics was mostly balanced except in the topic of estimate where no groups were ranked as good. Within other topics, however over 50% of units assessed contained students with poor ranks. These are the topics of most concern and included

- draw conclusions from surveys and experiments (draw conclusions)
- recognise and represent linear, quadratic function, reciprocal and exponential function (use linear and quadratic)
- making judgements as to the validity of mathematical reasoning (make judgments)
- understand bearings and construct maps (construct maps)
- solve simultaneous equations
- produce mathematical arguments to prove a proposition (prove a proposition)

Faculty of Science

Twenty eight responses were received from 43 units. When General and Year 10 topics were assessed as a group and compared with other faculties (Fig. 5) academics believed that commencing students have good abilities in some topics but percentages were very low. Academics were mostly concerned about the areas of general skills and working mathematically where over 40% of responses ranked students' abilities as poor.

Science however, is a diverse faculty made up of different degrees with different mathematical expectations. If faculty units are sub-divided into sections of General Science (14 responses), Corporate Units (4 responses), Psychology (4 responses) and Nursing (3 responses) a more detailed picture emerges, although caution should be extended because of the small numbers of responses involved (Fig. 12). However, it is clear that most academics responses indicate concern in the areas of corporate units and Nursing, with Nursing staff perceiving difficulties in areas of working mathematically, algebra, general skills and number while staff in the corporate units concern was in the areas of working mathematically, chance and data, algebra and measurement. The other sections of General Science and Psychology were perceived to have students of fair ability in those topics.

When General and Year 10 abilities were examined topic by topic, the following topics occurred most frequently (Fig. 11):

- use fractions, decimals, percentages and ratios (fractions)
- ability to perform pencil and paper calculations (pencil and paper),
- perform basic operations with +ve and -ve numbers (basic operations)
- demonstrate an ability to use instruments, eg calculator, computer, measuring instruments (use of instrument)
- recall and apply suitable units of measurement (units)
- use powers, roots, scientific notation (powers)
- communicate mathematical ideas and reasoning (communicate ideas)
- use formula
- use standard techniques to solve a problem (use standard techniques)
- use mathematical language and terms accurately and appropriately (use language)
- assemble, present and interpret data in tabular and graphical form (interpret data)
- estimate results and answers within a degree of accuracy (estimate)
- use mathematical skills to analyse and solve unfamiliar problems (use skills) generalise from one problem to another (generalise)

Within other topics, however, over 50% of the responding academics believed students had poor skills. These are the topics of most concern and included

- General skills
    - making judgements as to the validity of mathematical reasoning (make judgments)
    - estimate results and answers within a degree of accuracy (estimate)

    - use mathematical skills to analyse and solve unfamiliar problems (use skills)
    - generalise from one problem to another (generalise)
    - communicate mathematical ideas and reasoning (communicate ideas)
    - clarify mathematical questions to guide the investigation of a situation (clarify)
- Mathematical Skills
    - produce mathematical arguments to prove a proposition (prove a proposition)
    - manipulate algebraic fractions (algebraic fractions)
    - recognise and represent linear, quadratic function, reciprocal and exponential function (use linear and quadratic)
    - visualise, produce and describe translations, reflections, rotations and enlargements (translation)
    - use trigonometric ratios

Fig 6: Academics' Perceptions of Mathematical Abilities - Faculty of Arts

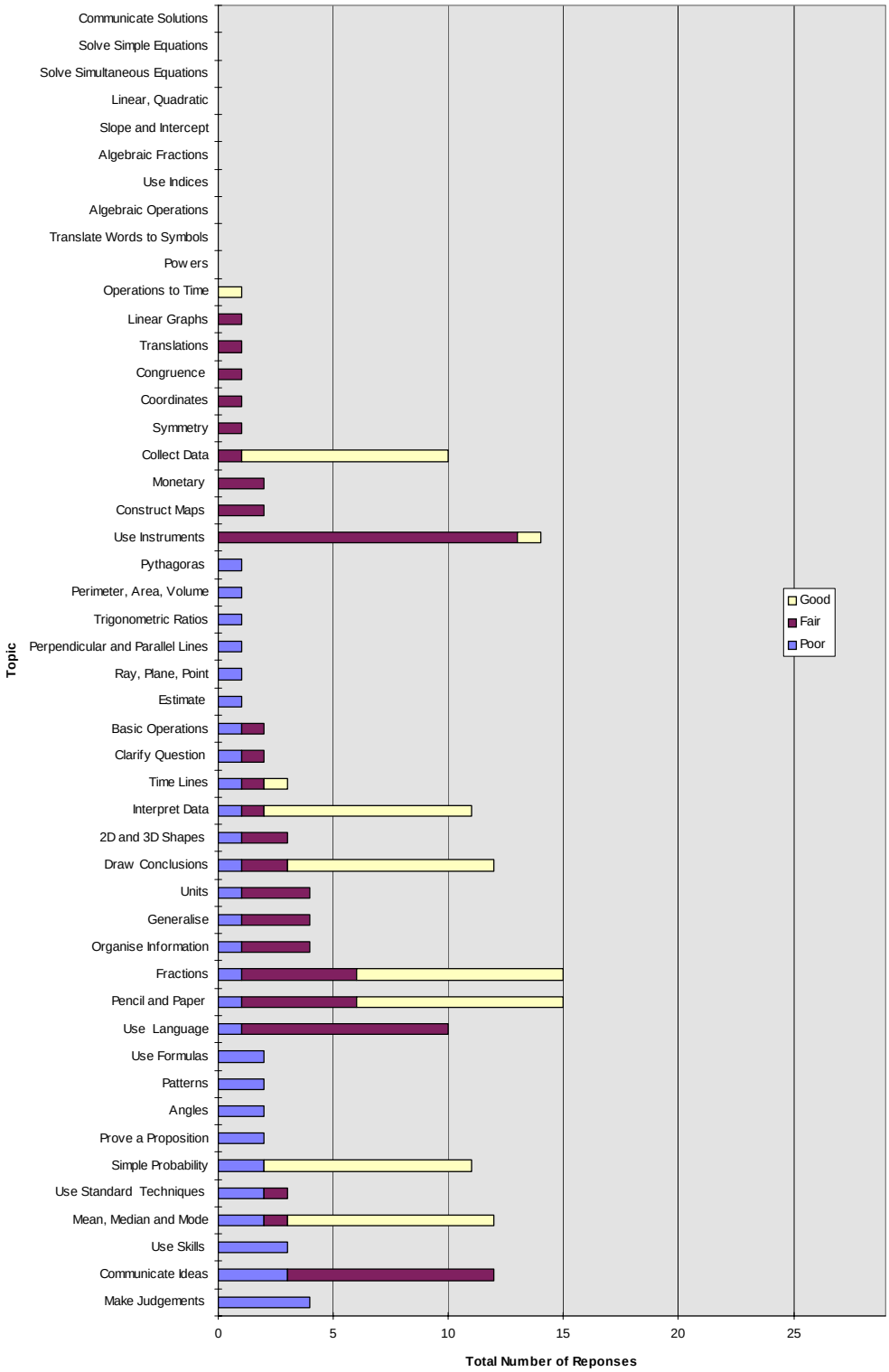


Fig 7: Academics Perceptions of Mathematical Abilities - Faculty of Business

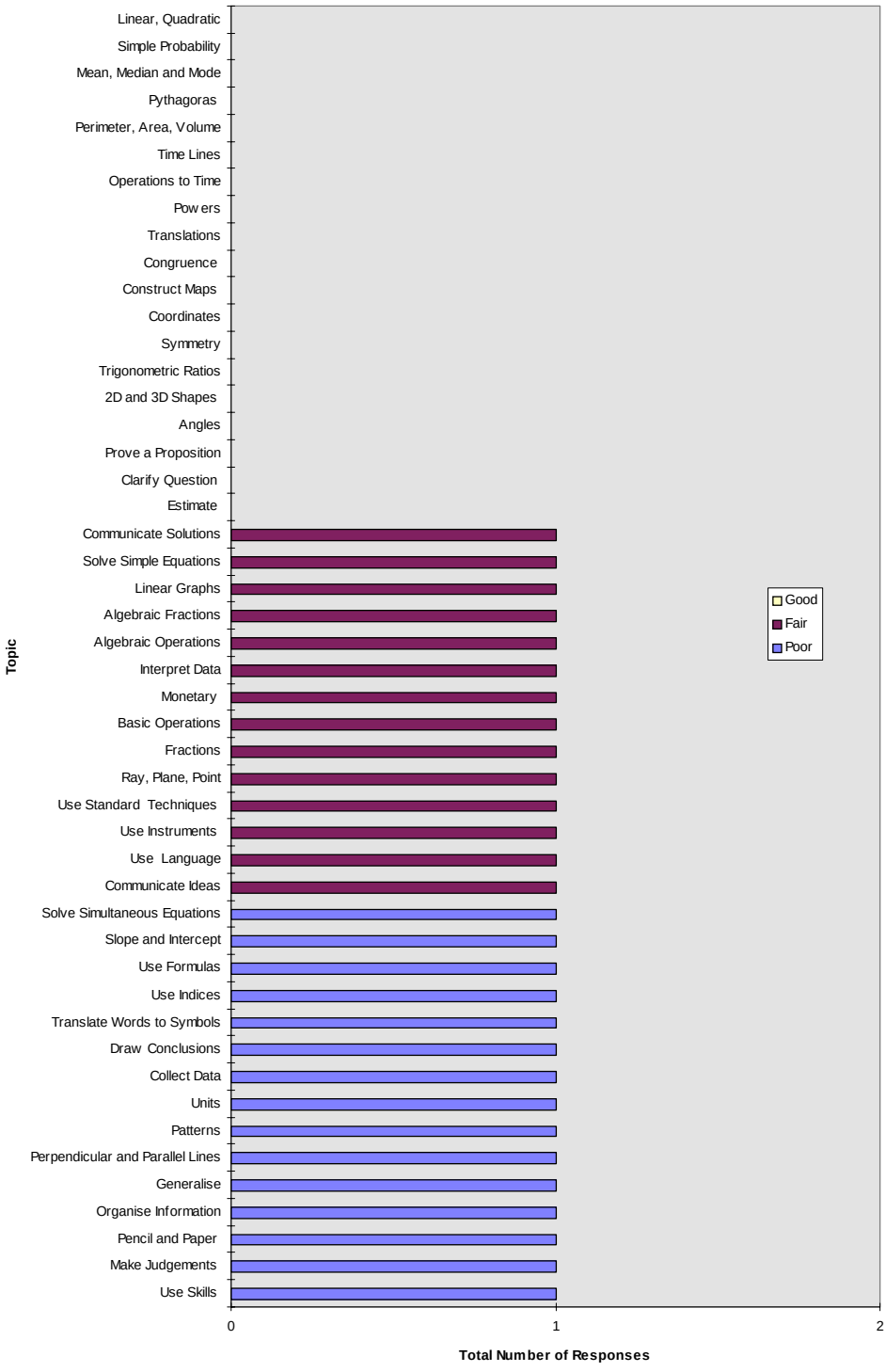


Fig 8: Academics Perceptions of Mathematical Abilities - Faculty of Commerce

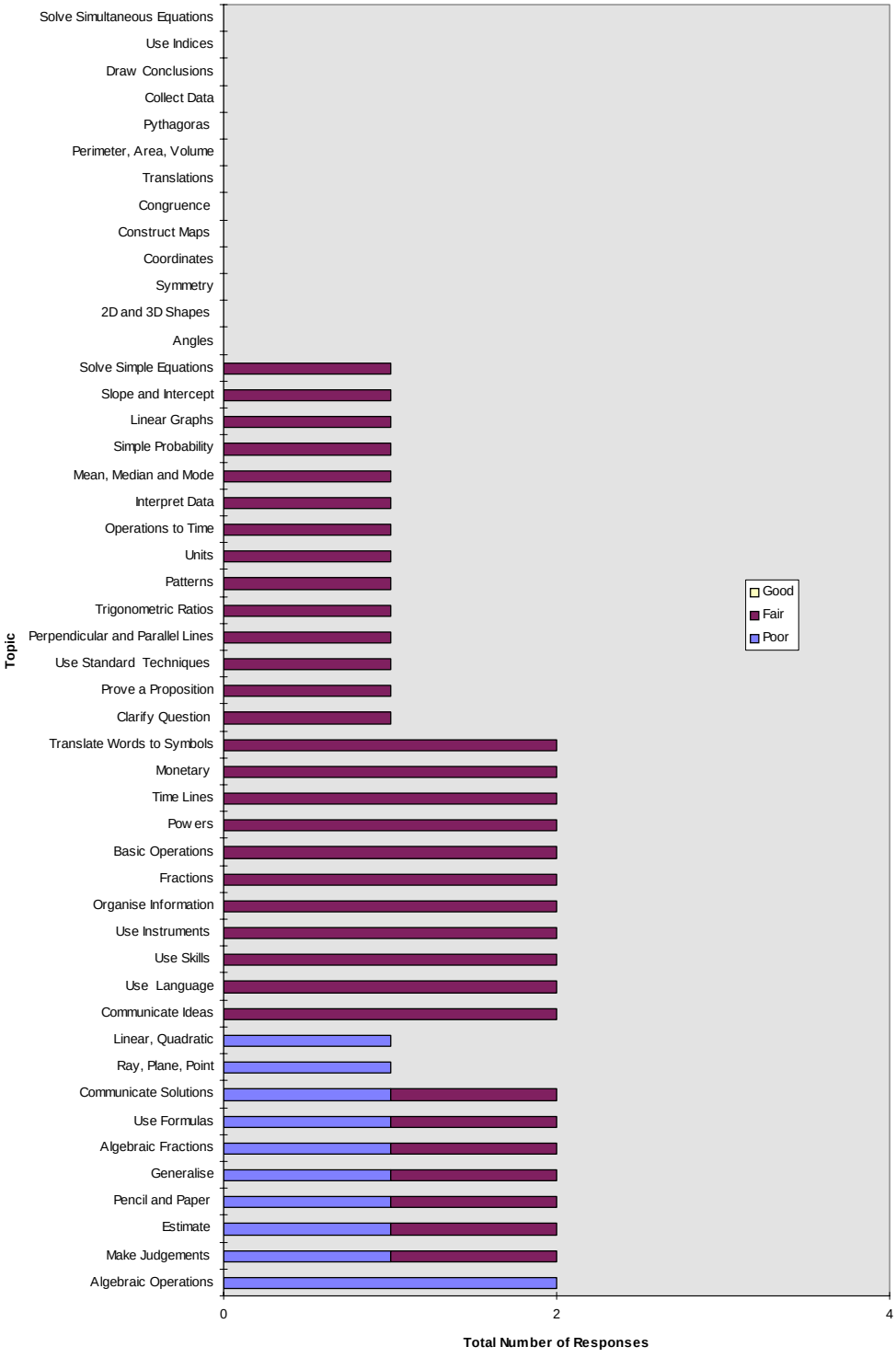


Fig 9: Academics Perceptions of Mathematical Abilities - Faculty of Education

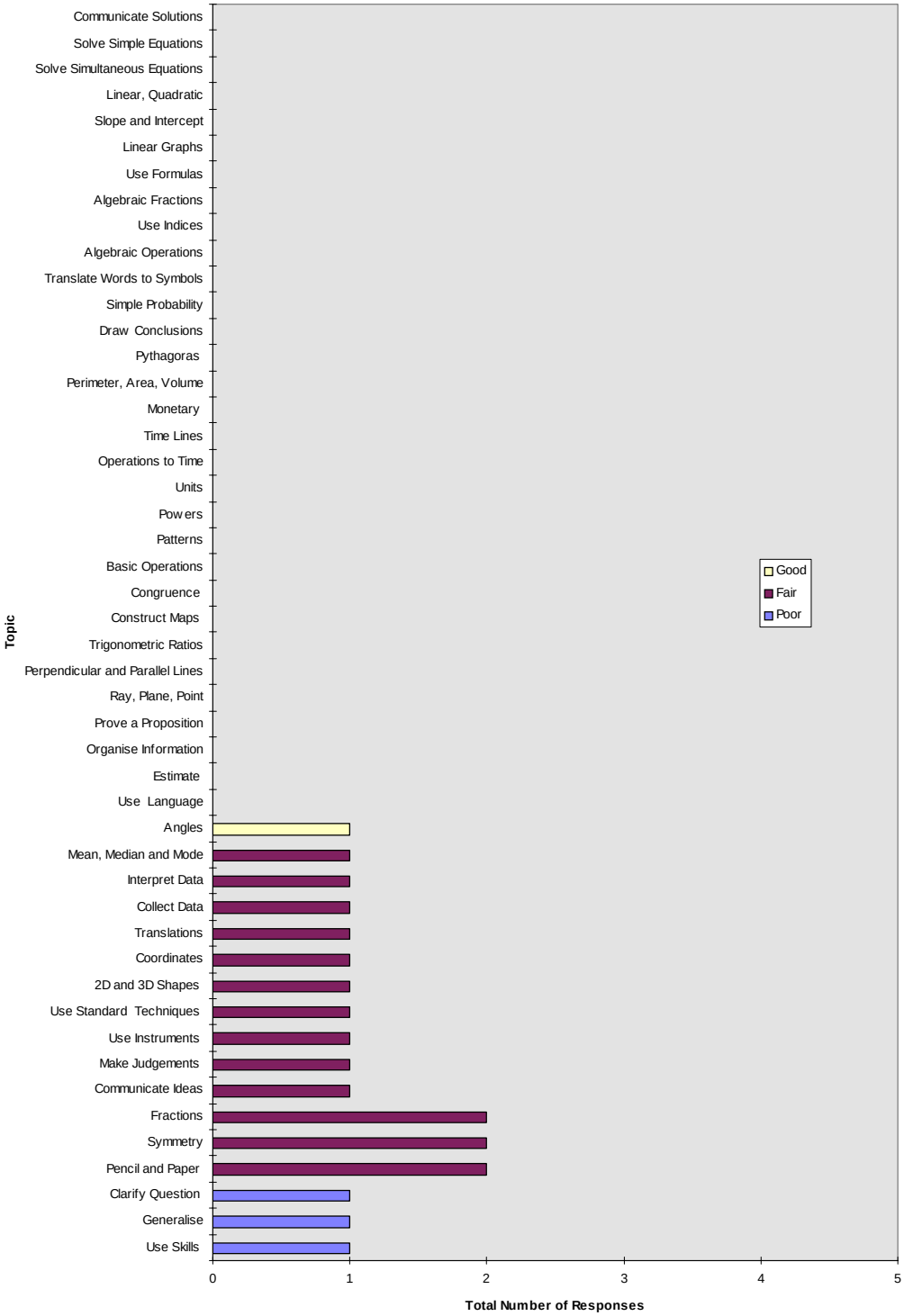

Communicate Solutions
Solve Simple Equations
Solve Simultaneous Equations
Linear, Quadratic
Slope and Intercept
Linear Graphs
Use Formulas
Algebraic Fractions
Use Indices
Algebraic Operations
Translate Words to Symbols
Simple Probability
Draw Conclusions
Pythagoras
Perimeter, Area, Volume
Monetary
Time Lines
Operations to Time
Units
Powers
Patterns
Basic Operations
Congruence
Construct Maps
Trigonometric Ratios
Perpendicular and Parallel Lines
Ray, Plane, Point
Prove a Proposition
Organise Information
Estimate
Use Language
Angles
Mean, Median and Mode
Interpret Data
Collect Data
Translations
Coordinates
2D and 3D Shapes
Use Standard Techniques
Use Instruments
Make Judgements
Communicate Ideas
Fractions
Symmetry
Pencil and Paper
Clarify Question
Generalise
Use Skills
Topic
Good
Fair
Poor
0
1
2
3
4
5
Total Number of Responses

Fig 10: Academics Perceptions of Mathematical Abilities - Faculty of Engineering and Surveying

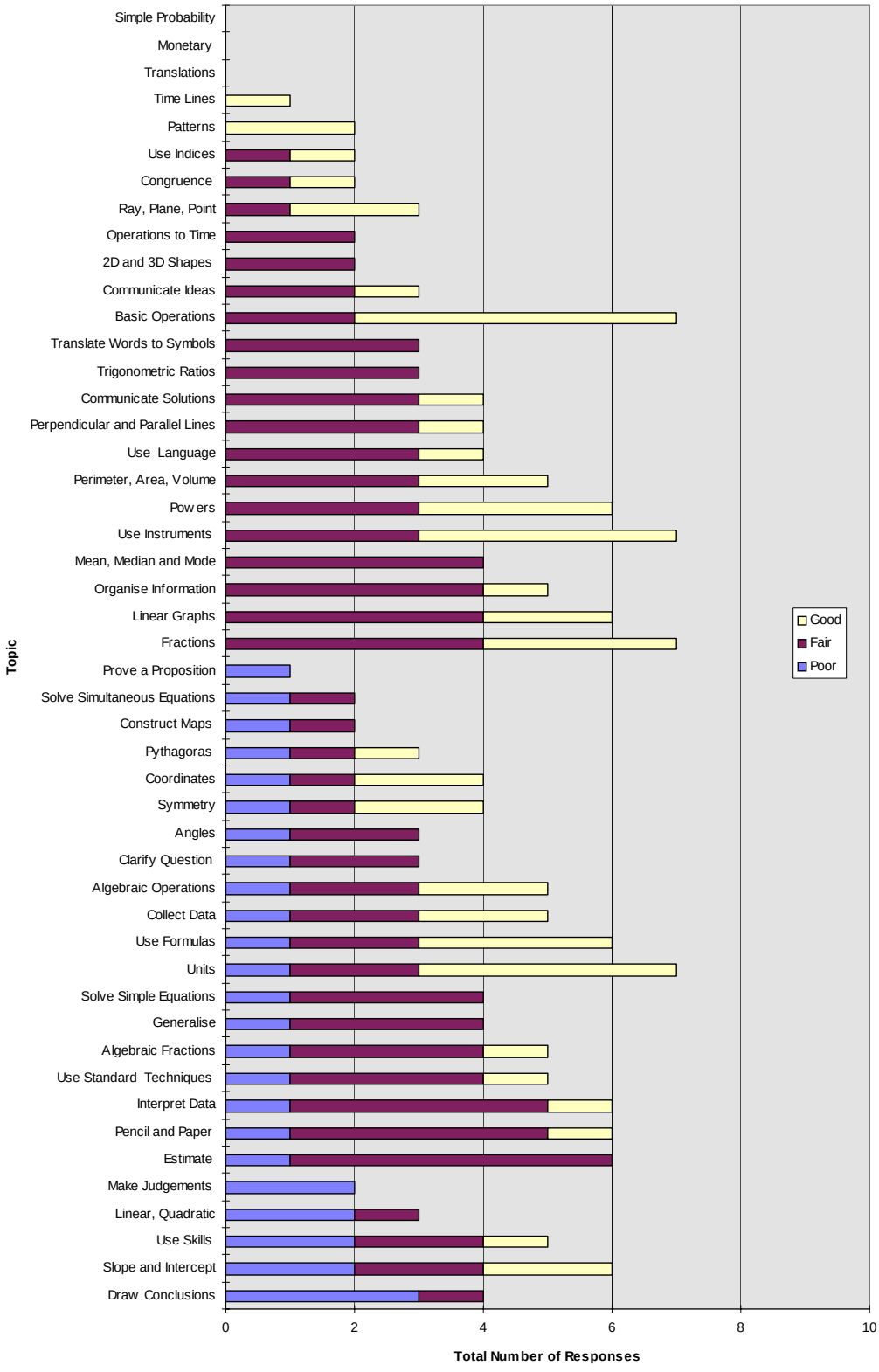


Fig 11: Academics Perceptions of Mathematical Abilities - Faculty of Science

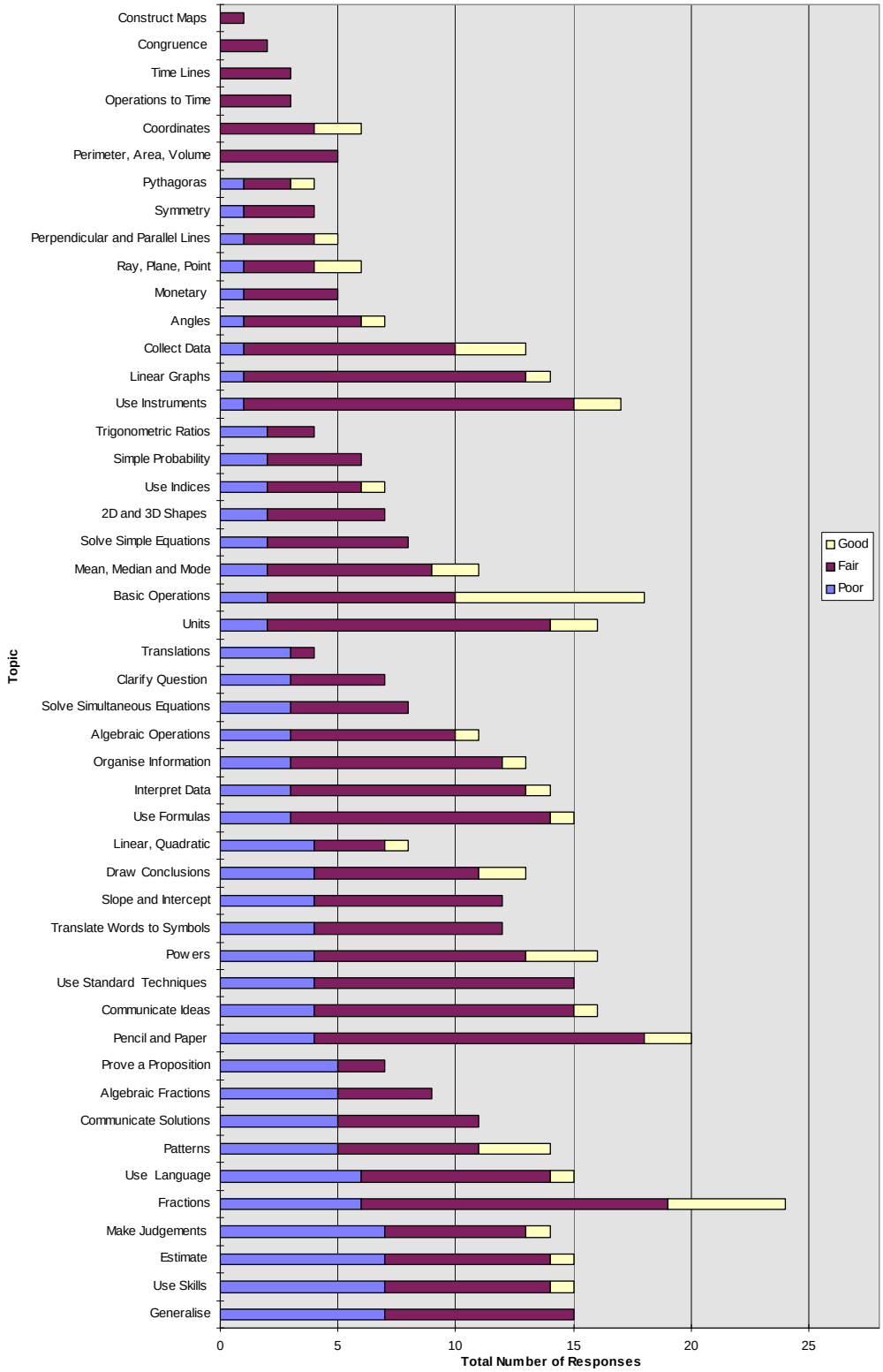
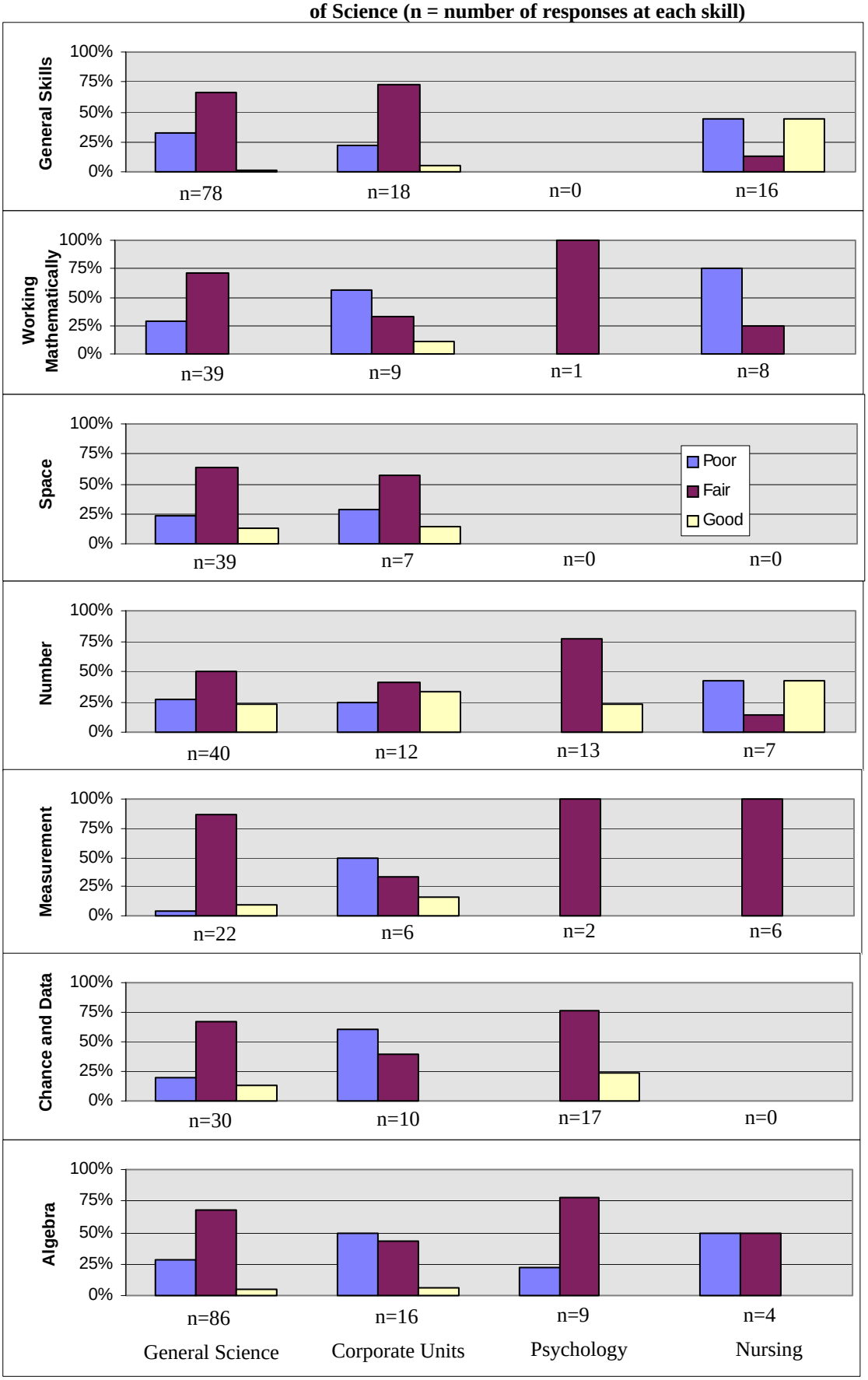


Fig 12: Academics' perceptions of mathematical ability within the Faculty of Science (n = number of responses at each skill)



4.0 Discussion and Conclusions

Numeracy concerns have become an increasing priority within higher education over the past 10 years. But what is numeracy. In this report numeracy is defined according to the definition of Yasukawa and Johnston (1994)

> *...being numerate is being able to situate, interpret, critique, use and perhaps even create maths in context...*

and so includes abilities to think critically and solve problems.

This report confirms that staff at USQ do have concerns about academic numeracy. Such concerns are being voiced throughout the world and in the Higher Education Sector are typified by the results found in a similar report conducted by the University of Adelaide in 1996.

Our concerns are centred on the following results of the report:

- mismatches do occur between stated mathematical prerequisites and expectations of the teaching staff,
- many units across all faculties contain students who are believed to possess poor mathematical skills especially in areas of general skills, working mathematically and algebra,
- it is believed that students' abilities to understand, interpret and communicate logical arguments are poor.

Mismatches

It is apparent that there were a number of mismatches between written prerequisites and the expectations of teaching staff. This is not unexpected as it is difficult for all academics to keep abreast and fully informed about changes in secondary school mathematics. The task is made even more difficult by the diversity of educational experiences that are accepted as entry requirements, especially with mature age students. This report supports a long held belief by the authors that a statement of "no mathematics" or the omission of any mention of mathematics from an entry requirement is interpreted differently by different people. Fifteen lecturers who ticked no mathematics for their unit went on to detail particular mathematical skills required for their unit...this included in one instance algebraic skills at the Maths B level. It is the authors' experience that a statement of "no mathematics" or the omission of maths skills from a unit description also leads a number of students to believe that absolutely no numeracy skills will be required.

Mathematical Abilities

Perceptions of mathematical abilities were varied and caution needs to be used as results are based on academics impressions rather than quantitative testing of students.

However, bearing this in mind it appears academics are concerned about students' abilities. Fractions, decimals, percentages and ratios and ability to do pencil and paper calculations are topics that are mentioned most frequently but are not the topics that academics believe students have the most difficulty with. These topics revolve around the general skills and skills associated with working mathematically, eg making judgments as to the validity of mathematical reasoning, using mathematical skills to analyse and solve unfamiliar problems, generalising from one problem to another and communicating mathematical ideas and arguments often occurred. Such concerns often revolve around the inability of many of our students to think critically and solve problems. Faculties and units were also found to have further specific mathematical concerns, eg Bachelor of Science (Nursing) with number work, Bachelor of Engineering with algebra. Routine mathematics testing which has taken place in some units (OPACS internal reports) over the past 5 or more years confirms these results.

The results of this report support the concept that mathematics is more than just working with numbers it is a complex interaction between numeracy, literacy and thinking skills and as such any programs involved in improving the mathematical understanding of USQ students needs to integrate all three components within discipline developments. To this end we would like to make the following recommendations.

5.0 Recommendations

- Academics require access to more information about commencing students' mathematical and general skills and knowledge and details of set prerequisites.

- OPACS should develop closer links with Faculties and faculty staff so that they can work collaboratively to improve academic numeracy levels, in the first instance, and then develop strategies to address the problems of academic numeracy and academic literacy in a systematic way.

6.0 References

Cousins, E. and Roberts, S. (1995) Perceived mathematical proficiencis in Level 1 subjects. Internal Report by Mathematics Learning Centre, University of Adelaide, South Australia

Queensland Tertiary Courses. QTAC. Print Point Australia, 1997.

McInnes,C. and James,R. (1995) *First Year on Campus.* AGPS, Canberra;

Yasukawa, K. and Johnston, B. (1994) *A numeracy manifesto for engineers, primary teachers, historians...a civil society - can we call it theory?* Proceedings of the Australian Bridging Mathematics Network Conference, Sydney University, pp 191 - 199.

7.0 Appendices

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7 September 2004

Dear Colleague

Re: Survey of numeracy skills

Prompted by concerns about the numeracy levels of first year students and recent changes to the senior secondary mathematics syllabus OPACS is undertaking a review of the numeracy skills and concepts needed by entering students and your perceptions of these students' proficiency with these skills.

We are seeking your assistance in determining which skills and concepts are assumed in your first year unit(s) and encourage you to complete the enclosed questionnaire. The questionnaire is divided into 3 sections: general skills, Year 10 skills and Year 11/12 skills. Although some of these skills may not appear relevant to your unit(s) we hope that you will consider each one to see which you assume students should possess on **arrival** in your unit and your perceptions of their proficiency in that skill.

Multiple copies of the questionnaire have been included so that you can distribute them to your moderator or other members of your team as you think appropriate.

In addition, it would be particularly helpful to us if you could participate in a brief interview to discuss your perceptions of the numeracy levels of previous students in your unit and to discuss any other numeracy concerns which may exist at this level.

Following completion of the project we will disseminate a written report widely in order to clarify the degree of mathematical proficiency required by incoming students. Such information should prove useful for course advice, and for helping to establish if additional assistance is required for students at risk. Such support is currently offered to a number of units through OPACS.

We know that your time is valuable and limited, and hope that you will be able to participate in this survey. Thank you for your cooperation.

Yours sincerely

Janet A Taylor
OPACS

Linda Galligan
OPACS

Numeracy Survey July 1997

Name:_____ **Unit name and number**: _____

Role in unit (eg leader, moderator, team member) : _____

Expected mathematics background (please circle your choice (s))

None Year 10 Maths A Maths B Maths C
(or equivalent)

To complete the survey tick each topic assumed at the commencement of your unit then tick your perception of the proficiency of on-campus and distance students (if applicable).

Return survey by internal mail to: DR JANET TAYLOR, OPACS

When you have completed the survey please return to this section to make any general comments about your concerns related to numeracy or comments about this survey:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

GENERAL TOPICS AND SKILLS	TOPICS AND SKILLS NEEDED	PERCEIVED STUDENT PROFICIENCY					
		On Campus students			Distance students		
		GOOD	FAIR	POOR	GOOD	FAIR	POOR
Communicate mathematical ideas and arguments							
Use mathematical language and terms accurately and appropriately							
Use mathematical skills to analyse and solve unfamiliar problems							
Make judgements as to the validity of a mathematical argument							
Demonstrate an ability to use instruments e.g. Calculator, computer, measuring instruments.							
Estimate results and answers within a degree of accuracy							
Ability to perform simple pencil and paper methods when necessary							

YEAR 10 TOPICS AND SKILLS	TOPICS AND SKILLS NEEDED	PERCEIVED STUDENT PROFICIENCY					
		On Campus students			Distance students		
		GOOD	FAIR	POOR	GOOD	FAIR	POOR
1 : WORKING MATHEMATICALLY							
Select and organise key information							
Generalise from one problem to another							
Clarify mathematical questions to guide the investigation of the situation							
Produce mathematical arguments to prove a proposition							
Use standard mathematical techniques to solve a problem							
2 : SPACE							
Draw and name angles							
Draw and name 2D and 3D shapes using basic tools							
Understanding terms - eg ray, plane, point							
Use properties of perpendicular and parallel lines							
Use trigonometric ratios							
Understand symmetry in plane shapes and solids							
Use coordinates in four quadrants							
Understand bearings and construct maps including using scales							
Interpret congruence and similarity of shapes							
Visualise, produce and describe translations, reflections, rotations and enlargements							
3 : NUMBER							
Use fractions, decimals, percentages, ratios							
Perform basic operations on +ve and -ve numbers							
Recognise patterns in numbers							
Use powers, roots, scientific notation							
4 : MEASUREMENT							
Recall and apply suitable units of measurements							
Apply basic operations to time situations							
Use time lines and timetables							
Calculate monetary items (e.g. Budgets)							
Calculate perimeter, area, volume for simple 2D and 3D shapes							
Use Pythagorus's theorem							
5 : CHANCE AND DATA							
Collect data for a simple survey or experiment							
Assemble, present and interpret data in tabular and graphical form							
Use mean, median and mode							

YEAR 10 TOPICS AND SKILLS	TOPICS AND SKILLS NEEDED	PERCEIVED STUDENT PROFICIENCY					
		On Campus students			Distance students		
		GOOD	FAIR	POOR	GOOD	FAIR	POOR
Draw conclusions from surveys and experiments							
Use and interpret measures of simple probability							
6 : ALGEBRA							
Translate from words to symbols							
Perform simple algebraic operations eg expand brackets, collect like terms							
Use indices							
Manipulate algebraic fractions							
Use formulas							
Draw linear graphs from a table of values							
Use slope and intercept in straight lines							
Recognise and represent linear, quadratic, reciprocal and exponential functions							
Solve simultaneous equations							
Use and solve simple equations and inequations							
Communicate solutions to problems in appropriate language							

If you think that your students need further mathematics please continue to Year 11/12 topics

YEAR 11/12 TOPICS AND SKILLS	TOPICS AND SKILLS NEEDED	PERCEIVED STUDENT PROFICIENCY					
		On Campus students			Distance students		
		GOOD	FAIR	POOR	GOOD	FAIR	POOR
MATHEMATICS B							
Interpretation and drawing of scale drawings and plans							
Application of trigonometry including sine and cosine rules							
Practical applications of volumes, surface area and circle geometry							
Concepts of relation, function, domain and range							
Practical applications of linear, quadratic, absolute value and reciprocal functions							
Investigate the shapes of polynomials							
Concept of an inverse function							
Solve two simultaneous equations using graphs							
Calculate and interpret average and instantaneous rate of change							
Interpret derivative as instantaneous rate of change including concept of a limit							
Derivative theorems for x^n, sums, product and chain rules							
Practical applications of derivatives eg stationary points, increasing and decreasing functions and optimisation							
Find derivatives of sin$x$, cos$x$, e^x, ln$x$							
Draw and interpret graphs of trig functions							
Solve simple trig equations							
Use Pythagorean identities							
Use definitions of a^x and $\log_a x$							
Use index laws							
Use logarithmic laws							
Draw and interpret exponential and logarithmic graphs							
Use logs to solve index equations							
Applications of exponential and logarithmic functions							
An understanding or networks and linear programming							
Perform interest calculations							
Use arithmetic and geometric progressions interest calculations							
Definitions of definite and indefinite integrals							
Calculate integrals for polynomial, exponential, sine and cosine functions							
Practical applications of the integral							
Use integration to find an area							
Numerical integration eg trapezoidal rule							
	TOPICS	**PERCEIVED STUDENT PROFICIENCY**					

YEAR 11/12 TOPICS AND SKILLS	AND SKILLS NEEDED	On Campus students			Distance students		
		GOOD	FAIR	POOR	GOOD	FAIR	POOR
Interpretation of graphical displays of data							
Identification and use of 5-number summaries							
Calculations and interpretation of measures of central tendency and dispersion							
Calculation and use of probability and probability distributions							
Use random sampling							
Formulations and testing of statistical hypothesis							
Define and use the normal distribution							
MATHEMATICS C							
Definition and properties of a group							
Structure of the real number system							
Structure, representation and operations on complex numbers							
De Moivre's Theorem							
Mathematical applications of complex numbers							
Definition, properties and operations on matrices							
Determinants and inverse matrices							
Solutions of systems of linear equations using matrices							
Applications of matrices							
Definition of vectors and relationship with matrices							
Operations with vectors including scalar and vector products							
Applications of vectors							
Curve sketching							
Integration of functions involving products and quotients							
Integration by parts							
Simpson's Rule							
Solution and application of simple linear first order differential equations							
General sequences and series, including arithmetic and geometric progressions							
Application of AP and GP							
Permutations and Combinations and their application							
Applications of patterns and use of finite differences							

Units Surveyed

Faculty	Unit	Title
Business	51002	Intro To Accounting
	51005	Introduction To Law
	51103	Financial Accounting
	51137	Financial Markets
Commerce	51004	Organis Behaviour & Mana'g
	51008	Economics
	51332	Economics Ii
	51340	Intro To M'ment Science
	51361	Introductory Marketing
	51379	Human Resource Management
	51382	Aust Political Institution
	51385	Govt-Business Relations
	75001	Introduction To Computing
	75111	Intro Business Info Sys
Science	60041	Foundation Mathematics
	60090	Foundation Psychology
	61611	Foundation Chemistry
	61611	Foundation Chemistry
	61611	Foundation Chemistry
	61613	Organic Chemistry
	61618	Inorganic & Physical Chem
	61618	Inorganic & Physical Chem
	61901	Science For Teachers
	62101	Foundation Biology
	62103	Animal And Plant Biology
	62121	Biological Methods
	63104	Evolution & Ancient Envir
	63105	Climates - Past & Present
	64001	Data Analysis
	64001	Data Analysis
	64611	Discrete Maths Computing
	64612	Algebra And Calculus I
	64613	Algebra And Calculus Ii
	64614	Operations Research I
	64902	Mathematics For Teachers
	65013	Astronomy
	65014	Remote Sensing & Meteor'y
	65901	Physics & Instrumentation
	65902	Physics For Surveyors
	66001	Introductory Computing
	66001	
	66003	Intro Profess'l Computing
	66121	Adv Procedural Programming
	67000	Medication Calculations 1
	67000	Medication Calculations 1
	67111	Nursing For Health

	67112	Nursing Foundations 2
Science	67117	Social Sciences Nursing
	67121	Nursing Foundations 1
	67431	Anatomy And Physiology
	67451	Biophys Sci Foundations
	67461	Behav Science Foundations
	67462	Phys & Pathophysiology 1
	69103	Social Process Behaviour
	69104	Biological Bases Behaviour
	69204	Human Learn:Theories & Iss
	69209	Physiological Psychology
Engineering & Surveying	70210	Eng Communicati0ns And Pra
	70230	Electrical Technology
	70245	Engineering Materials
	70270	Engineering Statics
	70335	Computer Engineering I
	70336	Computer Architecture
	70380	Geology And Surveying
	77500	Aircraft Materials
	77501	Aerodynamics
	E0001	Computers In Engineering
	E0003	Electrotechnology
	E0004	Applied Mechanics I
	E0006	Engineer'g Design & Draft
	E0007	Surveying A
	E1001	Geology And Hydrology
	E1002	Civil Engineer'g Materials
	E2001	Electronic W'shop & Prod
	E2003	Elect Measure & Analysis
	E2005	Telecommunication Principl
	E2012	Telecommunications Systems
	E3001	Fluid Mechanics
	E4003	Surveying B
	E4004	Survey Computations A
	E4018	Geographic Data Presentati
	E4023	Geographic Information Sys
Education	80131	Soc-Cult Phys Ed & Sport
	80140	Foundations Of Language
	80144	Health For Teachers
	80173	Computing And Design
	80233	Kinesiology
	80273	Learn Through Comp Program
Arts	90501	Communication & Scholarshp
	90502	Aust Asia & The Pacific
	90503	Communication Key Concepts
	91501	Performance 1
	91507	Music Craft 1
	91521	World Music 1
	91522	World Music 2

	92521	Intro To Studio Practice
Arts	92522	Visual Arts Practice 1
	92527	Found Stud In Hist Of Art
	92528	Visual Cultures
	92532	Technology And Design
	93528	Int Hist & Theory Drama 1
	93529	Int Hist & Theory Drama 2
	93530	Theatre Practice A
	93536	Acting 1
	93538	Voice And Movement 1
	93548	Stage Management 1
	93550	Sound And Lighting 1
	94180	Introductory Indonesian
	94190	Introductory Mandarin
	94193	Introduction To Journalism
	94196	Intro To Public Relations
	94280	Radio Production 1
	94282	Writing For Broadcast
	94507	Intro To Media Law & Ethic
	95100	World Civilization 1500 Ad
	95101	Intro Australian History
	95202	Public Relations In Aus. History
	96110	Environmental Systems
	96111	Culture And Landscape
	96191	World Archaeology: Intro
	96192	Introductory Anthropology
	96501	Intro Asian Civilisations
	96502	Arts In Asian Civilisation
	97102	Communicat'n Media Society
	97107	Communicat'n Cultural Form
	97120	Literature Criticism Cult
	97121	Narrating Australia
	97181	Introductory German A
	97183	German 1
	97940	Coorporate Communication
	97302	Pr Practice And Techniques
	97944	Advanced Pr Strategies
	97506	Pr Project
	97508	Issues Management And Strategic Planning
	97960	Crisis Management
	97943	Professional Communication
	97202	Writing Public Relations