The History and Development of Mathematics Examinations in New South Wales at the end of Secondary Schooling between 1788 and 2010

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Certificate of Authorship/Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Stephen A Curtis

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Dedication

This thesis is dedicated to my parents Elizabeth and Emery Curtis.
They believed that education and knowledge can never be
taken from anyone and made enormous sacrifices
so their children would have every
opportunity to study.

Table of Contents

Tables

Figures

Chapter 6

Leaving Certificate Honours (with calculus)

ABSTRACT

The History and Development of Mathematics Examinations in New South Wales at the end of Secondary Schooling between 1788 and 2010.

This doctoral dissertation reviews the historical developments of education and mathematics examinations used in New South Wales at the end of secondary schooling from 1788 to 2010. A heuristic investigative process, using a manual application of quantitative content analysis was carried out. Time was used as an independent variable with an application of middle range theory to underpin the theoretical framework for this research.

The hypothesis is that over an extended period of time, it would be reasonable to expect changes to the examination process due to the influence of factors such as historical and political events, curriculum developments, and changes in social values.

The results indicate there was just one significant change identified in the early 1960s. Contrary to expectations, an analysis of the taxonomy of terms has shown that the majority of the questions were skills based and did not test logical thinking and reasoning. Apart from gender and racial equality, the style and the type of questions have not taken into account any other social changes.

In view of the above the concluding chapter will suggest ways forward for educational research.

Chapter 1

INTRODUCTION

It is generally accepted that having an education is important as it equips us for life skills and hopefully beyond. Animals start training their young at an early age to gather food or hunt in order to survive. In much the same way, humans have also been training and teaching their young to survive in our more complicated world.

Early formal education began with the 3Rs. Initially children were taught to read the Bible and later instructed to write in order to communicate. At the same time they were also taught arithmetic to manage money and calculate measurements. It seems that mathematics in many ways has always been an integral part of our lives. As educators, are we doing a good job at teaching our students? Even if we think that we are doing well, surely we can do better. There are many questions that need to be answered and clearly this study cannot answer them all, but hopefully it will provide some meaningful suggestions towards improving the mathematics curriculum and the subsequent examination system at the end of secondary schooling in New South Wales.

1.1 Rationale for the research

As demonstrated by Genovese (2002), content analysis can be considered as a suitable technique to identify the style, content and format of examinations. Content analysis analyses the language used in documentation, such as examinations, by drawing parallels and making conclusions by comparing writings of different time periods. Britton and Raizen (1996) also used an application of content analysis to compare mathematics examinations produced by different countries. In addition to style, content and format, Britton and Raizen (1996) considered the cognitive requirements to answer questions. An adaptation of both these techniques was used in this thesis to analyze high stakes mathematics examinations.

It was shown there was a strong correlation between the curriculum and the high stakes examination and according to Eckstein and Noah (1992) examinations can be levers for curricular change or obstacles to it. The change could be viewed as positive or negative because according to Linn (1987, p.203) teachers teach to a test while students study to a test thus "*innovation in the curriculum fail to persist unless they are reflected in similar innovations in testing*".

This study looked at mathematics examinations at the end of secondary schooling by reviewing and analyzing the historical developments in New South Wales education in general, with a specific focus on mathematics examinations. There was no single theory found suitable to support all of the above mentioned concepts as well as the methodology used to analyze the examinations (Chapter 3). Therefore a middle-range theory (Merton, 1967) was adopted as the theoretical rationale for underpinning this thesis. A middle range theory starts with a number of empirical concepts such as *over an extended period of time some changes would take place*, then analyses the positive and negative commitment to this concept. The positive side describes what the theories should do, while the negative side discusses what the theory does not cover. The positive theories are able to highlight and identify the changes that have taken place in the examination process, however on the negative side these theories do not explore or provide an explanation as to why these changes have taken place.

1.2 Purpose of this study

This study will be looking for identifiable patterns and changes that may have occurred to the teaching and curriculum of senior mathematics by analyzing the high stakes examinations in New South Wales at the end of secondary schooling from 1788 to 2010. The hypothesis being that over an extended period of time there would be changes to the curriculum which in turn would be reflected in the examination process.

While analyzing changes, this study will explore why so many schools in 2010 are still using mathematics resources initially produced 30 - 40 years ago. Has there been any recent significant change to the teaching of mathematics? According to a discussion paper on school mathematics for the 21st Century produced by the Australian Association of Mathematics Teachers (AAMT, 2009, p.3) in May 2009 "*Mathematics — both the discipline itself, and its uses in other fields — has radically changed in the past 30 years, most notably through the development and uptake of powerful technologies for doing mathematics; school mathematics needs to reflect consideration of these changes."* Is this true, has this really happened?

World wide there has been a great deal of documented research into mathematics education in general. This research will aim to identify changes to the mathematics curriculum at the end of secondary schooling by analyzing the examination process. The assumption is that changes to the style, format and content of the examination papers should reflect corresponding changes to the mathematics curriculum and the way in which mathematics is taught in the classroom. A similar study conducted recently, analyzed the Regents examination system in New York (Watson & Semel, 2010).

The researcher believes that societies' views on issues such as social and political matters, population growth and multiculturalism are likely to have an impact on education. Technology, with the use of computers in our every day life, is also likely to influence the way we learn and the ways in which we teach. Gender and equity issues in providing equal opportunities for women and men as well as the influence of stake holders such as universities and Parents' and Citizens Associations have further influenced the teaching curriculum. The impact of economic upheavals such as the depression, World War I and II, the Vietnam War have all influenced the attitudes of people towards the importance of education. All these factors are likely to have directed the curriculum towards better ways of teaching and better ways of learning. Changes to the curriculum will be reflected in the examination process, hence the need for this study to identify and explore the changes that are likely to have taken place.

By looking at the past, one can perhaps make some pertinent predictions as to the direction of mathematics teaching and examinations for the future. This study will consider that changes to the teaching of mathematics in New South Wales may have been influenced by many factors such as:

Student numbers;
Historical events;
Curriculum;
Method of assessment;
Spread of ability;
University funding;
School funding;
Industry demands;
University demands;
Community expectations; and
Changes in social and cultural values.

These issues will be addressed in the Literature Review (Chapter 2) which discusses the relevant research papers and text books in relation to historical events, curriculum developments, educational taxonomies and social developments. The Methodology (Chapter 3) will provide a detailed description of the techniques and concepts used to analyze the high stakes mathematics examination. As there were no formal examinations before 1850, Chapter 4 will serve as a background to this study. Chapters 5, 6, 7 and 8 will progressively focus on different historical periods, encapsulating mathematics education and examinations from 1850 to 2010. Chapter 9 will take an approach similar to the Genovese (2002) study, by examining a snapshot of the cognitive competences and content of mathematics examinations 100 years apart. This chapter will also undertake a closer longitudinal analysis for a set of calculus and non-calculus examinations at ten year intervals. The final Chapter 10 will provide a conclusion and overall summary for this extensive study by making recommendations towards the direction of future examinations as well as exploring avenues for academic research not addressed in this study.

Chapter 2

LITERATURE REVIEW

A discussion paper entitled *"School mathematics for the 21st century: What should school mathematics of the 21st century be like?"* released by the Australian Association of Mathematics Teachers (AAMT) for National Mathematics Day 2009, expressed the idea that our society is very much driven by data and analyses of mathematical models that result from the use of the technologies. This might imply that everyone needs some mathematical skills and capabilities. However one could also argue that mathematics seems nowhere near as important today as it used to be, because most complex calculations can now be automated.

The AAMT also believes that the 21st century requires higher order mathematics for citizens to be able to understand, work with and create mathematical models that are accessible and powerful in the context of current and emerging technologies. Accordingly the teaching practices and the curriculum for the 21st century should reflect this trend. In order to discover whether in fact New South Wales has been heading towards "higher order" mathematics, this study has analyzed the evolution of mathematics through the eyes of the examination process. The literature review of this study focuses on material that will assist in understanding the mechanisms such as our changing society (Section 2.2) that influenced changes to the curriculum (Section 2.3) with the understanding that these changes will then be reflected in the examination process. Change is a complex issue and there are numerous factors that are likely to influence and impact on change. In order to answer the research questions, this study analyzed literature used to study mathematics examinations (Section 2.4), followed by a discussion on the types of research used to analyze the content, cognitive competencies and levels of critical thinking examined (Section 2.5). This thesis is also about teaching and learning mathematics. Therefore as part of the foundation of this research the understanding of "*mathematics*" is considered important in many circles and will be discussed in the next section.

2.1 Importance of Mathematics

At the Proceedings of the EM–ICMI Symposium, Geneva, 20–22 October 2000, Hyman Bass presented his paper on *the growing importance and challenges of mathematics education.* Although it is a lengthy introduction to this study, it encapsulates the need and rationale for this study based on the higher order thinking required to survive, prosper and grow in the 21st century.

"*Why study mathematics? - Our unquestioned premise of the central place of mathematics in the school curriculum (often 12 years of instruction) is now under widespread assault in almost every country. This is producing policies that can have profound impact on the cultural, intellectual, and material standing of mathematics, and its professional communities, in the educational enterprise."* (Bass, 2000, p. 334-335)

The traditional rationale for mathematics study has been a mixture of pragmatic, economic, social, intellectual, and cultural reasons.
Pragmatically, mathematics enables learning the basics.
Economic, arguments are based on the quantitative literacy demanded by the evolving technological workplace, and the desire to remain competitive.
Socially, mathematics provides the resources for responsible citizenship in helping the community.
Intellectually, mathematics provides discipline for science and offers the fundamental tools of analysis and reasoning.
Culturally, mathematics exposes students to some of the most subtle and sublime achievements of the human spirit.

According to the Australian Education Council (1990) mathematics involves observing, representing and investigating patterns and relationships in social and physical phenomena. Mathematical ideas are about number, space, movement, arrangement and chance. Mathematics must be an integral part of a general education because it can enhance our understanding of the world and the quality of our participation in society. Mathematics is used in everyday living, used at work and is the part of the Australian culture. At the same time there is plenty of anecdotal evidence to suggest that many people either dislike or feel intimidated by mathematics (Cockcroft, 1982). The Cockcroft Report of the inquiry into the teaching of mathematics in England and Wales argued that there was a need for everyone to have sufficient confidence to make effective use of whatever mathematical skills and understanding they possessed.

The researcher of this study believes that "*mathematics is all around us*". In one way or other we are all constantly exposed to some form of mathematics. It may be everyday shopping, paying bills, buying a bus ticket or using and applying some mathematical skills at work or play. The concept of learning and understanding mathematics was encapsulated by Schoenfeld (1992, p.334-370) as he summarized the goals of teaching mathematics:

"Mathematics is an inherently social activity, in which a community of trained practitioners engages in the science of patterns which are systematic attempts, based on observation, study, and experimentation, to determine the nature or principles of regularities in systems. The tools of mathematics are abstraction, symbolic representation, and symbolic manipulation. However, being trained in the use of these tools no more means that one thinks mathematically than knowing how to use shop tools makes one a craftsman."

Learning to think mathematically means:

- Developing a mathematical point of view.
- Developing competence with the tools of the trade.

This notion of mathematics has gained increasing currency as the mathematical community has grappled, in recent years, with issues of what it means to be mathematically prepared for an increasingly technological world. The following quotation from *Everybody Counts* typifies the view, echoing themes in the NCTM *Standards* (NCTM, 1989) and *Reshaping School Mathematics* (National Research Council, 1990). Mathematics is a living subject which seeks to understand patterns that permeate both the world around us and the mind within us. Although the language of mathematics is based on rules that must be learned, it is important for motivation that students move beyond rules to be able to express things in the language of mathematics. This transformation suggests changes both in curricular content and instructional style. It involves renewed effort to focus on:

- Seeking solutions, not just memorizing procedures.
- Exploring patterns, not just memorizing formulas.
- Formulating conjectures, not just doing exercises.

"As teaching begins to reflect these emphases, students will have opportunities to study mathematics as an exploratory, dynamic, evolving discipline rather than as a rigid, absolute, closed body of laws to be memorized. They will be encouraged to see mathematics as a science, not as a canon, and to recognize that mathematics is really about patterns and not merely about numbers." (National Research Council, 1989, p. 84)

Rapid changes in technology and the availability of powerful computers prompted educators to ask physical scientists, computer specialists and engineers about the idea of changing the mathematics syllabus (Press, 1987). According to Press (1987) the feedback they received was not altogether unexpected, generally stating that mathematical training offered by schools and colleges was inconsistent with what many were using in industry. It is the researcher's understanding that mathematics teachers in general are divided over the idea of whether schools should be training students for the workplace or not. Part of the answer may be attributed to changes in our society as discussed in the next section.

2.2 Changing society

One of the many factors that may have influenced the curriculum and subsequent examinations were the learning styles of the different generations with their individual characteristics and their approach to life and work. The Australian Bureau of Statistics (2010c) and a McCrindle (2006) Research Study, classified Australia's population since the beginning of the last century according to Table 2.1

Table 2.1 Australia's generation classification

Description	Born
Oldest Generation	Before 1926
Lucky Generation/Builders	1926 - 1945
Boomers	1946 – 1964
Generation X	1965 – 1979
Generation Y	1980 – 1994
Generation Z	1995 - 2009
Generation Alpha	After 2009

In a Discussion Paper called *School mathematics for the 21st century* released by the Australian Association of Mathematics Teachers (AAMT) in May 2009, students of previous generations were characterized according to Table 2.2, however they did not provide any details on Generation Z. According to Cliff (2009) there is anecdotal evidence that Generation Z can best be described as technology on Ritalin with the need to be "connected 24/7". By the time they enter high school most have graduated to their own Facebook account and they almost all have mobile phones. These students value speed over accuracy and have not seen life without the Internet. They bring iPods to class and teachers allow students to use them while they are studying.

Generation Z are opinionated, and have no boundaries in terms of privacy or distance. Teachers are expected to give their class their email address for contact and students will regularly send through jokes and other fascinating trivia at all hours of the day.

Unfortunately this researcher was unable to find any formal academic studies about the learning habits of Generation Z. The reason for the additional empty column was to highlight the lack of available knowledge and understanding about the current senior high school students in New South Wales who are all classified as Generation Z.

Table 2.2 Learning styles (AAMT, 2009)

	Boomers	Generation X	Generation Y	Generation Z
Learning format	Formal Structured	Relaxed Interactive	Spontaneous Multi-sensory	**?**
Learning environment	Classroom style Quiet atmosphere	Round-table style Relaxed ambience	Café style Music and multi-modal	**?**
Training focus	Technical Data/evidence	Practical Case studies /applications	Spontaneous Multi-sensory	**?**

A more detailed description of the different generations will be discussed individually in the subsequent chapters, while the next section will look at school curriculum and its impact on learning and the examination system.

2.3 Curriculum changes

The term "curriculum" has been defined in many ways and by many people. According to Oliver (Short & Marconnit, 1968) curriculum may be expressed as:

- All the experiences a person has regardless of when or where they take place;
- All the experiences the learner has under the guidance of the school;
- All the courses offered by an institution;
- The systematic arrangement of certain courses designed for certain pupil purposes; and
- Courses offered within a certain subject field, e.g. "the mathematics curriculum".

In the context of this study, the term 'curriculum' will refer to the courses offered within the mathematics subject.

Over the last 150 years the school curriculum has gradually moved from the vocational/neo-classical model followed by the liberal/progressive approach to the more recent social/critical orientation. The vocational/neo-classical model prepared the students for work, the liberal/progressive model was a preparation for life rather than work. Kemmis, Cole and Suggett (1983) believed that the socially/critical model was a better approach in that education needed to engage society and social structures immediately as it prepares students for their next stage in life (Kemmis et al., 1983).

Australian elementary schools followed England's model of education by adopting a curriculum similar to those used in Charity School in the United Kingdom (Clements & Ellerton, 1989). In the early 1800s the classroom system was established in New South Wales as the organized form of schooling. These schools were typically models of the factory system (see Section 4.2) (Short & Marconnit, 1968). As classes were separated into smaller groups because the student/teacher ratio improved, the factory system was dropped in favor of providing more individual attention to students. A general change in society saw an increasing concern of citizens to exercise control over the bureaucratic institutions that their society had created (Rosier, 1980).

During the first half of the nineteenth century the school curriculum was mainly interested in improving literacy (Wyndham, 1957). At the same time greater emphasis was placed on the classics for children of middle class families attending grammar schools. From 1820s onwards mathematics began to be accepted as an integral practical component of the curriculum and by 1840 the purpose of the curriculum was to provide a good classical, scientific and religious education to the boys of the middle and higher class society (Grimison, 1978). Following the Public Schools Act in 1867 a new curriculum extended elementary education beyond reading, writing, arithmetic and religion as standards of proficiency were established for each subject so that children would have a wider range of their "mental faculties" developed to be educated as good citizens (Barcan, 1988). A course of Secular Instructions as well as homework was officially introduced (Devin, 1973).

The secondary mathematics curriculum, which evolved from the primary curriculum, consisted mainly of algebra and Euclidian geometry with a theoretical rather than a practical orientation. The Public Instruction Act of 1880 placed the responsibility of elementary education on the whole community to be discharged by a Minister of the Crown. The secondary schools were mainly for the elite and had no interest in providing vocational education for the general population. The de-facto curriculum for secondary education was set by the University of Sydney for those wishing to enter tertiary studies by completing the Junior and/or Senior Public Examinations. The Knibbs-Turner Report in 1902 criticized the system at the time in that examinations led to "cramming" and to a distortion of the curriculum as well as of the method of teaching (Wyndham, 1957). Despite the introduction of new curricula for primary and secondary education following the Knibbs-Turner Report, the teaching of mathematics tended to be no different from the nineteenth century (Clements, 1975).

Clements (1978) believed that between 1855 and 1905 there were four main factors effecting changes in curricula:

- School teachers wanted to bring on change opposed by university professors;
- The need to keep up with developments, especially in England, to ensure that Australian qualifications would be accepted overseas;
- Educational politics often centred on issues removed from mathematics education, resisting forces towards innovation; and
- The single most powerful factor influencing teaching was the university entrance examinations.

In the first half of the century, during the depths of the Great Depression, progressive educators set out to reform education by calling for social reconstruction (Dewey & Childs, 1933). Many of the progressives believed that, due to school practices, schools and society were caught in a dualistic relationship which separated the school from mainstream society and created an isolation of the schools. They believed that what happened under the auspices of the schools was not real or reflective of the problems in society (Dewey & Childs, 1933). Furthermore, the progressives argued that the artificial environment of the schools was misdirected in that the youth of the country were not prepared to see and understand the values and issues which would confront them as they became adults (Dewey & Childs, 1933).

As discussed by Zuga (1992) some progressives proposed that the schools create a new social order. In 1937 the New Education Fellowship conference sponsored by the Australian Council for Educational Research (ACER), briefly stirred up the prevailing inactivity and complacency in educational matters based on Deweyan ideas because old educational values were challenged by post war attitudes (Cunningham & Radford, 1938). With World War II looming, there were no immediate outcomes from this conference.

In the decades after WWII the overall tendency had been to focus on the core curriculum (Kalantzis, Cope & Hughes,1983). By the 1950s there were many more students who wished to pursue a university education. This highlighted the fact that the candidature had a much wider spread of ability amongst the students. Responding to this, in 1951 an Alternative Curriculum for Secondary Schools was devised to cater for "average students" who were not likely to progress beyond the Intermediate Certificate (Year 10). Needless to say the mathematics curriculum went through significant changes to accommodate these factors as they were also influenced by such things as, multi-cultural education, adult learning, career education and work experience (Barcan, 1988).

A further review of the New South Wales mathematics curriculum began in the late 1950s following a visit to Australia by Caleb Gattegno, a British mathematics educator promoting *The Cuisenaire Movement* (Grimison, 1978) and the *New Maths* implemented in the United States (Moon, 1986). This review was further fuelled by the successful launching of the Sputnik satellite by the USSR in 1957 (Smart, 1978). During this Cold War period, Western nations, particularly the US were extremely concerned that the Russians were leading the race to gain supremacy of space, which would give them a huge tactical military advantage. By the 1960s new mathematics courses were developed containing little Euclidean geometry, but a lot of emphasis was placed on "self-evidence" in the teaching of numbers. Students were encouraged to discover mathematics principles by means of class activities involving both inductive and deductive thinking (Grimison, 1978). It was surprising to note that even though geometry had all but disappeared from the syllabus to be largely replaced by calculus topics, there was little mention of the term “calculus” in *"Colonialism and School Mathematics in Australia 1788-1988"* by Clements and Ellerton (1989) apart from noting that around 1910 civil service and university authorities in England introduced calculus in their entrance examinations (Howson, 1973). Within a few years calculus had also been included in mathematical studies in senior secondary mathematics classes in all Australian states (Carslaw, 1914; Grimison, 1978; McQualter, 1974, p.16).

In the early 1960s the term “new” mathematics was suggested with the purpose to increase the ability of students to solve problems by getting students to learn about mathematical operations and the nature of number systems (Rosier, 1980). At about the same time Clements (1989) commented on the fact that in the 1950s, the mathematics text books most commonly used by senior secondary students in Australia had been first published in England in the early 1890s. While in 2009, many schools in New South Wales are still using mathematics text books produced over thirty years ago in the mid 1970s. This reinforces comments made by Schoenheimer in 1975 at a conference of the Mathematics Association of Victoria where he described the conservatism of mathematics teachers as "granite-hard" (Schoenheimer, 1975).

The introduction of the metric system in 1966 led to simplified financial calculation and money handling. Along with the gradual conversion from the imperial system to the metric system, the mathematics curriculum also had to change. Although this study has not focused on this issue, the general introduction of low cost hand-held calculators also had a significant impact on both the primary and secondary school curricula. According to Kissane (2000) one expected that as the more sophisticated graphics calculators were becoming more affordable, their usage would increase in secondary mathematics teaching. However in New South Wales from 2000 graphics calculators were only permitted in the non-calculus General Mathematics course for the Higher School Certificate, while students attempting the more advanced mathematics courses were only permitted to use conventional scientific calculators.

Rosier (1980) expected that as student numbers would double between 1964 and 1978, the range of mathematics courses would also widen. This in fact did not happen because since 1960 (except for a short period during the 1980s to early 1990s) only four to five separate mathematics courses continued to be offered to students completing their secondary education. Students wishing to study science, engineering or commerce courses at universities were encouraged to take mathematics subjects which included some calculus. However students who did not take the more advanced mathematics subjects were still accepted into the "more scientific" courses provided they completed bridging subjects provided by the universities.

According to Ridgway (1988) and Brown, Bull and Pendlebury (1997) a number of commentators have identified problems with conventional approaches to the teaching of mathematics in high schools and colleges. Weaknesses are related to pedagogy and assessments which emphasize the mastery of mathematical techniques, but emphasize neither the conceptual side of mathematics nor the development of the habits of mind that characterize mathematical thinking. Traditional testing methods in mathematics have often provided limited measures of student learning, and equally importantly, have proved to be of limited value for guiding student learning. The methods are often inconsistent with the increasing emphasis being placed on the ability of students to think analytically, to understand and communicate, or to connect different aspects of knowledge in mathematics (Ridgway, 1988; Brown et al., 1997).

As a consequence Schoenfeld (1992) suggested that the sequence of thinking processes that students should learn in order to progress from '*analyzing*' to '*interpreting*', or to move from '*designing*' to '*making*', should include the following progressions:

- Exploring, experimenting, investigating;
- Formulating, conjecturing, hypothesizing;
- Analyzing, interpreting;
- Evaluating, comparing;

- Planning, organizing;
- Designing, making;
- Justifying, proving;
- Generalizing and; and
- Reflecting, explaining, summarizing.

According to Brady and Kennedy (1999), the NSW Government's White Paper *Excellence and Equity* on curriculum reform shifted all responsibility for secondary curriculum development to the Board of Studies (NSW Ministry of Education and Youth Affairs, 1989). The Committee's recommendation was to group all subjects into individual Key Learning Areas (KLA). Mathematics students were expected to be involved in learning the basics of number, algebra, measurement, geometry and statistics and developing reasoning, prediction and verifying skills. This document neglected to mention trigonometry and calculus, particularly since both these areas were taught and examined in far greater detail than geometry. Some teachers believed that the White Paper deemphasized the importance of mathematics in that all candidates for the HSC were required to study at least one 2 Units subject from one of three areas, namely Science, Mathematics or Technology and Applied Studies (TAS). If they did not want to study mathematics they could have chosen one of the other two subjects. Other teachers felt that mathematics was not really deemphasized because prior to the release of the White Paper mathematics was not compulsory. This meant that students were able to gain their HSC without mathematics. In the end many students chose to study Mathematics in Society which was first introduced in 1982. This requirement was once again changed in 2001, so that English was the only compulsory subject for the Higher School Certificate by 2006.

It was stated earlier that curriculum and the examination system are closely linked, with each having influence over the other. As the aim of this study is to analyze changes to mathematics examinations, it is therefore appropriate and necessary to understand the examination process in New South Wales and this is discussed in the next section.

2.4 Examination process

The model of formal and public examinations can be traced back to England in the 1740s when the first list of Tripos was published under the name of "Senate House Examination". The examinations began with Euclid and basic algebra. The lists of successful candidates were divided into Wranglers, Senior and Junior Optimes. By 1824 the mathematical Tripos at the University of Cambridge had set the standard for public examinations (Rayner, 1989). In the United Kingdom when Queen Victoria was crowned in 1837, industrial change had started to occur. At that time in the area of education, opportunities were largely governed by the economic and social position of the family. The class character of the education system was clearly divided between the public and elementary schools. Children of the wealthier middle class and the aristocratic society attended public schools, while children of the poor attended elementary schools. This system was endorsed by the recommendation of both the Taunton Commission of 1868 and the Bryce Commission of 1895. Although the Education Acts of 1870 and 1891 made elementary education free and compulsory, they did little to change the low social class status of the students (Barcan, 1988).

During the first half of the nineteenth century, elementary education in New South Wales was based on the British model in which education was provided to the lower classes by church schools (Clements & Ellerton, 1989). This system was subsidized by the State and led to a government system of education established in 1848. The University of Sydney was established in 1850 and in 1867 the University introduced a system of public examinations in New South Wales called the Junior and Senior Public examination. It was later noted by Carslaw (1914) that these examinations were almost identical to those used by Oxford and Cambridge examiners in their local examination papers. The Public Instruction Act of 1880 marked the formal acceptance by the State of its role in the provision of secondary education. After some thirty years of turmoil a new scheme of secondary education was implemented in 1910. Carslaw (1914, p.11) further wrote on the effects of the examinations in relation to the schools:

> *"The success or failure of their pupils in the examinations has been regarded as the chief test of the value of the school".*

A similar situation exists today. There is an ongoing conflict between the State government and the Teachers Federation about releasing student performance data by school to the public, and about providing detailed reports on individual student performance to the parents (NSW Teachers Federation, 2010). The Federation argued that parents may wish to transfer their children from schools that perform poorly in external examinations, and that this would also reflect poorly on their members (the teachers). This once again raised the issue of accountability of the education system, including schools and its teachers.

By 1960 the NSW Public Institution Act had been amended some ten times since 1902. These acts followed the acceptance by the NSW Government of proposals for the reorganization of secondary education in New South Wales contained in the Report of the Committee on Secondary Education of 1957. This committee of ten, whose membership covered a broad range of educational and community interests, met over the period 1953-1957 under the Chairmanship of Dr H. S. Wyndham, then Director-General of Education in NSW.

The Wyndham Report explained the new four-plus-two structure in the following terms:

> *"...the School Certificate is designed to recognise the completion of a sound course of secondary education. There will be some…who…will have begun to aspire to some form of tertiary education…For these pupils…we recommend that a further stage of two years of secondary education be provided."* (Wyndham, 1957, p.30)

Within this secondary school structure, a variety of courses in Years 11 and 12 including compulsory English, was made available. Within each subject a number of courses were offered to suit different purposes; some of these led directly to further study of the subject at tertiary level. The extra year added to the length of secondary schooling was proposed particularly for the minority of pupils at the time who wished to continue on to university. During subsequent decades the holding power of students into the senior forms, grew to a degree not anticipated by that Committee.

During the past one hundred years, primary school in the early 1900s ended with a Qualifying Certificate leading to High School. After two more years of study students obtained the Intermediate Certificate. A further two years of study (three years by 1918) led to the Leaving Certificate (or matriculation). During the 1930s a review of the secondary education took place. This led to the replacing of the old Board of Examiners by representatives of schools. The implementation of the Wyndham Scheme in 1966, following the 1961 Education Act ended the five year program of the Intermediate Certificate and the Leaving Certificate. This was then replaced with a four year School Certificate program followed by a further two years of study to obtain the Higher School Certificate.

2.4.1 Matriculation examination

Following the establishment of the University of Sydney in 1850, the university matriculation examination provided a new goal for students attempting the classical curriculum (including mathematics) in grammar schools (Barcan, 1988). Examinations were offered at both "Pass" and "Honours" levels. According to Barcan (1988) the early by-laws of the University in 1881 stated that:

> The examination for matriculation shall be in the following subjects:
>
> - The Greek and Latin Languages
> - English Grammar and Composition
> - Elementary Chemistry, Physics or Geology
> - Arithmetic
> - Algebra to simple equations inclusive
> - Geometry, first book of Euclid.

In 1907 the matriculation standards were revised to include English, history and science which was an important movement towards the humanist-realist version of liberal education (Barcan, 1988). By that time public examinations had been established to reduce the dominance of the university matriculation examination. The majority of students entering university completed the Junior and/or Senior public examinations and these were later replaced by the Leaving Certificate.

2.4.2 Junior and Senior Public examinations

Following criticism that the University of Sydney matriculation examination caused isolation from the community and lack of "usefulness", the University began a system of Junior and Senior Public examinations in 1867. According to Barcan (1988) the By-Laws of the University stated that these public examinations will be open to all male or female candidates. Subjects offered for the Junior Public examination included English language and literature, history, geography, Latin, Greek, French, arithmetic, algebra, geometry and natural science. The Senior Public examinations included additional higher mathematics, drawing, music and natural philosophy. Acceptance into University was set by the Rules of Orders of the Senate.

2.4.3 Leaving Certificate

Peter Board, as Director of Education in New South Wales, initiated a new examination system because according to him the university-controlled Junior and Senior Public examinations did not offer a broad academic curriculum. However looking at the broad spectrum curriculum already offered for the Public examinations, this researcher believes that Board's ultimate aim was to reduce the University's influence on the secondary school curriculum. The first Leaving Certificate was held in 1913 and attempted by 156 candidates (Barcan, 1988). Student numbers for the Leaving Certificate steadily increased to about 3000 by the end of the depression in 1932. The list of subjects (including mathematics) had also increased from 20 to 30. In 1938 it was announced by the government that by 1942 the Leaving Certificate would be awarded after four years of study and a Higher Leaving Certificate one year later. The unsettled conditions during World War II prevented its implementation, nevertheless the number of subjects necessary for the Leaving Certificate was reduced from a maximum of ten to eight papers. The Government abandoned the entrance examination for secondary education in 1943, and by the 1950s progression to secondary school was available to all, but not without restrictions. Students wishing to study further had the option of an external examination to continue at school for a further two years to attempt the Leaving Certificate which was conducted by the Board of Secondary School Studies. At the same time the University of Sydney granted matriculation to students passing their required subjects. Student numbers for the Leaving Certificate continued to grow, fuelled by post-war migration and a tendency for students to stay at school beyond the minimum leaving age. In order to cater for “less academic” students, General Mathematics was introduced as a new subject.

2.4.4 Higher School Certificate

Secondary education was transformed in New South Wales from 1962 following the Wyndham Report (Wyndham, 1957) by extending the lower secondary school from three to four years and the retention of upper secondary school beyond that. The first group of students to complete the full six years received the new Higher School Certificate (HSC) in 1967 (McGaw, 1997). The need to cater for the increasingly diverse range of students led to new subjects as well as new, less demanding courses added within these subjects. The Wyndham Committee at the time expected the majority of students to leave school after completing four years (the Intermediate Certificate). However, contrary to expectations by the 1980s and 1990s upper secondary education had become almost universal.

Mathematics enrolment at all levels grew as the student population broadened. The key influence on enrolment in advanced courses (including mathematics) was the impact of scaling the results. Scaling was the means by which universities differentiated between less demanding and more demanding subjects. In other words 60% in a “less demanding” subject was scaled down, while 60% in a “more demanding” subject was scaled up increasing the student's chances of gaining a place at university. According to the Board of Studies the scaling of marks conferred an unfair benefit on students studying at higher levels, so the Board made no direct use of scaled marks for the Higher School Certificate since 1978.

Assessment was by external examination, supplemented since 1986 with school based assessment. Reporting on results to candidates by the Board of Studies NSW "*Before 1986 the Board of Senior School Studies applied iterative scaling procedures across different subjects to produce scaled examination marks for each course. These were combined with adjusted school estimates to arrive at scaled course marks. An aggregate mark was derived from these scaled course marks and was used as a basis for selecting students for entry to tertiary institutions and for some areas of employment. These procedures were discontinued by the Board in 1986."* (BOS, 2001, p.7)

Since 1986 the aggregate mark has been calculated and moderated by the University of Sydney and expressed as a single number called the TER (Tertiary Entrance Rank), an explanation and description of the rationale for this scaling process was prepared by the Board of Studies (2001). In 2001 the TER was replaced by the UAI (University Admissions Index). This was once again replaced in June 2009 by the Australian Tertiary Admission Rank (ATAR). Today conversion factors are used for students wishing to apply to interstate universities.

Following a review of the historical aspects of the examination process at the end of secondary school, this study will look at relevant research studies that were used to analyze *high stakes* examinations.

2.5 Analysis used to study mathematics examinations

The following studies were found to be the best and most suitable examples of applications of content analysis used to compare and contrast examination papers. A more detailed discussion on content analysis will be carried out in Chapter 3. Each of the studies discussed in this section covered some aspects of the examination process to highlight what was similar and what was different in the examinations. However none of these studies has covered all the aspects addressed in this study. Some parts or concepts of the methodologies used from each of these studies were taken and adapted for the purpose of analyzing high stakes examinations in New South Wales at the end of secondary schooling.

2.5.1 Cognitive competencies

Genovese (2002) described high stakes examinations as one way a society expresses the cognitive competencies it values. His study suggested that examinations from the early 1900s demanded deep declarative knowledge of culturally valued information and simple interrelation between facts, whereas one hundred years later students were expected to understand complex interrelations between concepts but expected to have only superficial knowledge of culturally valued information.

Genovese (2002) applied the technique of quantitative content analysis to high stakes examinations used in Ohio USA between 1902-13 and 1997-99. He compared the frequencies of certain words and phrases used by the Boxwell-Patterson high school entrance examinations during 1902-13 with a ninth-grade proficiency test in the 1990s. By analyzing and counting selected categories of words, Genovese was able to make inferences about the manifest and latent messages in text (Stirman & Pennebaker, 2001). Sawa (1999) expressed the concern about the decline of scholastic standards of university students. He cited two specific reasons, one was the anti-intellectual trend that has swept Japan since the mid-1970s and the other was blamed on the system of university entrance examinations. Although Japanese schools crammed a great deal of knowledge into students, he believed that knowledge gained through cramming was easily forgotten and the important things were not what students memorized but what they learned. He used the example "*It is not mathematics itself that really matters, but the logical way of thinking that comes with it"* (Sawa, 1999, p.1).

Consequently, his impressions were that Japanese students today are less capable of logical and thinking abilities. These concerns have contradicted the findings of Genovese (2002) which stated that modern examinations in the US expected the students to understand complex interrelations between various concepts.

2.5.2 Examining the examinations

Britton and Raizen (1996) compared a range of high stakes examinations in mathematics and science undertaken by students who were planning to enter colleges or universities in eight different countries. This study grouped all the mathematics topics taught and examined into nine areas, namely:

- Numbers;
- Measurement;
- Geometry form;
- Geometry relation;
- Proportionality;
- Functions, relations and equations;
- Data representation, probability and statistics;
- Elementary analysis; and
- Validation and structure.

These nine areas were then split for further analysis as shown in Figure 2.1 which shows the extent to which the researchers had gone to capture and record all possible areas of mathematics that may be examined at the end of secondary schooling.

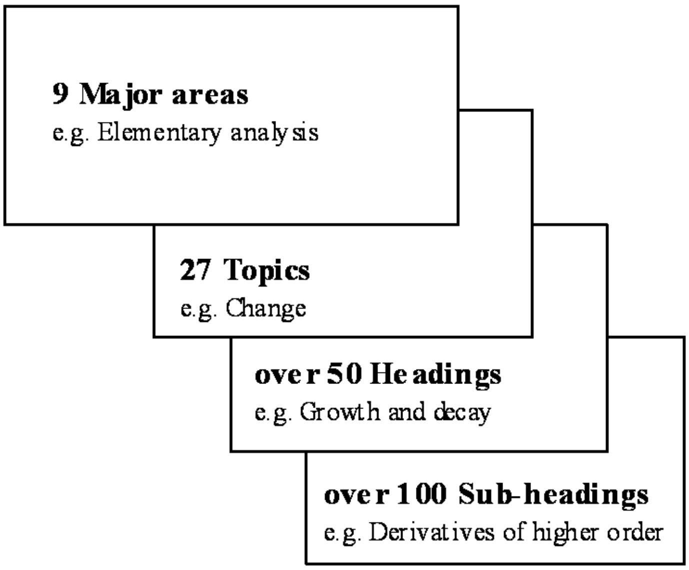


Figure 2.1 Examination topics to be considered

The percentage of the examination score to determine the content of each paper was then calculated based on a combination of headings and sub-headings as shown below:

- Application of derivative and definite integrals;
- Derivatives: maximum and minimum;
- Fundamental theorem of calculus;
- Trigonometric equations and identities;
- Probability distributions;
- Polar coordinates;
- Geometric transformations;
- Mathematical induction; and
- DeMoivre's Theorem and complex numbers.

Contrary to the possibility of testing any of the nine major areas covered by 27 topics with over 50 headings and 100 subheadings (see Figure 2.1), the results concluded that the mathematics examinations used just three universal topics:

- Differentiations, integrations;
- Functions and relations; and
- Geometric transformations.

The five other less common and missing topics were:

- Probability and statistics;
- Geometric relations;
- Proportionality;
- Number systems; and
- Measurement.

This extensive international study highlighted significant differences between the general structure of the examinations; style of the examinations; examination topics; performance expectations and difficulty. A team of researchers in each of the countries used the same approach to compare the examinations. They considered:

- The number of questions in the paper and whether the examination was separated into different major parts;
- The time allowed for the complete paper, the suggested time to spend on each module;

- The number of questions in the paper;
- The type of questions e.g. multiple choice; standard short answer on various topics; descriptive; based on practical situations and physics based, etc; and
- Use of selection and alternatives.

The findings of Britton and Raizen (1996, p.193) on mathematics examinations may be paraphrased as: "*examinations treated mathematics as an abstract discipline. They focused heavily on symbol manipulation and only required students to recall and apply facts and definitions to solve problems similar to textbook examples. There was no evidence of modeling, attempt to connect mathematics to real-world problems or use of other disciplines as context for mathematics. There was little evidence that any examinations involved uses of technology or types of problems reflecting calculus reform efforts which emphasize the power of computer algebra systems*."

The performance expectations including the categories considered for analysis was based on the TIMSS study. This will be discussed in Section 2.5.4.

Britton and Raizen (1996) had also planned to analyze and grade the difficulty of the examinations by ranking every examination item on a 3-point difficulty scale based on:

- Length of the examination;
- Whether there were options to select alternative choices;
- Type of questions, such as multiple choice and free response;
- Range of topics tested; and
- Cognitive expectations such as, recall, analyze and so on.

However the general consensus of the team was that the results were unreliable, because other factors surrounding the examinations would also need to be considered, such as:

- How students were prepared for the examinations;
- How the course of study was linked to the examination; and

- Number of examinations required for students to matriculate.

Thus, it was impossible to grade the examinations.

The summary of the examinations by Britton and Raizen (1996) also agreed with the findings described in the National Council of Teachers of Mathematics' Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) in that mathematics examinations had not included the "problem solving" vision for school mathematics.

2.5.3 Using instructions to test critical thinking strategies

The Board of Studies website has a comprehensive *Glossary of Terms* for general use as shown in Table 2.3. It provides a general guide to the kind of response required by a number of key words or instructions. According to the Board of Studies, Table 2.3 was meant to be used only as a guide. It was also made clear that terms like *evaluate* would have a different meaning and interpretation for different subjects and should be treated accordingly.

According to Table 2.3 the items in the right-hand column such as *describe, identify and outline* are typically used in questions requiring recall of knowledge. These questions generally require less depth and are worth fewer marks. Questions using terms such as *assess, evaluate and justify* require higher-order thinking. These would generally require an answer of greater depth and usually attract higher marks. Other terms such as *explain and discuss* can vary considerably in the mark value and depth of response required (Board of Studies NSW, 2010).

Table 2.3 Board of Studies glossary of terms used in HSC (BOS., 2002)

Groupings of syllabus knowledge, skills and understanding	**Groupings of key words or instructions**
Skills in analysis and critical thinking	Analyze, distinguish, examine, explain, extract, investigate
Skills in application and performance	Demonstrate, discuss, apply, calculate, construct
Knowledge, recall and understanding	Define, describe, explain, give an account, identify, outline, recall, recount
Skills in evaluation	Appreciate, assess, discuss, evaluate, justify, predict, account for
Skills in problem solving	Apply, calculate, clarify, compare, contrast, construct, deduce, demonstrate, investigate, predict, propose, recommend
Skills in synthesis and creative thinking	Classify, extrapolate, interpret, summarize, synthesize

Table 2.3 is similar to Bloom's taxonomy of educational objectives (Bloom et al., 1956). Bloom et al. (1956) created their taxonomy for categorizing "competencies" in educational settings, as defined by skills demonstrated by learner type or intelligence. This breakdown provided a useful, incremental framework of complexity in demonstrating mastery of a subject or topic. The following explanations and description for the terms *knowledge, comprehension, application, analysis, synthesis* and *evaluation* are an excerpt from Bloom's taxonomy for learning, teaching and assessing (Anderson et al., 2001).

Knowledge - To know something means to be able to remember or recall facts or bits of information, though one can "know" something without understanding it or being able to put it into a higher context. This process is illustrated by recall of sequences and lists, of events and dates and even memorized definitions and explanations.

Verbs include: *choose, define, describe, enumerate, identify, label, list, locate, match, memorize, name, quote, recall, recite, recognize, reproduce, select, show and state.*

Comprehension - To comprehend a fact or piece of information is to understand what it means, and be able to provide new examples or instances of the concept. The key is that the learner can demonstrate a subject from a personal, internalized perspective, rather than a formal externally driven one. This process is illustrated by describing or defining words or situations in one's own words, or perhaps illustrating a concept with pictures or words or actions, or describing a main theme or best answer, or rephrasing an idea.

Verbs include: *associate, convert, classify, create analogies, diagram, distinguish, draw out, estimate, generalize, graph, explain, illustrate, map, match, outline, predict, relate, paraphrase, relate, restate, summarize and systematize.*

Application - To apply information means to use it according to principles and rules. This process is illustrated by being able to derive new examples from principles, as in answering "how" a person would apply what they have learned. For example, being able to add examples from your own life or experience to those studied that demonstrate a principle, or even being able to change a condition and give an example that fits the new situation.

Verbs include: *apply, assemble and construct, calculate, change, collect and organize, complete, defend, demonstrate, diagram, discover, dramatize, forecast, illustrate, interpret, make, prepare, produce, relate, show, solve and translate.*

Analysis - To analyze is to break information down into the sum of its parts and to see how those parts work together and to be able to organize or place it into meaningful and new patterns or relationships. This process can be demonstrated in a number of ways, as in making illustrations that reinforce or detail a story or concept; or acting out a story. A researcher might exemplify with an outline or apply the scientific method to a study, or create a model or plan of an object or building.

Verbs include: *analyze; arrange, compare, categorize and differentiate, connect, distinguish and contrast; examine, explain, role-play, subdivide, research, disassemble, separate, investigate and infer.*

Synthesis - To synthesize means to take the knowledge you have and connect it with other knowledge, or putting parts together to form a new and original whole. Application of this process could research new applications, adapt routine or studied movements into new applications, adapt conventions and rules into new products, take chance occurrences and recognize new applications.

Verbs include: *adapt, create, combine, compile, compose, design, develop, experiment, forecast, formulate, hypothesize, imagine, integrate, invent, originate, plan, predict, speculate and synthesize.*

Evaluation - To evaluate means to be able to judge whether information or an argument is good or bad. This process is illustrated by defining a set of standards or criteria and applying a situation or instance to them to evaluate whether or not it fits, or detail how it does not.

Verbs include: *assess, award, commend, conclude, criticize, critique, debate, discuss, estimate, evaluate, judge, justify, opine, prioritize, rank, recommend, self-evaluate, standardize, support, weigh and value.*

Based on the above descriptions developed in Bloom's Taxonomy (Bloom et al., 1956), Dalton and Smith (1986) and Davis (1993), Table 2.4 summarises the categories, definitions and instructions with reference to the six levels of competencies.

Table 2.4 Adaptation of Bloom's critical thinking strategies.

Category	Definition	Instructions
Knowledge	Memorizing, recalling information	Define, describe, find, how, list, show, state, what, when, which, who, why
Comprehension	Interpreting, paraphrasing	Discuss, describe, explain,
Application	Problem solving, applying information	Demonstrate, draw, interpret, solve
Analysis	Subdividing into component parts	Analyze, compare, contrast
Synthesis	Combining ideas	Compose, design, predict
Evaluation	Judgment, making value decisions about issues	Assess, evaluate

Chapter 3 on Methodology will discuss the techniques used to collect and analyze the type of instructions shown in Tables 2.3 and 2.4.

2.5.4 TIMSS

The Trends in International Mathematics and Science Study (TIMSS) is the world's longest running school mathematics and science study, and is designed to help countries improve student learning. It collects student educational achievement data at Year 4 and Year 8 to provide information about trends in performance over time. Approximately 60 countries participate in TIMSS, which is a project of the International Association for the Evaluation of Educational Achievement (IEA). The Australian Council for Educational Research (ACER) is responsible for undertaking the data collection in Australian schools. TIMSS is conducted on a four year cycle: the most recent cycle was 2006-07; and the next collection in 2010-11. In Australia some 10 000 students from all states and territories were invited to participate in the 2006-07 TIMSS collection.

TIMSS assessments were constructed using "content" domains and three cognitive domains in each curriculum area for knowing, applying and reasoning. These data were collected from tests that were developed in a collaborative process.

According to Cochrane (1999) four general categories were considered for analysis (Table 2.5).

Table 2.5 Categories considered for analysis (Cochrane, 1999)

Knowing	**Using routine procedures**	**Investigation and problem solving**	**Mathematical reasoning**
Representing Recognizing equivalents Recalling mathematical objects and properties	Using equipment Performing routine procedures Using more complex procedures	Formulation and clarifying problems and situations Developing strategy Solving Predicting Verifying	Developing notation and vocabulary Developing algorithms Generalizing Conjecturising Justifying and proving

TIMSS also considered the general structure of the examinations in more detail, such as multiple choice; free response items; essay and word phrase items; practical activity questions and use of diagrams, graphs and tables.

Thomson and Buckley (2009) analyzed the TIMSS 2007 Report on behalf of ACER. They found Australia's overall performance was average and a summary of the key findings from an Australian perspective included:

Year 4 mathematics – *"Australian students' average scores in Year 4 mathematics have increased significantly by 17 points since 2003. In terms of relative position internationally, Australia was again outperformed by many Asian countries as well as England and the United States".* (Australian Council for Educational Research, 2007, p.V)

Year 8 mathematics – *"The result for Australia is similar to 2003 but achievement scores have decreased since the first administration of TIMSS in 1995. Increases in scores achieved by students from England, the United States and Lithuania, in combination with a decrease in Australia's score, resulted in those countries significantly outperforming Australia in 2007. Overall, Australian students performed poorly in the areas of geometry and algebra."* (Australian Council for Educational Research, 2007, p.V)

In addition TIMSS examinations also provided data which were analyzed by the researcher against characteristics of the cognitive domain established by TIMSS as shown in Table 2.6

Table 2.6 Cognitive domain criteria (TIMSS, 2009)

Cognitive Domain	Year 4	Year 8
Knowing	40%	35%
Applying	40%	40%
Reasoning	20%	25%

The charts in Figures 2.2 and 2.3 were extracted by the researcher from data available in the TIMSS 2007 Report to show the relative percentages of five countries (including Australia) against the average mark of 500. The colors blue, red and yellow represent the cognitive domains for knowing, applying and reasoning. Australian students in Years 4 and 8 performed poorly in our region in comparison with students from local trading partners as well as from England and the United States.

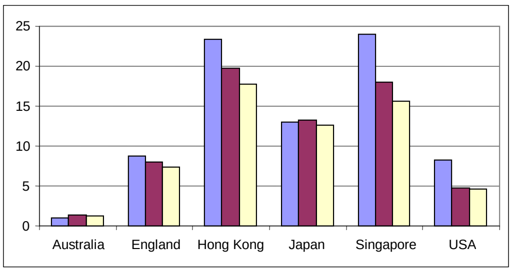


Figure 2.2 ***4th Grade*** *selected results for Knowing, Applying & Reasoning*

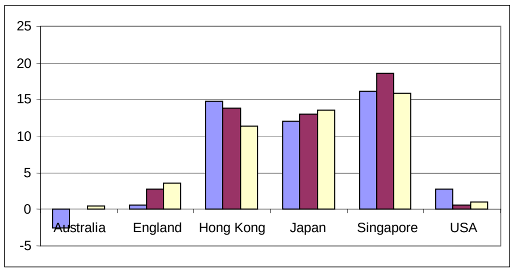


Figure 2.3 ***8th Grade*** *selected results for Knowing, Applying & Reasoning*

Half the data collected by TIMSS came from questions that were specifically developed to gather data about the cognitive domain for Years 4 and 8 students. These results have prompted the researcher of this study to consider the implications of the cognitive domain for mathematics students at the end of secondary schooling by looking at the curriculum changes through the examination process.

There were a number of reasons for including and discussing TIMSS in this study. It was interesting to understand the reasons for this major study and more specifically that this study identified and recognized the importance of collecting and analyzing cognitive domain data. The researcher was concerned by the Australian results (Figures 2.2 & 2.3). Hence this was one of the reasons for analyzing the instructions used in the examinations at the end of secondary schooling.

2.6 Review

The Genovese study in Section 2.5.1 compared two sets of examinations ninety years apart highlighting significant and specific differences in the style of the examinations. Unfortunately Genovese did not explain why these changes occurred. Furthermore the study did not discuss aspects of the examinations that remained the same, nor did it analyze any intermediate stages along the way. Nevertheless it was an informative study, insofar as it demonstrated cultural differences over a long period of time. In Chapter 9 of this study two sets of examinations will be analyzed in a manner similar to the research done by Genovese.

The Britton and Raizen (1996) study in Section 2.5.2 was helpful because it compared a number of areas of similarly produced mathematics examinations during the same time period by a number of developed countries. Their methodology was also suited to analyze some aspects of mathematics examinations in New South Wales. In the Britton and Raizen (1996) study all the examinations analyzed were produced under a similar socio-political climate so the differences in the examinations were due to the different curricula used by the individual countries. Unfortunately there were no explanations provided as to what may have influenced the curricula in these countries. Furthermore the Britton and Raizen (1996) study did not analyze the instructions used in the examinations as only the topics tested were considered.

Prior to collecting data, Britton and Raizen (1996) and their team carried out extensive research to identify and describe all possible areas of high school mathematics, as shown by Figure 2.1. The team in the first instance planned to categorize the examination papers according to the list of subjects in Figure 2.1.

However they found this impractical because the majority of the examinations contained just three universal topics and five other additional less commonly used topics. This study may also have to rationalize the range of topics analyzed to achieve a set of meaningful and conclusive results.

The method Britton and Raizen (1996) used to analyze the relative difficulty of the examinations was inconclusive. Although they identified a number of possible areas that would need to be considered in order to grade the difficulty of the examinations (Section 2.5.2) this was not done.

The reference in Section 2.5.3 to Bass (2000, p.335) in his paper on *The growing importance and challenges of mathematics education* summed up the belief of most people involved in mathematics. He stated that the *intellectual* justification for mathematics *"is the enabling discipline for all of science, and that it offers fundamental tools of analysis, quantitative expression, and disciplined reasoning*".

The New South Wales mathematics curriculum has often referred to thinking strategies along the lines of *knowledge, comprehension, application, analysis, synthesis* and *evaluation,* as discussed by Bloom et al. (1956). Thus an analysis of instructions used in the examination process should provide an insight into the application and practice of the level of critical thinking used to answer mathematics examinations.

The importance of mathematics as discussed in Section 2.1 has been clearly supported by numerous academics and educational groups such as the Cockcroft Report (1982), Australian Education Council (1990), Schoenfeld (1992) and Bass (2000). To critically analyze mathematics examinations at the end of secondary schooling in New South Wales, this study will discuss the history and development of education, curriculum and social changes in our society. By having a clearer understanding of the circumstances that may have influenced change, this study will be in a position to explore the following research questions:

- What changes may have occurred in the mathematics examination process brought on by the changes in our ever evolving world?
- Why have these changes taken place?
- Is the teaching of mathematics to develop logical thinking and reasoning being tested in the examinations?

Before this study is in a position to explore the list of questions above, a formal process of "*search and find*" needs to be in place. This formal process and the theoretical framework underpinning this research will be explained in the following chapter on the methodology used to identify and explain the changes to the examination process based on the research discussed in this chapter.

Chapter 3

RESEARCH METHODOLOGY

3.1 Theoretical concepts

The main objective of this research study is to identify patterns and changes that have taken place in mathematics examinations at the end of secondary schooling in New South Wales, Australia and to explore the reasons for the changes. This chapter will initially discuss the theoretical framework used for this study, followed by a description of historical research and applications of content analysis methodologies relevant to the framework.

Since no single theoretical framework described the research carried out in this study, it was decided that a middle-range theory, first introduced by Merton (1967) would be a suitable concept to encapsulate this research. A middle-range theory organizes a set of concepts and propositions in a way that enhances our understanding of a specific aspect of the social world such as education and the examination process. Middle-range theories consist of limited sets of assumptions from which specific hypotheses are logically derived and confirmed by empirical investigation. In this study the assumption is that: the changes in society will be reflected in the examination process. The hypothesis for this study is that: the teaching of mathematics and the subsequent examination process has not changed as much as the world we live in. The empirical investigation refers to the *collection and analysis of all data used to substantiate the assumption and the hypothesis.*

According to Merton (1967 p.68):
"*The middle-range orientation involves the specification of ignorance, rather than pretend to knowledge where it is in fact absent. It expressly recognizes what must be learned in order to lay the foundation for still more knowledge. It does not assume itself to be equal to the task of providing theoretical solutions … but*

addresses itself to those problems that might now be clarified in the light of available knowledge".

Middle-range theories can be formal - developed from a broad conceptual area of general theory, or substantive - developed for a specific area of social concern such as a secondary classroom (Neuman, 1997). This study had well defined boundaries for gathering data from high stakes mathematics examinations. As explained in Section 3.4.2 it was a heuristic investigative process. This general concept also aligns with Kuhn's (1962) theory of the use of available intellectual knowledge at a given period. He considered the conceptual knowledge that was available to people at a given time period. For example, no one would have thought of using computers as a teaching tool in the 1930s, because this technology was not available. However we can now ask the question – to what extent are computers used today in the teaching of mathematics, since computers have now been around since the 1950s? Kuhn (1962) further argued that scientific or historic developments were not a straight forward process with one step following another. He described developments that did not follow a logical progression, as non-linear scientific or historical processes. Developments were not as simple as cause and effect, in which events took place. Instead they tended to be non-linear in which events moved in cycles.

More recently, it was stated by Amenta, (2003 p.96) that:

"*Comparative and historical scholarship in social policy has proposed and developed major middle-range theoretical explanations of social policy, by developing an entire perspective to explain anomalies. Theoretical advancement has also come in part through the testing and rejection of hypotheses. The advances here have also included the refinement of theory by comparing social policy and tracing historical processes."*

This study will trace the historical processes of mathematics education and changes to the curriculum by analyzing the examination process and then referring to social policies as identified by social demographers such as the Australian Bureau of Statistics (ABS).

It will also use content analysis where the words and phrases of the high stakes examinations are analyzed. Because of the inferential nature of content analysis, it can predict or infer phenomena that cannot be directly observed (Mouly, 1978; Krippendorff, 2004). Depending on the content analysis application, different methods of reasoning may be used. Thus by identifying specific changes to the examination process, it would then infer other changes made to the curriculum. Examples include:

- deductive reasoning - which is implied in their premises; and
- inductive reasoning – which is not as logically conclusive as deductive reasoning but has a certain probability of being correct (Krippendorff, 2004).

As an example, where mathematical generalization is used from a small sample set of examination papers, it is then applied to the entire set of examinations. Krippendorff (2004) also discusses abductive reasoning. Accordingly:

- Abductive reasoning - proceed across logically distinct domains such as text, to another kind of domain such as numeric data to answer the analyst's questions.

As an example, quantitative data from examination papers may provide answers for changes to the examination process. Krippendorff, (2004) further stated that deductive and inductive inferences are not central to content analysis. However abductive inferences applied to content analysis are similar to inferences drawn from phenomena that are not directly observable. In these cases a mixture of statistical knowledge, theory, experience and intuition may be used to provide answers to research questions.

According to Cohen and Manion (1994) data in education research are used for inference, interpretation, explanation and predictions, which are generally associated with the positivistic model and includes both normative research as well as those associated with the interpretive paradigm. Normative research tends to control the research condition such as human behaviours through scientific methods. Since it is controlled, the normative paradigm may generalize the findings with one truth. The advantage is that it is easy to be objective in normative research because it is very structured and clear. The weakness is that not all phenomena in education can be investigated, such as behaviour, motivation and values (Douglas,1973) however this study does not focus on human behaviour. The interpretative paradigm has a concern for the individual by studying their human characteristics, different behaviours, opinions, and attitudes (Cohen, Manion, & Morrison, 2000). This paradigm has the advantage of finding meaningful observations of objects. However the weakness is in the obtained results, because it may be more complex to analyze and interpret objectively. In practice it would be more difficult to be objective in human research than in a science setting.

In summary, a middle-range theory was used as the basis for this study, while the methodology was heuristically evolved and similar to the objectivist or positivist approach. This study was using an application of the normative paradigm.

3.2 Historical research

Historical research has been defined as *"the systematic and objective location, evaluation and synthesis of evidence in order to establish facts and draw conclusions about past events"* (Cohen and Manion, 1994, p.45). More recently McCulloch and Richardson (2000, p.5) described historical research as "*an important means of understanding and addressing contemporary concerns*". During the past 200 years many mistakes as well as significant successes have been achieved in mathematics education. Having a better understanding of the changes that have taken place and why these changes occurred should assist us to develop curriculum to meet the needs for future education.

Berg (1998) has identified five further reasons for conducting historical research. Without trivializing Berg's intent, suggested education related explanations were added by this researcher:

- *To uncover the unknown* – what new topics will be introduced into future mathematics examinations?
- *To answer questions* – what societal circumstances have led to the particular examination structures over the years?

- *To identify the relationship that the past has to the present* – some things have not changed, such as questions on “factorizing” algebraic expressions.
- *To record and evaluate the accomplishments of individuals, agencies or institutions* – in hindsight it is always easier to look back and evaluate the accomplishment of others. One must ensure that this is done in the context of the circumstances of that period.
- *To aid our understanding of the culture in which we live* – Australians have moved from a class structure to an egalitarian society. Funding needs to be available to ensure that all schools and students have equal access and availability to the latest technologies.

Aspect of curriculum changes were discussed by Genovese (2000) in addressing his research question, while a different view of change was suggested by Sawa (1999) in *Cramming cripples Japan.* Both these views, on changes to the mathematics examinations were discussed in Chapter 2. Answers to the above questions in relation to mathematics examination papers will be addressed in subsequent chapters as this study seeks to learn more about the examination process over the last 160 years in order to answer the research questions stated in Chapter 1.

3.3 Description of content analysis

Historical research is mainly qualitative (non-numerical). Inherently this type of data collection and interpretation relies to a large extent on personal judgment which may skew the results. According to Neuendorf (2002, p.1) “*content analysis is the systematic, objective, quantitative analysis of message characteristics”.* Content analysis is the counting of words associated with certain cognitive characteristics of text, by comparing two or more sets of data chosen some years apart and treating this qualitative data as (numeric) quantitative data. In this study, three sets of data were collected.

First set - instructional words and phrases used in the examination questions, such as *find, solve, calculate, what if* and *explain* etc. were manually counted and analyzed as quantitative data.

Second set - contained general information about the examinations such as the duration of the examinations, types of questions asked, use of diagrams and graphics.
Third set - contained information about the content of topics tested in the examination papers, such questions on algebra, geometry or calculus.

The topics tested in each question were subjectively collected and treated as quantitative data, where the categories were based on studies carried out by Britton and Raizen (1996). One may argue that this is qualitative data because the categories were identified subjectively, meaning that the researcher was the person who identified and categorized each question. This was not considered as a limitation because experienced mathematics teachers would argue that they can tell the difference between a question on "quadratic equations" and "differentiation**".** This issue will be addressed in more detail when reliability is discussed in Section 3.3.2.

3.3.1 Validity

Content analysis assumes that patterns in text can be discerned and quantified in that it measures what was set out to be measured (Cohen and Manion, 1994). Content analysis has proved a useful technique for discovering the underlying characteristics of text, such as lexical complexity, latent themes and level of abstraction. This may well be true for a novel, however examination questions in mathematics generally use simple unambiguous text with specific terms having specific meanings, such as "factorize" or "differentiate" giving a clear direction to the students of what is required. In this thesis all the instructions in examination papers were manually counted and the totals recorded in spreadsheets for later analysis. Instructions were manually tallied and whenever a new instruction was noted, it was then added to the tally and continued for each examination paper (Figure 3.1). The manual tally was then transferred to a set of spreadsheets for later analysis.

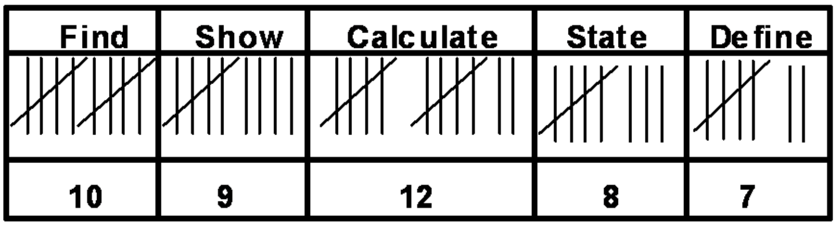


Figure 3.1 Example of tally of instructions

The content of each examination paper was also added in a similar manner, but instead of using a tally, the marks awarded to each individual question were recorded for every topic examined. The marks were added together and checked against the total marks (usually 100%) allocated for each paper. If the calculated total was not exactly 100 then this process was repeated until the totals matched. In the worse scenario this process had to be repeated up to three times. If the total was not out of 100, then the marks were converted to a percentage. These individual marks were then transferred to a spreadsheet for later analysis. General data about each individual examination paper were also recorded and analyzed in the results section of subsequent chapters.

It could be argued that this process may have some limitations regarding the integrity of the data. The researcher agrees that it would have been better for at least one other person to verify the accuracy of the count. Unfortunately this option was not available to the researcher. Nevertheless the researcher maintains that the data was accurately counted and should there be minor errors, they will not impact the overall results and the integrity of this study.

Each paper was carefully analyzed to collect all the relevant data and then the entire process was repeated to ensure the accuracy of the count, thereby maintaining data reliability.

3.3.2 Reliability

According to Krippendorff (2004) in the context of this study two types of reliability are pertinent for content analysis:

- stability; and
- accuracy.

Stability refers to the extent to which the results of content classification were invariant over time; this was a relevant issue because new classification criteria may be needed to cater for changes taking place over a long time period. As the mathematics syllabus changed, new terms such as *differentiate* and *integrate* started to appear after 1913 with the introduction of the Leaving Certificate. Other instructions such as *simplify*, *calculate* and *find* have been found in almost every examination paper, the meaning of these terms has not changed and are likely to remain the same in the future.
Accuracy refers to the extent to which the classification of text corresponds to a standard or norm. This is the strongest form of reliability. As discussed in Section 3.3.1 in this study all the examination papers were checked at least twice to ensure the reliability of the data. Specific rules used by this researcher (Section 3.4.3) were used to count the number of questions, considering the fact that most questions have a number of parts and sections within these parts. In relation to topics tested, there were further rules on how to handle questions such as *differentiating a trig function* - should this be treated as a calculus or trigonometry question - or both? For the sake of consistency in identifying as many topics as possible it was decided by this researcher to treat these as a trigonometry question. After 1962 a further heading labeled "Total of all calculus" was added to highlight the impact of calculus. This new heading included all previous calculus questions on algebra, logarithms and exponential functions. Trigonometry questions were further analyzed and it was observed that typically half the trigonometry questions required an understanding of calculus. Half the total of all trigonometry questions were also added to the "Total of all calculus" section.

Collecting these data was a more difficult and a less accurate procedure, mainly due to the problem that over a period of time (as seen in the results section of subsequent chapters) the topic headings changed to accommodate newer examinations and in addition topic headings had to be adjusted to capture a wider group. As an example, in the early examinations the algebra section was subdivided into factorizing, simplify, equations, indices and surds. However in later examinations with a smaller algebra content it made more sense to collect all these topics together and just call them "algebra".

The initial set of rules devised to carry out the content analysis was not always appropriate for all the papers hence the rules had to be revised – at times more than once. Every time a rule was changed the entire process of content analysis had to be repeated to ensure the accuracy and consistency of the results. On each occasion it was found that the two sets of results were not always the same (although similar). Whenever this occurred the process was repeated for a third (or fourth) time. It was generally found that the later set of data was more accurate, possibly because the researcher by this stage had more practice in gathering and cataloguing the data from the examination papers.

3.4 Methods of content analysis

Data gathering and analysis techniques discussed in Chapter 2 were adapted to analyze examination papers for this study.

3.4.1 Identifying changes in the examination papers

To critically analyze mathematics examination papers in New South Wales this study used an adaptation of the methodologies described in Section 2.5.

Genovese (2002)

Krippendorff (2004, p.18) defined content analysis as a *"research technique for making replicable and valid inferences from text or other meaningful matter to the contexts of their use".* Genovese (2002) used quantitative content analysis to identify and count terms and phrases used in examinations one hundred years apart. Text is considered to be qualitative data (Krippendorff (2004), however applying scientific methods such as reliability, validity and replicability to analyze this data, means that they were treated as quantitative data (Neuendorf, 2002). Genovese used Miller's (1995) VBPro content analysis software for the analysis. VBPro compares a specific text with the research list and calculates the percentage of text sentences that contain search words (Genovese, 2002).

In this study the instructions used for questions were also identified and manually counted, then entered into a spreadsheet and formulas were added to combine totals and calculate percentages.

Techniques used by Britton and Raizen (1996) and TIMSS (2007)

Collectively these studies looked at a range of questions; whether the examinations were separated into different sections: the duration of the paper; the number of questions; type of questions e.g. multiple choice; standard short answer on various topics; descriptive questions; based on practical situations; use of selection and alternatives; free response items; essay and word phrase items; practical activity questions and use of diagrams, graphs and tables.

Although a great deal of specific data were collected, these studies were more interested in an overall theme and trend, because they were comparing different countries with significantly different cultural standards. Furthermore Britton and Raizen (1996) considered analyzing the difficulty of the examinations relative to each other by using a 3-point difficulty scale. The difficulty was based on:

- Length of the examination
- Whether students were given the option to choose among questions
- Types of questions used, such as a combination of free response and multiple choice
- The breadth of the coverage of the examinations' topics
- The cognitive operations expected from students to answer questions

According to the Britton and Raizen (1996) study, the results obtained to measure the difficulty of the examinations proved to be "unreliable" in that they were not able to accurately grade the examinations. This would imply that other aspects of the examination would need to have been considered to measure the "difficulty" of an examination. Initially, this researcher also considered what data might be used to measure the difficulty of examinations. Based on the Britton and Raizen (1996) experience, it was decided to exclude "difficulty" from this study however this issue will be discussed later in the concluding chapter.

After reading a number of reports including TIMSS et al. (2007) the researcher decided on the data to be collected from the examination papers. This researcher also decided to use similar headings to the ones used by the Britton and Raizen (1997), because their study also analyzed high stakes mathematics examinations. However there were still a number of major differences:

- The reference studies were all done at roughly the same time, whereas this study was a longitudinal study with examination papers spread over 100 years. Topic headings were chosen for their longevity so that realistic comparisons could be made over an extended period of time.
- The reference studies collected only "general" details about the examinations (as listed above), whereas this study captured every detail on every question then analyzed the data. The additional data collected included a breakdown of every topic tested.

Strictly speaking, a longitudinal study refers to observing and analyzing the same item over an extended period of time. In this thesis "similar" examination papers were observed and analyzed and this will be referred to as a "longitudinal" study. A manual application of quantitative content analysis was used to collect data from mathematics examination papers from 1881 (earliest complete set available) to 2010 selected at ten year intervals. Initially different time gaps were considered, ranging from all years to five and ten year intervals. Since not all the examinations were available in every subject, consecutive years were not a realistic option. It was also felt that five year intervals may not be sufficiently long enough to demonstrate changes, hence it was decided to analyze examinations at ten year intervals.

In the first instance, the research techniques were based on previously used methodologies to collect data from "similar" examinations, however it soon became apparent that different techniques had to be devised to collect and analyze longitudinal data. Thus the methodology used in this research may be best described as "***heuristic investigative process of data analysis***" as discussed in Section 3.4.2.

This technique was used to compare, contrast and analyze the following examination papers regarded as primary data source, namely (see Table 3.1):

- Junior and Senior Public Examinations
- Matriculation Examinations
- Leaving Certificate Examinations
- Higher School Certificate Examinations

3.4.2 Heuristic investigative process

A manual application of content analysis of all possible data items was implemented to collect and record data in spreadsheets. The issue then remained as to what to do with the tens of thousands of collected data items. Clearly to make meaningful sense of the data, it was important to compare examination papers that were similar to each other, referred to as vertical comparison. By chronologically listing all the examinations in order of difficulty as set by the examiners (Table 3.1) it became obvious as to which of the examination papers were "similar" to one another. Often a corresponding Matriculation and Leaving Certificate (previously the Junior and Senior Public) examination used similar descriptions to describe the examinations. This helped to compare the examination papers both "vertically" and "horizontally" as explained further in Section 3.5.

Vertically – subjects of a similar standard, such as all "2 Unit" (or equivalent) were compared with one another.

Horizontally – in any particular year, all non-calculus and calculus based examinations were analyzed for a common theme and style of questions. They were then compared with the subsequent and previous ten years, because of a possible "trickle down" effect. This meant that some topics studied at university at one time may later find their way into the high school curriculum and further down the track perhaps included in the primary syllabus.

Table 3.1 Examination papers used for analysis.

Course	with Calculus			without Calculus	
Year	**1st Level**	**2nd Level**	**3rd Level**	**Higher**	**Lower**
1881 *Matriculation*				Senior Public *Honours*	Junior Public *Pass*
1891 *Matriculation*				Senior Public *Honours*	Junior Public *Pass*
1901 *Matriculation*				Senior Public *Honours*	Junior Public *Pass*
1911 *Matriculation*				Senior Public *Higher Standard*	Junior Public *Lower Standard*
1922 Leaving *Matriculation*			Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Higher Standard*	Mathematics *Higher Standard*
1932 Leaving *Matriculation*			Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Higher Standard*	Mathematics *Lower Standard*
1942 Leaving *Matriculation*			Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Higher Standard*	Mathematics *Lower Standard*
1952 Leaving *Matriculation*		Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Mathematics I* *Mathematics II*	General Mathematics *General* *Mathematics*	
1962 Leaving *Matriculation*	Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Mathematics I* *Mathematics II*	Mathematics III Pass	General Mathematics *General* *Mathematics*	
1973 HSC *1974* *Matriculation*	1st Level Paper A	2nd Level Paper B *Level 2F* *Paper B*	Paper C *Level 2 F/S* *Paper C*	3rd Level Paper D *Level 3* *Paper D*	
1982 HSC	Mathematics 4 Unit	Mathematics 3 Unit	Mathematics 2 Unit	Mathematics in Society	
1992 HSC	Mathematics 4 Unit	Mathematics 3 Unit	Mathematics 2 Unit	Mathematics in Society	Mathematics in Practice
2002 HSC	Mathematics Extension 2	Mathematics Extension 1	Mathematics 2 Unit	General Mathematics	
2008 HSC	Mathematics Extension 2	Mathematics Extension 1	Mathematics 2 Unit	General Mathematics	

In much the same way topics studied at 4 Unit (higher level) may later be included in the 3 and 2 Unit (lower level) syllabus.
There are numerous examples of this happening such as:

- Set theory originally taught at university level has at a later stage been taught as part of the primary school program; and
- Calculus previously studied at universities 100 years ago, has now been implemented in the Year 11 program.

There was a certain amount of “trial and refine” process involved because some comparisons had not yielded useful results when insufficient data were available. A useful result did not necessarily reflect a “change”, because static results also indicated certain trends and patterns. The researcher made every effort possible to attribute all patterns of change (seen in the graphical charts) of later chapters to a clearly identifiable historical or social event. Although this was qualitative data (Krippendorff, 2004), a quantitative approach was used to analyze the data. Initially as part of this “trial and refine” process sample data were analyzed using both SPSS statistical software and Excel spreadsheet generated calculations and charts. The statistical analysis included nominal regression, likelihood ratio tests, pseudo R-Square and Chi-Square distribution. As it turned out the more sophisticated SPSS analysis did not yield results that were different from the simpler spreadsheet results, hence they were not included in this study.

Data collection began with the early examinations and gradually progressed to the more recent examinations. In the first instance columns for data to be recorded were set up, largely based on Britton and Raizen (1996) and TIMSS (2007). As the data collection progressed further columns were added to accommodate as yet unclassified data. When it came to analyzing data for a particular time period, some columns of data were rationalized by combining them with others to provide a consistent longer term overview. This technique will be discussed in more detail in the following sections.

3.4.3 Data collection

Using the heuristic investigative process, this study analyzed mathematics examination papers at the end of secondary schooling from 1788 to 2010. Detailed document analysis identified significant milestones in the history of New South Wales leading to five carefully chosen time periods. These were decided on because of their historic or education significance effecting change, namely:

1788 - Governor Arthur Phillip landed in New South Wales

1850 – The University of Sydney was established

1904 – Knibbs-Turner Report signifying major educational changes

1939 – Australia enters World War II

1962 – The start of the Wyndham Scheme

With historical research the data already exists, however care must be taken to ensure that bias is minimized and the interpretation of the data is unambiguous. To achieve this, data were collected and analyzed from a number of different and independent sources such as examination papers, university records, curriculum documents, minutes of meetings, biographies and newspaper records as detailed in this section.

Data can be classified into two categories, namely primary and secondary data. Primary sources of data are ones in which the creator was a direct witness or in some way was directly involved in an event. These may include photographs, original manuscripts, transcript of interviews (Burke & Christensen, 2000). In this study all the examination papers, curriculum documents as well as books and reports produced by eminent educators such as Cockcroft (1982), Wyndham (1957) and McGaw (1997) were generally considered as a primary source when they were referring to their "present". However data from these same people such as Wyndham (1957) were also treated as secondary data when they referred to "past" events in their reports. Table 3.2 was designed to provide a more detailed explanation about the sources of primary and secondary data used in this study.

Secondary sources of data were often created from primary sources. These data were at least one step removed from the original source. In this study information taken from historians such as Barcan (1988), Turney (1972) and many others has been treated as a secondary source of data. With secondary sources, one needs to be extremely mindful of any possible bias in the way in which the historian presented the data. In order to eliminate or at least minimize the effects of bias, information was collected from a number of different sources and whenever possible, these data were cross referenced back to a primary source.

Table 3.2 References

<table>
<tr><th>Chapter</th><th>Primary Reference</th><th>Secondary Reference</th></tr>
<tr><td>2</td><td>ABS, Britton & Raizen, Genovise, TIMSS</td><td rowspan="8">All historical references from sources such as: Austin, Barcan, Clements, The Sydney Gazette and Turney</td></tr>
<tr><td>3</td><td>ABS, Britton & Raizen, Cockcroft Report, Genovise,</td></tr>
<tr><td>4</td><td></td></tr>
<tr><td>5</td><td>All examination papers</td></tr>
<tr><td>6</td><td>All examination papers, ABS, Carslaw, University of Sydney</td></tr>
<tr><td>7</td><td>All examination papers, ABS, Murray Report, National Archives, Wyndham Report</td></tr>
<tr><td>8</td><td>All examination papers, Auditor general, ABS, ACER, McGaw Report, MCEECDYA, Wyndham Report</td></tr>
<tr><td>9</td><td>All examination papers, ABS, BOS</td></tr>
</table>

Acronyms and abbreviations:
All examination papers – including Junior and Senior Public Examinations, Leaving Certificate, Higher School Certificate, Matriculation Examinations
ABS – Australian Bureau of Statistics
ACER – Australian Council for Educational Research
BOS – Board of Studies
MCEECDYA – Ministerial Council for Education and Youth Affairs
TIMSS – Trends in Mathematics and Science Study

In addition to the primary data collected from the examination papers further primary and secondary data used in this study were also collected from the following areas:

Research into early New South Wales history – even though there were no formal examinations before 1868, there were students, teachers and schools. The early direction of the education system set the foundation for subsequent developments. In order to make a judgment on the progress of the education system it was necessary to understand the circumstances that influenced teaching before formal education was legislated.

Academic literature on examinations, particularly in New South Wales – many eminent historians and educators such as Barcan (1988) have researched and detailed the development of education in New South Wales. Some have also commented on examinations at the end of secondary schooling including mathematics education. Their research has assisted greatly in providing an explanation for the development of mathematics examinations.

Government reports and gazettes – these have provided factual information about the workings and decision making of governments towards education in general.

Curriculum documents prepared by the Board of Studies (or equivalent) – provide the framework and instructions to teachers and schools as to what they have to teach, how to teach and what the students are expected to learn and understand after completing their course. In this study changes in the curriculum were analyzed in relation to end of year examinations.

A wide range of text books on examinations, social changes, curriculum, research methodology, etc. – in order to understand and explain the developments in the examination process, it was necessary to learn from the experience of others in relation to a wide range of factors. To minimize bias, it was necessary to look for a variety of sources on any single issue.

Statistical data – from many reputable sources, such as the Australian Bureau of Statistics (2010a), Board of Studies (2010), McCrindle (2010), and the Trends in International Mathematics and Science Study (2007).

Personal interviews with people earlier involved in either setting the curriculum or the examination papers – although there were numerous interviews conducted the actual interviews were not included in this research because of the possibility of bias. These interviews were still very helpful in suggesting avenues for research as well as suggesting places where information may be found.

3.4.4 Data evaluation

All secondary data were viewed with some skepticism because these data might be influenced by bias, political and economic climate, religious and cultural beliefs (Burke & Christensen, 2000). It was also possible for data to have been falsified or deliberately altered, although it is unlikely that the data used in this study were deliberately altered. Much of this background information was collected from historical documents or taken from academic books written by eminent historians, hence there was no reason to suspect that these data were altered. Historical criticism is generally undertaken in two stages. One needs to verify the authenticity of the source, in the first instance this is referred to as *external criticism* and secondly to consider the worth or accuracy of the data, referred to as *internal criticism* (Cohen & Manion, 1994). Data extracted from copies of past examination papers, curriculum documents and statistical data from Government sources were considered genuine, because they satisfied the criteria for external criticism. Data accuracy was discussed in more detail in Section 3.3.2.

3.4.4.1 External criticism

To ensure that the data were genuine, all data used in this study have either been directly copied from original documents or a copy was made from what appeared to be an original document. All these documents were deemed to be "original" because they were archived at reputable sources, such as Board of Studies, Archives of the State Library or from known, recognized and reputable researchers such as the Australian Bureau of Statistics (ABS). The Board of Studies held either the original or copies of past Leaving and Higher School Certificates as well as curriculum documentation, while Fisher and Mitchell Libraries between them hold most copies of Junior and Senior Public Examinations and the Matriculation Examinations.

3.4.4.2 Internal criticism

There was generally a concern to establish the meaning and reliability of the data. Although most documents tend to be neutral (no bias) in character (Cohen & Manion, 1994), researchers must first engage in "*positive criticism*" (Christie,

1975) in that the researcher must clearly understand the statements made or the meaning conveyed by various sources. Fortunately with the language of mathematics the meaning of terms such as “equations” or “geometry” has not been affected or altered by the passing of time, although the style of the English language has certainly changed. An expression such as *enunciate* used in the early 1900s is rare in examinations in the early 2000s where the term *state* is used. As a specific example, in the 1891 Junior Public Geometry examination, Question 3 asked “*Enunciate and prove the theorem and corollaries, which deal with the sum of the angles of a triangle, and of a rectilinear figure*”. In the 1962 Mathematics I Honours paper, part of Question 10 asked “*State the comparison test for the convergence of a series of positive terms…..*”. In this instance the words *enunciate* and *state* may be interchanged.

According to Burke and Christensen (2000), there are other concerning aspects that also need to be addressed by a researcher to minimize any possible ambiguities and misunderstanding, such as: vagueness; modern expressions (presentism); negative criticism; corroboration; sourcing and contextualization. For example, *vagueness* refers to the uncertainty in the meaning of certain words or phrases as the meaning of expressions such as colloquial terms may change over a period of time. In this study, all possible care has been taken to ensure that all terms and expressions have a clear and literal meaning. *Presentism* assumes that present day expressions existed in the past. Clearly the term “computers” as we understand them today did not exist prior to 1950. *Negative criticism* looks at the reliability or authenticity and accuracy of data. The researcher needs to make a value judgment regarding the use of data from “questionable” sources. In this study all sources of data were considered reliable because they were either from a primary source or from a recognized secondary source. Gathering data about the same event from multiple sources helps to *corroborate* the accuracy of the data. Historical data were collected from known historians coming from different backgrounds, thus reducing the risk of negative criticism. Furthermore the information that identified the source, called *sourcing* also helped to reduce the risk of “untrustworthy” information as it was referenced back to the authors.

Whenever available, *contextualization* was used to identify the source as to when and where an event took place (Wineburg, 1991) and referenced accordingly. The Britton and Raizen (1996) study has proved to be an important factor in this study for a number of reasons. On the positive side, it provided some useful methodologies for collecting and analyzing data, while on the negative side it highlighted the limitations in providing inclusive results for the difficulty of examinations and it also showed that data may be interpreted in a number of different ways. This researcher has made every effort by using triangulation to ensure that the data used in this study were accurate and unambiguous

3.5 Application of content analysis

In most cases it was possible to longitudinally compare many aspects of examination papers from 1881 to 2010. As shown in Table 3.1 the researcher was able to review the progress of non-calculus examinations starting with the senior public examination in 1881 through to the HSC General Mathematics examination in 2008 (see Chapter 9). It was also possible to compare entry level calculus examinations starting with the Leaving Certificate honours in 1916 through to the HSC 2 unit in 2008 (see Chapter 9). All five sets of examinations (Table 3.1) were compared with each other, within their shorter respective periods as discussed in Chapters 5 – 8.

Examination papers within the pre-defined time periods were compared horizontally and vertically against the following criteria. Comparison lists are shown in Table 3.1:

Horizontally - Junior Public examinations with Matriculation examination
Senior Public examination with Matriculation Honours
Leaving Certificate examinations with Matriculation

Vertically - Length of examination papers, topics tested, looking for a pattern such as no-change, growth, decline and introduction and deletion of topics and use of instructions

The content of every examination paper from Table 3.1 was critically analyzed and the results recorded in spreadsheets from which charts were generated to identify all consistencies and changes over a period of time. The data were collected from two separate groups of examinations, those with calculus and others without calculus. From the time when the Leaving Certificate first appeared in 1913, there had always been a natural separation between the calculus and the non-calculus examinations. Universities in Australia and overseas also use this distinction as a general rule to separate the mathematics, science and engineering courses from the social sciences. Results in Chapters 5 -9 will also be separated into calculus and non-calculus groups as shown in Table 3.1.

To clarify the origins of the examinations in Table 3.1:

- Matriculation examinations were set and marked by the University of Sydney until 1978;
- HSC and Leaving examinations were set and marked by the Board of Studies (or equivalent) since 1913;
- Senior – means Senior Public examination;
- Junior – means Junior Public examination;
- HSC – means Higher School Certificate;
- All examinations up to 1901 such as Junior, Senior, Pass, and Honours, had 3-4 separate 3 hour examinations in individual subjects such as: arithmetic, algebra, geometry and trigonometry; and
- By 1911 Matriculation papers were consolidated into two sets of 3 hour examinations, while the Junior and Senior Public examinations continued as previously described.

As already discussed in Section 3.4.1 after careful consideration it was decided to collect data at ten-year intervals. Unfortunately this was not always possible because not all the papers could be found for every year. This led to some small discrepancies with the collection dates. However this did not impact on the overall results, because the examination papers on both sides of the chosen date were also analyzed for changes. As an example some of the 1972 examinations could not be found, hence the 1973 examinations were used instead. To make sure that the 1973 year would suffice, the researcher also analyzed (although did not include) the 1971 examinations and found them similar to the 1973 papers. Hence it was concluded that the 1972 and 1973 papers were similar and that one may be substituted for the other without altering the overall results.

Mathematics examination papers generally contain few words, even accounting for more recent General Mathematics examinations. In all cases only a limited vocabulary was used to either describe a problem or to ask a question. The bulk of the papers were made up of mathematical expressions, equations, statements and diagrams relating to a range of curriculum topics. All the data were manually counted and recorded under the following headings (Section 2.5.2):

- Year of the paper (e.g. 2002).
- Subject level and description (e.g. Mathematics 2 Unit).
- Name (e.g. Matriculation, Leaving or HSC).
- Length of Paper – at the beginning of all the examination papers it was always clearly stated as to the duration of time allowed for the examination (usually between 2-3 hours).
- Number of individual questions (with multiple-choice separated) Break-down of the total number of parts within the questions – in all mathematics examinations the content is separated into different topics (or questions) and often each question is further sub-divided into smaller components to specifically test student knowledge and understanding (most papers had around ten main questions).
- Use of graphics – whether diagrams, graphs and tables or any other pictorial representations were included with the questions. These were a single combined total.
- Type of questions, as a percentage (e.g. multiple-choice, short answer, practical, etc.).
- Individual topics as a percentage (e.g. linear functions, locus, statistics, probability, etc.) – this was by far the largest section. In the first instance topics were separated into the five main groups, namely:

arithmetic, algebra, geometry, trigonometry and calculus. Then depending on the type of examination paper one or more of these groups were further divided to highlight subgroups that consistently represented at least five percent of the examination paper. Example 1: Arithmetic was not included in calculus based examinations. Example 2: Questions on projectile motion and simple harmonic motion were separated out because they were consistently asked in the more advanced calculus based examinations. These topics as well as half of trigonometry questions (Section 3.5.2) were included in the "total calculus" section.

Data were also collected and analyzed based on the number and type of instructions. According to Bloom et al. (1956) most mathematics question included one of the following terms or phrase, such as: *simplify, what is, how, solve, prove, define, find, divide, multiply, resolve, calculate, describe, show, state, draw, construct and explain*.

TIMSS (2007) recognized the significance of these instructions and developed specific questions for testing the cognitive processes for knowing, applying and reasoning involved in working mathematically and solving problems (Section 2.5.4). Unfortunately this study did not have the luxury of TIMSS' purpose developed questions to review the cognitive domain. Instead all the instructions used in questions were used to analyze the cognitive domain, based on the theories developed and explored by Bloom et al. (1956), Anderson et al. (2001) and others. This researcher has not been able to find any specific previous studies or literature undertaken to analyze instructional terms used in mathematics examinations at the end of secondary schooling. In order to analyze instructional terms the following procedures were carried out:

- All the instructions used in every question were counted for each paper. This providing a more accurate picture for the actual number of questions asked. A typical question containing instructions such as; *define, find* and *show* was in fact not just "one" question but "three" separate questions. This issue will be discussed in more detail in the result section of subsequent chapters.

- Some instruction also gave additional insight into the examination process. When a question asked the student to *state* or *write down,* it usually meant to reproduce something that was rote learned. On the other hand, using instructions such as *describe* and *explain* would require higher order thinking, more in-depth knowledge and logical deduction (Bloom et al., 1956).

3.5.1 Data recording

Data such as duration of paper and number of questions were recorded as integer values, whereas the questions on individual topics were always expressed as relative percentages (out of 100%). Based on examples provided by Britton and Raizen (1996) an example shown in Table 3.3 describes a typical examination paper that may contain the following topics:

Table 3.3 Content of topics for a sample examination paper

Topic	**Percentage**
Algebra	23
Series	4
Geometry	31
Trigonometry	12
Calculus	22
Logarithm and Exponential	8
Total	**100**
Total Calculus (calculus + logs & exp + 0.5 × trig)	36

With the early examinations prior to the Leaving Certificate, it was necessary to estimate the relative percentages of topics examined because the examinations did not have a marking scheme. This was a limitation of the research and in those instances each question was considered of equal value. Once marking schemes were added to the examination papers, it became a simple task to convert the marks allocated to each question as a relative percentage.

When comparing a Junior Public examinations with a Matriculation examination, it was necessary to combine the totals of two separate 3 hour arithmetic and algebra papers and express them as a relative percentage, because the corresponding Matriculation examination was a single 3 hour combined arithmetic/algebra examination. The same technique was used to record the instructions.

3.5.2 Data representation

In order to compare equivalent levels of examinations, sets of "*similar*" papers were combined to provide a meaningful comparison. As indicated in Table 3.1 Junior Public examinations were compared with Pass or Lower Standard Matriculation examinations. Senior Public examinations were compared with Honours or Higher Standard Matriculation examinations. Until the Higher School Certificate there were two sets of matriculation examinations, both papers had similar names corresponding with each other and contained many of the same topics (except calculus). Considering the period up to and including 1942, there were just two sets of non-calculus papers, a higher and a lower set which were clearly distinguishable. In 1952 and 1962 there was just one set for each period and both sets were called "General Mathematics". In 1973 there were three sets of Matriculation examinations partly called Paper B, Paper C and Paper D to correspond with the Higher School Certificate examinations.

All the data from the spreadsheets were presented in over 400 charts for consistent interpretation, with each set of subjects displayed under four categories:

- *Content by individual topics at 10 year intervals* – to identify individual trends;
- *Content of all the topics together at 10 year intervals* – to identify overall trends in the relative movement of content;
- *Individual instructions at 10 year intervals* - to identify individual trends; and
- *All the instructions at 10 year intervals* - to identify overall trends in the relative usage of instructions.

In most instances this method worked well, as generally the researcher could add up all the columns in a chart and account for 100 percent of all the data. To maintain consistency over 30 – 50 year period, only the data from the more popular topics were transferred into charts. This created some anomalies, however they did not impact on the overall results because these isolated instances represented only 2 – 3 percent of an examination. There were also instances when the columns for some of the topics and instructions did not total 100 percent. These special cases were highlighted and explained in the individual results sections for Chapters 5, 6, 7 and 8.

3.5.3 Societal influences on the examination process

As stated earlier in Chapter 2, there were many factors that may have influenced and affected the changes to the examination process. In order to understand this process the researcher had to explore many different academic sources as well as looking at early newspapers and chronicles of each period to gain an understanding of the societal factors at play. This also included extensive and close reading of material that related to such things as: student numbers, historical and political events, technological developments, curriculum changes, method of assessment, spread of student ability, university and school funding, industry demands, university demands, community expectations, changes in social and cultural values, just to name a few.

3.6 Review

This chapter examined the process of collecting and analyzing data to answer the research questions stated at the end of Chapter 2. This chapter also demonstrated that Britton and Raizen (1996) and Genovese et al. (2002), were able to extensively analyze thousands of data items, collected according to strict guidelines from a wide range of examination papers. Furthermore a detailed heuristic methodology was presented based on studies done by Britton and Raizen et al. (1996). It showed that data collected from over one hundred different mathematics examination papers, produced over a 150 year period, should indicate whether there are identifiable patterns of changes in the style, format and content of high stakes mathematics examinations.

The following chapters will provide a detailed analysis of educational developments and subsequent final examinations for consecutive time periods starting from the time when Captain Arthur Phillip first landed at Farm Cove in New South Wales.

Chapter 4

NEW SOUTH WALES IN THE EARLY DAYS 1788 – 1850

This thesis is within the historical framework of the development and growth of mathematics education in New South Wales at the end of secondary schooling. There were no formal examinations during this period, however to understand the examination process, it is important to give a detailed historical background of the relevant events surrounding each era. Chapters 4 to 8 will each commence with a historical overview of the education, curriculum and examination process relevant for that time period.

In 1788 Governor Arthur Phillip arrived in New South Wales and established a British settlement at Farm Cove. During the early days of the colony surviving in this primitive and hostile land was challenging enough without having to worry about high stakes examinations or for that matter any examinations. There were no schools, few children and even fewer people who were able to teach. It is important to note that in the short space of about 60 years the education system in New South Wales matured to the point where there was a need to establish a university in Sydney, hence the requirement for high stakes examinations at the end of secondary schooling.

4.1 Historical background

Governor Phillip arrived with 568 male and 191 female convicts (Fletcher, 1967) as well as eight children who were of school age. This number grew to 1000 children by 1800 (Barcan, 1988). As there were no teachers sent with the First Fleet, the Rev. Richard Johnson, who was the first official Anglican chaplain of the Fleet, was given the task to allocate land in each town for the building of a church and the allocation of a schoolmaster, however there was no immediate financial aid provided.

According to Turney (1969) educational development in colonial New South Wales fell into two main divisions; the pre-national education from 1788 to 1848, followed by the rise of national education from 1848 onwards. The early administrators in this new colony of New South Wales wanted to duplicate the educational institutions and policies of England. Unfortunately educational facilities were insufficient and the teachers were mainly unskilled and incompetent, reflecting their low pay and social status (Barcan, 1988). The convict character of the early settlement produced an emphasis on elementary education with moral and religious indoctrination provided by the Charity schools and run by the Church of England. It was assumed that the middle and upper classes would make their own arrangements for educating their children (Clements, 1989).

In 1793 the first church building in Sydney was used as a schoolhouse during the week. This was the beginning of formal education and as there were no records discovered of any teachers arriving in New South Wales at that time, the classes were most likely taught by convicts. By 1798 the Reverend Richard Johnson combined the three Sydney schools into one with 150-200 students and during that year four missionaries arrived from the non-conformist London Missionary Society, boosting the number of qualified teachers (Barcan, 1988).

As the population of New South Wales continued to increase, Governor King in 1800 replaced the tentative approach to teaching by introducing a “definite and determined” policy (Turney, 1969). His foremost achievement was to open the first Female Orphan School, reflecting his educational view on gender tolerance. He also utilized the missionaries who arrived earlier to provide elementary education to districts outside of Sydney and Parramatta.

At that time England already had a number of educational systems operating. One such approach was the Monitorial System which was established in 1789 by Joseph Lancaster, a keen 20 year old Londoner, who set up a school for the poor. He employed older and more experienced pupils who he called “monitors” to teach the younger pupils. People were attracted by the cheapness of this scheme and in 1805 the Royal Lancastrian Society (later named the British and Foreign

School Society) was founded. The schools were religious but non-denominational. A few years later Dr Andrew Bell initiated a similar monitorial system calling it the National System. The difference being that under the patronage of the Archbishop of Canterbury they were also spreading the doctrines of the Anglican Church (Smith, 1917).

The Lancastrian System was first implemented in New South Wales in 1811, here only the most orderly, punctual and advanced students were selected and these people had to turn up to school a half hour earlier to clean the slate and prepare the classroom for the day. Each monitor was allocated 20 students and when students were called by their monitor they had to stand in a semicircle and recite the lesson they learned the previous day. Discipline was maintained by awarding marks, one mark each for attending both morning and afternoon. Marks were also awarded to students who turned up neat and tidy however marks were withheld if they turned up late. (Turney, 1972). Around 1800 the first private school was opened by John Tull, offering primary and secondary education for middle class students (The Sydney Gazette, 1817).

William Bligh, who followed Philip King as Governor in 1806, had a continued interest in education. As a consequence, evening schools and adult education began in New South Wales because people had no time to improve themselves during the day due to shortages of labour (The Sydney Gazette, 1807). After Governor Macquarie took office in 1810, he issued a proclamation that the upper classes should provide an example for the lower classes. Under Macquarie the religious, social and moral purposes of education became a dominant factor with funding for education coming from revenue raised from customs duties on spirits and license fees for publicans (Barcan, 1988).

By 1815 with government assistance of providing land and money, the Church of England tried to establish a monopoly in elementary education for the lower classes. The rudimentary condition of this funding was to also provide for more advanced (higher) education to the middle and upper classes. Apart from a small number of leading families who either sent their sons to study in England or were taught by tutors, the majority of middle class children went to the newly established small private venture schools or grammar schools where a classical curriculum was provided in Latin, Greek and mathematics (Barcan 1988).

Commissioner J. T. Bigge was appointed to enquire into the state of the colony and in 1819 he produced a number of reports, including education. His third report was focused on religion and education, however he did not suggest any reforms except for his recommendation that the National (or Bell) System of Education be introduced. Unfortunately the National System turned out to be an unsuccessful experiment because by modern standards it was mechanical and largely ineffective. Nevertheless it still improved the instruction provided by the generally poorly qualified teachers (Turney, 1969). Bigge's secretary was Thomas Scott (later Archdeacon Scott) who on his return to England submitted a report in 1824 recommending the appointment of an Anglican archdeacon for New South Wales to control the church and the education. His forward thinking plan envisaged advanced schools as well as a university under the supervision of the Church (Correspondence: Scott to Bathurst, in Austin, 1963), however several major problems soon became apparent and these will be discussed in detail below:

- Religious conflict caused by the dominance of the Church of England;
- General shortage of teachers; and
- Irregular student attendance.

Even though these issued did not relate directly to mathematics examinations, they represent important issues concerning the establishment of schools and formal education which in turn had led to formal examinations.

Religious conflict caused by the dominance of the Church of England - Archdeacon Scott returned to New South Wales in 1825, however in his short absence much had changed and he faced considerable opposition to his plans. As a result of Macquarie's emancipist policy, many former convicts had prospered with some becoming prominent members of colonial society. When Governor

Brisbane in 1824 allowed the freedom of press, he neglected to insure that it should also be a "responsible" press. As it turned out, it suited the viewpoint of the publishers of *The Australian* and *The Monitor* to openly attack Scott, the Church and the School Corporation which had been established in 1826 to oversee public education. Scott also faced considerable opposition from his own clergy as the religious scene had greatly changed with the arrival of Catholic priests and other denominations (Barcan, 1988).

***General shortage of teachers* -** The National Board had enormous problems in recruiting suitable teachers. Most were immigrants, however the Board also wanted to train local people. In 1826 the School Corporation was established to take over the management of all 20 schools from the Government. At that time approximately 1000 students were taught for a cost of ₤9500. Over the next seven years student numbers doubled while school expenditure was reduced to ₤6000. Unfortunately these savings were at the expense of teacher's salaries which were kept at the lowest level, discouraging any credible and knowledgeable person from joining the teaching profession (Smith, 1917).

***Irregular student attendance* -** The Rev. Thomas Reddall originally trained under Dr. Bell's National System reported to Governor Macquarie in 1821 that the Male Orphan School was a well-ordered school but the chief hindrance to the success of the system was the great irregularity of the pupils' attendance (Smith, 1917). Since there were plenty of jobs around, students preferred to work and earn money instead of attending school.

In 1825 Archdeacon Scott also took up the question of poor attendance and directed both the clergy and the schoolmasters to convince the parents about the importance of schooling (Barcan, 1988). He also cited the incompetence of teachers for the irregular attendance of students and determined to overcome this problem by arranging a three months training course for all teachers.

At the insistence of the Church of England and the Colonial office, one-seventh of the land in each county of New South Wales was set aside for the maintenance of the Church and the education of the youth (Jones, 1974). Even though considerable progress was made in extending the school system by opening more schools, increasing the enrollment and improving the attendance, Archdeacon Scott resigned in 1828 and returned to the England to resume his post as a parish vicar (Austin, 1963, p.13).

By 1831 the attempt by the Anglican Church to impose a typical British system of education in New South Wales had failed, instead it started to assume a more local colonial character. Sectarian bitterness from the Catholic Church forced the demise of the School Corporation in 1833. In the early 1830s as an alternative to the Anglican dominated school system, Governor Bourke tried to introduce the Irish National System of Education by establishing non-secular government schools, by bringing together children from all backgrounds. Strong opposition forced the abandonment of this scheme from quarters other than Roman Catholic because it was labeled “Irish”. Instead the government introduced a pound for pound subsidy, called the “half and half” system, for denominational schools (Jones, 1974), so for every pound offered by the government, the denominational schools had to contribute an equal amount.

Bourke's efforts were hampered from the start because of the delayed response from England in gaining approval to introduce the (Irish) National System. He lost the tactical advantage to the Church of England by allowing William Broughton the first Bishop of Sydney to organize an opposition to the idea based on religious and political grounds (Turney, 1969). Broughton found an ally in the Reverend Henry Carmichael, who was recruited in Britain by Dr John Lang. Carmichael was a dedicated educator influenced by the teachings of a utilitarian philosopher, Jeremy Bentham and his disciples called the Benthamites. Their teaching method was based on the Lancastrian monitorial system which was non-secular and disallowed corporal punishment. Students progressed through the four classes depending on their attainment in various subjects (Turney, 1969).

Carmichael because of his very liberal views left Lang's Australian College to establish the Normal Institute in 1834. The aims of the Institute were to help boys form their own opinions and to think critically. The Normal Institute also provided much needed teacher training as well as adult education in the colony (Barcan, 1988). Bourke finally relinquished his plans for the Irish system in 1836. Shortly after additional education grants were provided to schools run by the Church of England, Roman Catholic, Presbyterian, Wesleyans, Baptists and finally the Congregationalists by 1839. A small number of colleges had also been established around 1840 to provide secondary education to the middle and upper classes.

Due to sectarian rivalries, the educational system modeled on the British and Foreign School Society also suffered the same objections as the Irish system. During the years 1840 - 1843 after the economic depression, Governor Gibbs cut educational spending but the Constitution Act of 1843 fortunately relieved the burden of looking after education (Barcan, 1988). The four main churches received State funding for elementary education; however their failure to provide schools in rural areas resulted in the introduction of State elementary schools by 1848. According to Jones (1974) by 1848 a dual system of education was established under Governor Fitzroy whereby government aid was provided to various denominations.

The Board of National Education was established in 1848 (Barcan, 1988) empowered to establish State elementary schools, called National schools. Economic efficiency led to educational efficiency, inefficient church schools were closed and replaced by additional State run schools. In the 1950s the Church of England had over 60 schools, representing the majority of schools in the Diocese of Sydney. At the same time the number of Presbyterian schools was declining, leaving a small number of Catholic schools to cater mainly for the less fortunate children. However these schools were also in poor condition. The Wesleyan Methodist schools were less committed to their own system and were leaning towards the newly established National schools (or state elementary schools) which were established by the Board of National Education in 1848 (Barcan, 1988). The National Schools were first established in rural areas, by 1856 they also had four schools in Sydney with 2300 students (Ely, 1971).

Earlier in 1835, the Sydney College was established as a non-denominational corporate school to provide a classical education, unfortunately if failed to cater for the growing need to provide a more scientific and commercially oriented education (Baker, 1963). This eventually led to the closure of the Sydney College as its buildings were then earmarked for a university, yet to be established. The need for higher education was stimulated by the opening of the NSW Bar in 1848. Both lawyers and doctors had hoped that better trained members would improve the status of their profession. In September 1849, William Charles Wentworth himself a lawyer and a shareholder of Sydney College moved the Legislative Council for the Select Committee to consider establishing a university (Barcan, 1988). A Bill was introduced in 1850 for funds to be made available to establish a university in Sydney with the objective to initially confer degrees in Arts, Law and Medicine. Thus, the University of Sydney was founded. Buildings previously owned by the Sydney College were rented in 1851, three professors were initially appointed and teaching commenced in 1852 (Ward, 1951).

4.2 Curriculum changes

In early colonial days elementary schools were mainly for the lower classes. The main aims of the elementary education were to develop religious beliefs, political loyalty, moral values and basic vocational abilities. The religious purpose emphasized the need for lower class children to be able to read, giving them access to the Bible and other religious writings (Barcan, 1988; Wyndham, 1957).

Australian elementary schools adopted a curricula similar to those used in charity schools in the United Kingdom (Clements, 1989). In the early 1800s the classroom system was established as the primary form of organized schooling and the schools were typically models of the factory system (Short & Marconnit, 1968). In a factory the raw material being “the student” entered first grade and would then proceed through the system, as if on a conveyer belt to graduation in sixth grade, which was the finished product. The original purpose of the factory system was to provide a cost effective way of educating a large and diverse group in the basics: reading, writing and arithmetic. This system was later changed substantially as classes were separated into individual grades and the student/teacher ratio improved (Short & Marconnit, 1968).

Middle and upper schools had different educational objectives, curricula and methods, while higher education implied grammar schools. Children attending grammar schools had a much greater emphasis on a classical education. From the 1820s onwards mathematics began to be accepted as an integral practical component of the curriculum (Grimison, 1978). By 1840s the purpose of the curriculum was to provide a good classical, scientific and religious education to the sons of parents in the middle and higher ranks of society. Boys from middle and upper class families proceeded after their basic studies to superior, advanced or higher education. Superior education had a commercial slant including subjects such as bookkeeping, while higher education was based on the classical curriculum, including Latin, Greek and mathematics. This was mainly academically oriented and closely associated with the requirements for Oxford and Cambridge university entrance (Barcan 1988).

As reported in 1844 by Lowe who was the Chairman of the Select Committee on Education, (Barcan 1988) the curriculum of the private venture schools such as the ones established by John Tull and the Isaac Nelson Academy in Sydney had predominantly utilitarian or commercial objectives (The Sydney Gazette, 1817). Apart from the 3Rs the students were also taught English, bookkeeping, French and an expanded mathematics course which included geometry and trigonometry.

4.3 Examination process

During the early history of examinations from the middle of the eighteenth century the traditional method was based on a set of oral examinations. This was gradually replaced by written papers, with a simultaneous switch in changing the emphasis from Latin disputation to mathematical questions. Before the 1850s the universities in England already had a structured examination process in place. The University of Cambridge in England divided the different kinds of honours bachelor's degree by Tripos, a word which has an obscure origin. However this term may be traced back to the three-legged stool candidates once used to sit on when taking oral examinations. A common (but unqualified) myth says that students used to receive one leg of a stool in each of their three years of exams, receiving the whole stool at graduation (Fancher, 1989).

All degree candidates were expected to show at least some competence in mathematics. The standard examination pattern of *bookwork* (mostly memorised theorems) plus *rider* (problems to solve, testing comprehension of the bookwork) was introduced (Roach, 1971). The technique of memorised bookwork was certainly part of the Junior and Senior Public Examinations which began in 1867 (see Chapter 5).

There was no formal examination system in the early colonial days of New South Wales. In 1798 Dr Andrew Bell a clergyman published an account of teaching with the help of monitors. By 1811 a rival society was set up with the support of the Church of England and the Tories (The Sydney Gazette, 1811). Larger schools used monitorial instructions to teach and the teachers were supervised by school governors or the clergy, smaller schools were left unregulated.

Some of these colleges held public oral examinations (similar in style to the early oral examinations held in England) to advertise their teaching and as an incentive to their students. In 1835 some 120 boys of the Sydney College were examined in the presence of a number of dignitaries however this method of examination was later abandoned in favor of a "*ticketing system*" which was introduced by the Australian College. Tickets were handed out during the year to recognize the students who distinguished themselves consistently throughout the year, rather then on the day of the final examination (The Sydney Gazette, 1836).

4.4 Review

Education did not have a high priority in the establishment of a colony in New South Wales. Nevertheless primary schools were established at an early stage based on the British school system, aimed at teaching the children to read the Bible. Consequently most of the schools and educators came from a religious base, particularly the Church of England but closely followed by other Christian faiths. Amidst considerable opposition from the various churches and particularly from the Church of England, non-secular schools and teaching began around 1830.

The education system faced numerous hardships from many areas. In the first instance there was the religious conflict caused by the dominance of the Church of England. Adding to this problem, was a general shortage of qualified teachers, irregular student attendance as well as the reluctance of parents to pay teachers promptly.

Up to the early 1820s there were only a handful of high schools, as most of the upper and wealthy middle class families, sent their boys to England for further studies. Girls and those boys who were not sent to England were generally taught by local tutors. There was no real formal examination system; each school had its own method of assessment and there was no consistency from one school to another. Attempts were made to formalise examinations, but this was more of a marketing plan rather than an attempt to truly measure individual performance.

The next chapter will begin with the foundation of the University of Sydney in 1850. This may well have been the catalyst for formal examination with the introduction of the Junior and Senior Public examinations in addition to the Matriculation examinations.

Chapter 5

START OF FORMAL EXAMINATIONS 1850 - 1904

The previous chapter provided us with a background of largely primary education as it developed from the time the First Fleet landed at Farm Cove, New South Wales. At that time secondary education was mainly for the boys from middle and upper class families and many of these young adults were generally sent to England for their studies, hence there was no need for any local examination process. Even though there were no formal examinations for anyone, it was important to note that the education system had developed to the point where formal examinations were becoming important and in fact were likely to become an integral part of the education process. Examinations (including mathematics) at the end of secondary schooling began in New South Wales during 1867 prompted by the opening of the University of Sydney in 1850. The Education Act of 1870 guaranteed free, compulsory and secular education for everyone provided by state controlled elementary schools. However wealthy parents generally sent their sons to private grammar schools where the final examination was aimed at matriculation for entry into university.

5.1 Background

Prior to the establishment of the University of Sydney in 1850 there was little progress in the growth of high schools. The University commenced its operation by offering a course in classics and two years later in October 1852 expanded its program by adding mathematics. Around that time there were only a few academic schools, namely the King’s School which opened in 1832, St Mary's College, Lyndhurst in 1852 and Sydney Grammar School in 1854. To feed the University it became obvious that there was a shortage of suitable schools able to prepare students to the academic standards required to enter university (Barcan, 1988).

Between 1851 and 1866 the Churches were determined to retain their traditional control on education (Austin, 1961). During that time, five different systems of state elementary schools existed in New South Wales, namely the Anglican, Catholic, Presbyterian, Methodist and National, organized under two boards, the Board of National Education and the Denominational Schools Board for the church schools. There was a conflict between the two Boards in that teachers in denominational schools lacked the security, protection and opportunities for promotion offered by the National Board. Progressive politicians of the day were keen to resolve these issues and eventually they were able to succeed with the help of two people, William Wilkins a headmaster of the National Model School who later became a School Commissioner and Henry Parkes a flamboyant, erratic publicist and politician. In an article by James Ruthledge, a Wesleyan teacher, Wilkins' role was described as the one who prepared the situation in which Parkes could act. This was to demonstrate to the public and the Parliament that only a unified State system would solve the education problem (Barcan, 1988**).**

Wilkins and his fellow School Commissioners discovered that out of the 200 schools they inspected, five different teaching systems were used, ranging from individual, Scottish parochial, Bell or monitorial, collective and mixed systems (discussed in Chapter 4). The Parochial Schools of Scotland were important because they performed the functions of three schools, namely: Primary (or elementary), commercial (or Burgher) schools and Grammar schools. It was stated by James Kay-Shuttleworth in 1853 that "*owing to its constitution the Scotch Parochial Schools have been distinguished by one beautiful feature. Upon its benches the children of every rank in life have met, and contended for honours earned only by higher natural gifts, or superior moral qualities.*" (Bloomfield, 1961).

The Commissioners also found that more than half of the 200 teachers surveyed were untrained. To improve this system they made a number of recommendations including the unified control of elementary schools, the appointment of inspectors and the training and improvement in conditions of teachers (Barcan, 1988). Australian examinations followed the British model with "local examinations" for boys attending middle high school (Wyndham, 1957). These examinations set the academic standards and provided an incentive for effort. In New South Wales several of the professors of the University of Sydney acted as examiners on request from individual schools as well as establishing public examinations by 1867.

In Australia there was little demand for well educated public servants because recruitment was generally based on personal recommendation, hence there was no need for examination standards. In 1866 the Public Schools Act established a Council of Education to manage all State controlled elementary schools. The Act also required the Council to establish schools for teacher training which helped to raise the status and quality of teachers. It also imposed severe restrictions on the development of Denominational elementary schools, making a shift towards State based secular education (Barcan, 1988).

The growing number of State schools and the move towards a secular education led to the introduction of compulsory elementary education. The Public Instruction Act provided for the appointment of a Minister of the Crown to administer a Department of Public Instruction. Its main objectives were to provide primary education, establish evening schools for persons over the age of fourteen, and State high schools for both boys and girls (Devin, 1973). The New South Wales government also made generous provisions for religious education in State schools.

The University of Sydney, established in 1850, generally had a slow beginning, initially aiming to cater for the three main professions, namely law, medicine and theology. However this need was largely met by the British universities, colonial solicitors' offices, hospitals and theological colleges. Nevertheless the University had the academic rigor matching those of the Universities of Oxford and Cambridge. The first graduates were accorded privilege by Royal Charter. Their rank, style and precedence were equal to those of graduates of universities within the United Kingdom (Brown, 1927).

The University had little impact until the 1860s when it began to perform examination functions. The admission of girls in New South Wales to the university matriculation followed the opening of high schools to girls in 1883. They were keen to accept female undergraduates in order to increase student numbers (Clements, Grimison, & Ellerton, 1989).

Educational opportunities continued to be governed by the economic and social position of the family. This system was endorsed by the recommendation of both the Taunton Commission of 1868 and the Bryce Commission of 1895 although the Education Acts of 1870 and 1891 made elementary education free and compulsory, it did little to change the status of the lower social class (Barcan, 1988).

The State government introduced major changes to education with the introduction of the Public Instruction Act, 1880 that repealed the Public Schools Act of 1866 and;

(1) Thereby dissolved the Council of Education and transferred its responsibilities to the Minister for Public Instruction.

(2) Provided for the establishment of (i) Public Schools (ii) Superior Public Schools (which included some high school education) (iii) evening public schools (for adults who had not had the opportunity of school education) (iv) high schools for boys, which prepared them for University entrance (v) high schools for girls.

(3) Established Provisional schools and appointed itinerant teachers.

(4) Established secular education in sparsely-populated areas with at least four hours secular education per day, although denomination-specific religious education could be given by a clergyman.

(5) Education was compulsory for children between the ages of six and fourteen years. Daily fees were set at 3 pence per child with a maximum of 1 shilling per family.

(6) The Colony was divided into Public School Districts each with a board of up to seven persons, whose authority included inspecting and reporting upon the schools under their supervision, if necessary suspending teachers, endeavoring to

induce parents to send children regularly to school and reporting those who refused or failed to educate their children.
(7) The Act provided for the cessation of all aid to Denominational Schools from 31 December 1882. It was still possible that these schools could become certified as public schools if the required quantity of secular education was given, or their premises could be acquired by the Department of Public Instruction for the creation of public schools.
(8) A system of teacher training commenced.
(9) The first Minister for Public Instruction took office from 1 May, 1880
(NSW Government Gazette, 1997)

By the 1890s after a slow start and during the economic depression, the University of Sydney was offering courses in medicine, law and arts as student enrolments increased in both private-venture schools and at universities. This increase was due to the fact that during difficult times people with formal academic qualifications found work more easily. Unfortunately the depression also led to a reduction in the salary of teachers (Barcan, 1988).

Cunningham (1972) described education in the late 1800s as copper plate writing in exercise books which were carefully saved up for the headmaster to inspect, while arithmetic started with the memorization of tables. According to Cunningham (1972) schools were trying to pack as much information as possible into the empty minds of children, regardless of whether or not the material was meaningful.

Following the depression of the 1890s economic efficiency led to educational efficiency. Inefficient church schools were closed and replaced by additional State-run schools which the government had hoped to manage more effectively.

General literacy had been achieved by 1901 because education was compulsory between the ages six and fourteen. As the six colonies federated in 1901 becoming the States of the Commonwealth of Australia, there was also an expansion in secondary schools and colleges to accommodate the needs of the growing number of independent and wealthier middle classes to educate their children. The importance of education was further influenced by the introduction of public examinations such as the Public Service Examinations, Institute of Bankers' Examinations and Insurance Company Examinations (Devin, 1973).

Musgrave (1988) argued that the sole purpose of a centralized examination system should be to measure educational objectives. He believed that examinations bred inequalities because in the first instance it did not always measure educational objectives and secondly, examinations influenced both the students and the people who administered them.

A Royal Commission into Education commenced in March 1902 prompted by a speech from Professor Francis Anderson in June 1901, at the annual conference of the NSW Teachers Association. Consequently two commissioners, namely Knibbs and Turner were sent to Europe and America to investigate teaching methods and educational systems. In 1903 Peter Board, who later became Director of Education, took six months long service leave and at his own expense traveled to England and the Continent to investigate educational systems, taking every opportunity to speak with teachers and administrators (Crane & Walker, 1957). Following the recommendations made by Peter Board and a detailed report completed in 1905 by Knibbs and Turner, the Report on Primary Education influenced education for the next fifteen years (Wyndham, 1957).

5.2 Curriculum changes

The early school curriculum in New South Wales was limited because candidates in their final year at school were examined only in classics and mathematics which consisted of arithmetic, algebra and Euclid with a theoretical rather than a practical orientation. By 1840 this curriculum was expanded to provide a more sound classical, scientific and religious education to the sons of parents in the demanding middle and higher ranks of society. However the pragmatic demands of the middle class wanted an even broader curriculum in areas such as modern languages, music, bookkeeping, etc (Turney, 1975).

The Reverend Dr John Woolley became the president of the Board of Studies after its establishment in 1856 (Simpson, 1969). Under his direction in 1867 a new curriculum extended elementary education beyond reading, writing, arithmetic and religion, as standards of proficiency were established for each subject. Furthermore homework was officially introduced (Devin, 1973). The Public Instruction Act of 1880 placed the responsibility of elementary education on the whole community to be discharged by a Minister of the Crown.

The secondary schools for the elite had no interest in providing vocational educational for the general population, their curriculum was influenced by the University of Sydney. Students wishing to enter tertiary studies had to complete the Junior and/or Senior Public examinations set by the University. The Knibbs-Turner Report of 1902 criticized the system, claiming that examinations led to "*cramming*" and to a distortion of the curriculum as well as of the method of teaching by focusing on matriculation requirements (Wyndham, 1957). Their Report on Secondary Education released in 1904 stated that the curriculum needed reconstruction because it lacked character building subjects, such as ethics and civics while other subjects were generally handled in a narrow and academic way (Cole, 1927)**.** Despite the introduction of new primary and secondary courses the teaching of mathematics changed little over the years and as a consequence there were no changes in the examination process (Clements, 1975).

According to Clements et al. (1989) between 1855 and 1905 there was a powerful colonialist influence affecting education and teaching in New South Wales for a number of reasons:

- Most of the education administrators and teachers gained their own education and teaching experiences in Britain, thus their attitudes towards school mathematics was greatly influenced by their own (overseas) experiences, which helped to foster "colonialism";

- The majority of the mathematics textbooks used in New South Wales schools were produced and printed in Great Britain (Clements & Ellerton, 1989);
- The colonial aristocracy and wealthy middle class had planned to send their own children (boys in particular) to further their studies in English schools or universities; and
- English professional associations (such as the General Medical Council of Great Britain) indicated that they would not register New South Wales graduates unless the mathematics courses of the colonial universities were in line with the entrance examinations of British universities.

This was also substantiated in the Manuals of Public Examinations of the University of Sydney from 1867 - 1916 and noted by Carslaw, who was appointed its third Professor of Mathematics in 1903 (Crane & Walker, 1957). Apart from the strong "colonial" influence Clements (1978) also suggested at least five issues affecting changes in mathematics curricula:

- It would be unfair to always regard the university academics as being conservative as far as school mathematics curricula was concerned;
- Often school teachers fought to bring about change, but on other occasions changes were also initiated by the university professors;
- Along the lines of the colonial influence it was always a concern that New South Wales qualifications be recognised and accepted overseas (England in particular);
- Educational politics did not always line up with mathematics education. There was a long term on-going debate about the need of Euclidian geometry. It was not until 1902 that the Mathematical Association of Great Britain finally succeeded in persuading all the British universities to accept radically different mathematics courses for their mathematics entrance examinations; and
- The course of study prescribed by the University of Sydney provided the single most powerful influence on how secondary mathematics was taught in New South Wales.

5.3 Examination process

In 1867 the University of Sydney introduced a system of public examinations in New South Wales called the Junior and Senior Public examination (described in more detail in Section 5.3.1.1). Candidates had to pass the Junior Public examination before they were allowed to attempt the Senior Public examination. The 1856 Matriculation examination in mathematics set by the University of Sydney had eight questions on arithmetic and seven questions on basic algebra (Turney, 1975). It was later noted by Carslaw (1914) that these examinations were almost identical to those used by Oxford and Cambridge examiners in their local examination papers. The Public Instruction Act of 1880 marked the formal acceptance by the State of its role to provide secondary education. State high schools were established, the curriculum was not clearly defined as there was no "*tradition*" of previous secondary education. Previously existing superior public schools continued to offer additional lessons in higher branches based on the curriculum for the Junior and Senior University Examinations, however it was admitted by the inspectors in charge that these schools were becoming "*cram*" shops (Crane & Walker, 1957).

Many students attended superior schools and gained matriculation to university even though they had no intention of going to university. In fact they were looking for an opening in the vocational area, thus the schools had become **"***holding centers***"** (Crane & Walker, 1957), meaning that the students would have been better off to attend a school where there was more focus on vocational education.

The Sydney University clearly controlled the curriculum in the schools because the public examinations were written and marked by its professors. According to Goodman (1968**)** even though the New South Wales Senior public examinations were open to every class of the community, by the 1890s its main purpose was to prepare students for university.

5.3.1 Description of examination papers

There were numerous public examinations at the end of secondary schooling, such as Public Service Examinations, Institute of Bankers' Examinations, Insurance Company Examinations as well as the Junior and Senior Public Examinations and the Matriculation Examination set by the University of Sydney. This thesis will specifically focus only on mathematics examinations at the end of secondary schooling.

5.3.1.1 Junior and Senior public examinations

There was criticism that the University of Sydney matriculation examination caused isolation from the community and lack of "*usefulness*", in that the topics chosen and examined had little if any relevance to everyday life. The University, in consultation with schools and industry, began a system of Junior and Senior Public Examinations in 1867 (Barcan, 1988). According to the by-laws of the university these Public examinations "*shall be open to all Candidates male or female who may present themselves*". Subjects offered for the Junior Public examination included English language and literature, history, geography, Latin, Greek, French, arithmetic, algebra, geometry and natural science, while the Senior Public examinations included additional higher mathematics, drawing, music and natural philosophy. Acceptance into university was set by the Rules of Orders of the Senate. Although the Junior and Senior Public examinations were also set by the University of Sydney these papers were quite different from the matriculation examinations (see Section 5.4 for details).

5.3.1.2 Matriculation examinations

Following the establishment of the University of Sydney in 1850, the university matriculation examination provided a new goal for grammar school students studying the classical curriculum which also included mathematics. In each subject the examination was offered at both 'Pass' and 'Honours' level (Barcan, 1988). The early By-Laws of the University in 1881 stated that:

"*The Examination for Matriculation shall be in the following subjects:*

- *The Greek and Latin Languages*

- *English Grammar and Composition*
- *Elementary Chemistry, Physics or Geology*
- *Arithmetic*
- *Algebra to simple equations inclusive*
- *Geometry, first book of Euclid*". (The University of Sydney, 1881, p.156)

There were two sets of examinations set by the University of Sydney, namely the Matriculation and the Matriculation Honours examinations. The Matriculation examination in Mathematics had three separate components each three hours long, a combined total time of nine hours. The three papers were arithmetic, algebra and Euclid (geometry). The three Honours papers were also three hours each in duration, a combined total time of nine hours. The three papers were arithmetic & algebra, geometry & geometrical conics, and trigonometry.

5.4 Results

The Junior Public examinations were similar in format and content to the matriculation examinations and the Senior Public examinations were similar in format and content to the matriculation honours examination. The Junior Public and the Matriculation examinations each consisted of three separate three hour papers in arithmetic, algebra and geometry. While the Senior Public and Matriculation Honours examinations had an additional trigonometry component as the fourth paper. Tables 5.1 and 5.2 describe the content of the topics included in the examination papers.

Table 5.1 Topics examined for Junior Public and Matriculation examinations

Junior Public and Matriculation Examinations		
Arithmetic	**Algebra**	**Geometry**
Calculation	Simplify	Definitions
Mensuration	Factorize	Proofs - Triangles
Simple and Compound Interest	Equations	Proofs – Polygons
Finance	Proofs	Proofs - Circle

Table 5.2 Topics examined for Senior Public and Matriculation Honours examinations

Senior Public and Matriculation Honours Examinations			
Arithmetic	**Algebra**	**Geometry**	**Trigonometry**
Calculation	Simplify	Definitions	Proofs
Mensuration	Factorize	Proofs - Triangles	Logarithms
Simple and Compound Interest	Equations	Proofs – Polygons	Sine & Cosine Rule
Finance	Proofs	Proofs - Circle	3 Dimensional
	Indices	Locus	Compound Angles
	Surds	Parabola / Conics	Power Series
	Logarithms		Graphs
	Binomial Theorem		Other

Note 1. The 1901Junior and Senior Public examinations could not be found instead the closest available 1896 papers were used.
Note 2. Trigonometry was tested only in the Senior Public and Matriculation Honours examinations.

The following figures illustrate the relative percentages for the popular topics examined as well as the instructions used for arithmetic, algebra, geometry and trigonometry during 1881, 1891 and 1901 spanning a 30 year period.

To keep all the figures as neat and simple as possible, no legends were added to the charts. To maintain consistency, the lighter color (blue) represents the Junior or Senior Public examinations and in later chapters the Leaving Certificate or Higher School Certificate, while the darker color (red) represents the Matriculation or Matriculation Honours examinations. The vertical axis always shows percentages (%) while the horizontal axis may be showing years, content or instructions depending on the section.

5.4.1 Higher level - Senior Public and Matriculation Honours

The 1881 and 1891 Senior Public examinations had separate arithmetic and algebra examinations while the corresponding Matriculation Honours examination had a combined arithmetic-algebra paper. By 1991 both sets of examinations had separate arithmetic and algebra examinations. To ensure the correct representation of topics between the two sets of examinations the relative percentages were calculated based on combined arithmetic-algebra papers.

Therefore the percentages for all senior public examinations were halved, thus treating each paper as fifty percent. The 1901 matriculation examination percentages for both examinations were also halved, treating arithmetic and algebra as a combined single examination (see Section 3.4.1.3).

5.4.1.1 Content

5.4.1.1.1 Arithmetic by topics (Figures 5.1 – 5.3)

As demonstrated by the three sets of examinations 10 years apart, all senior public examinations contained questions on calculations, mensurations and finance. Questions based on calculations had increased (Figure 5.1), finance had decreased (Figure 5.3), while questions on mensurations stayed relatively constant (Figure 5.2). When the matriculation paper had a combined arithmetic-algebra examination only one arithmetic topic area was tested, however all three topics were included by 1901 when arithmetic and algebra were divided into separate examinations.

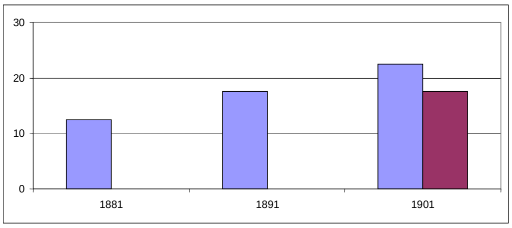


Figure 5.1 Content: Calculation

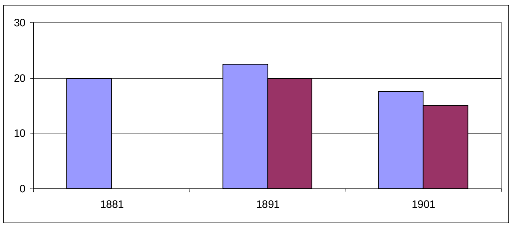


Figure 5.2 Content: Mensuration

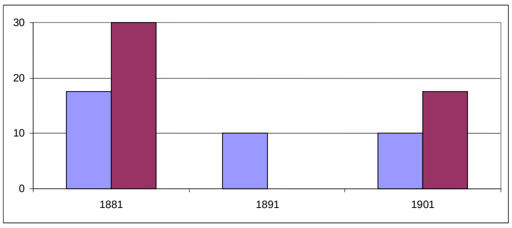


Figure 5.3 Content: Finance

5.4.1.1.2 Arithmetic at ten year intervals (Figures 5.4 – 5.6)

There was little similarity between the two sets of examinations for the 1881 and 1891 examinations, except for the finance section in 1881 (Figure 5.4) and mensuration in 1891 (Figure 5.5). By 1901 both papers were very similar in content (Figure 5.6) because they both had separate examinations for arithmetic and algebra.

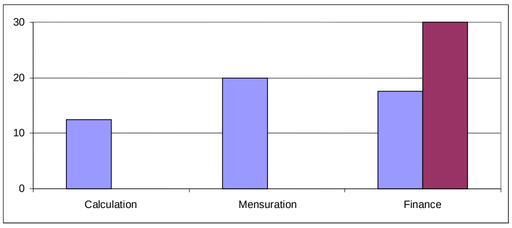


Figure 5.4 Content in 1881

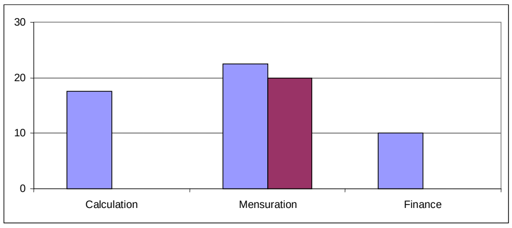


Figure 5.5 Content in 1891

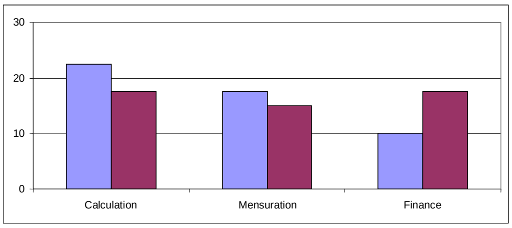


Figure 5.6 Content in 1901

5.4.1.1.3 Algebra by topics (Figures 5.7 – 5.14)

The only topic tested consistently by both examinations was *equations* (Figure 5.8) as this is the only chart that indicates questions for both subjects at regular 10 year intervals. It would appear that there was less change and generally more topics examined in the curriculum of the senior public examinations because topics such as *equations, proof, series and logarithms* appeared in most charts. The Matriculation had fewer topics and apart from *equations*, was examined less frequently.

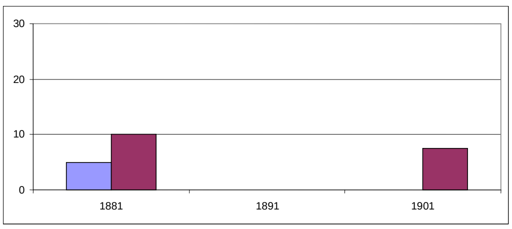


Figure 5.7 Content: Simplify

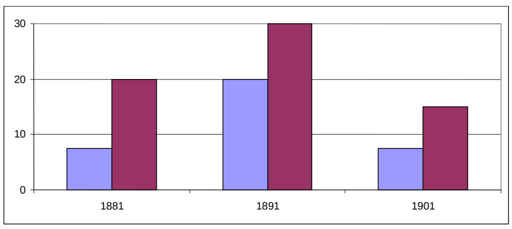


Figure 5.8 Content: Equations

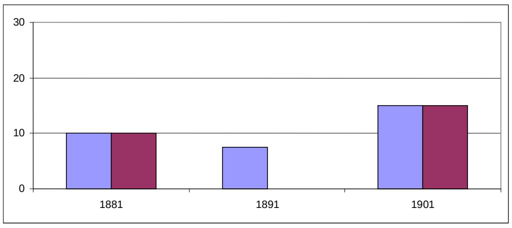


Figure 5.9 Content: Proof

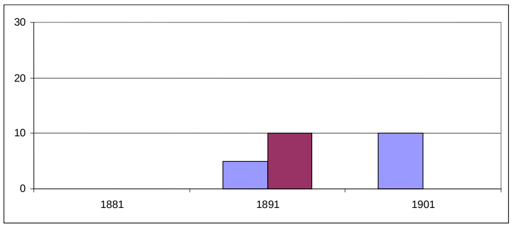


Figure 5.10 Content: Factorize

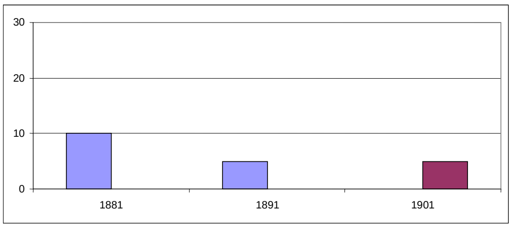


Figure 5.11 Content: Indices & Surds

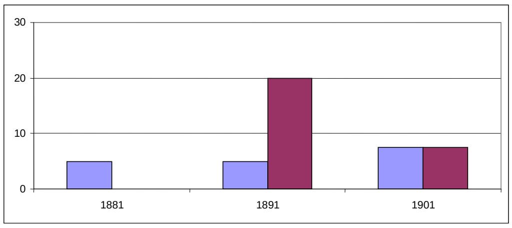


Figure 5.12 Content: Series

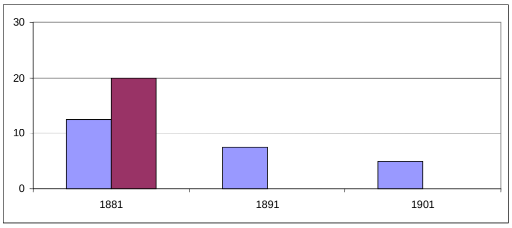


Figure 5.13 Content: Logarithms

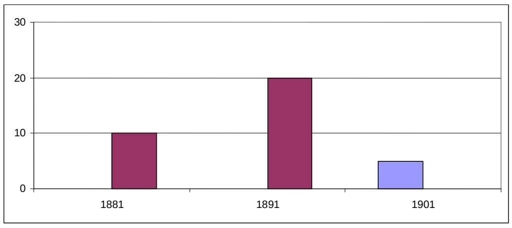


Figure 5.14 Content: Binomial theorem

5.4.1.1.4 Algebra at ten year intervals (Figures 5.15 – 5.17)

The Senior Public examinations covered a broader curriculum because consistently a wider range of topics were tested than in the Matriculation examination. As an example in 1881 the content of *simplify*, *equations*, *proof* and *logarithms* were examined by both papers, whereas *indices/surds* and *series* were only examined in the Senior Public and *binomial theorem* only in the Matriculation examination. There were no questions on *factorization* in either paper.

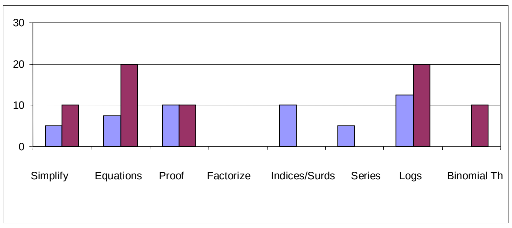


Figure 5.15 Content in 1881

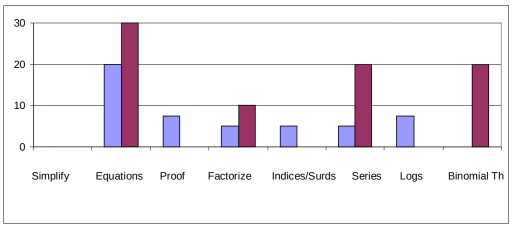


Figure 5.16 Content in 1891

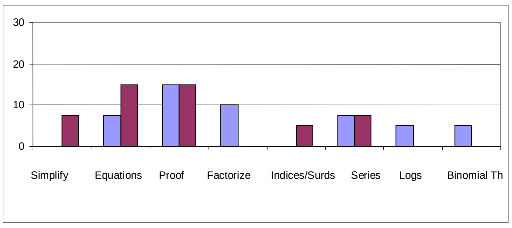


Figure 5.17 Content in 1901

5.4.1.1.5 Geometry by topics (Figures 5.18 – 5.21)

The geometry curriculum was based on few definitions and proofs, much of this material depended on rote learning. The Senior Public examinations consistently tested *proofs* on *triangles, circle, linear* and *polygons* while the Matriculation examination at any one time only examined two out of the three topics. Other topics tested include *locus, parabola* and *conics.* In the early Matriculation examinations questions on parabola and conics played a big part, 50% in 1881 and 30% in 1891 however there were no questions on this topic in the 1901 examination. Linear proofs appeared only in the 1901 examination (10% - Senior Public, 35% - Matriculation) consequently these topics were not included in Figures 5.18 – 5.21. Because of inconsistencies in the testing of these topics *parabola* and *conics* and *linear proof* were also excluded from this set of data.

Figure 5.18 Content: Definitions

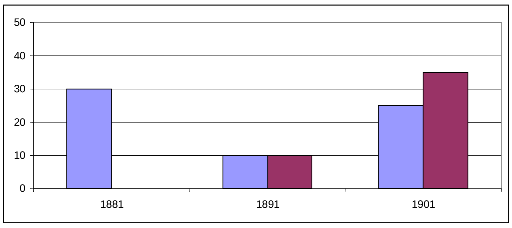


Figure 5.19 Content: Triangle proof

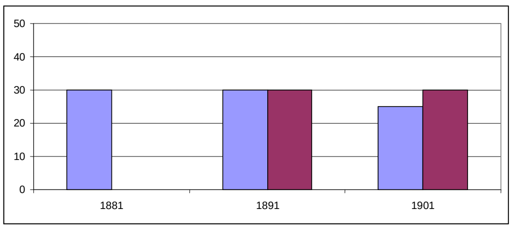


Figure 5.20 Content: of Circle proof

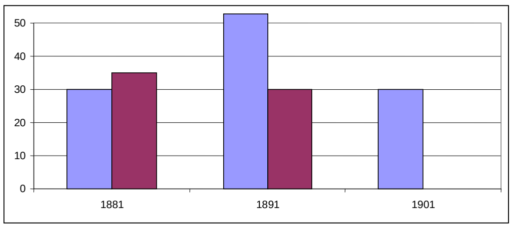


Figure 5.21 Content: Polygon proof

5.4.1.1.6 Geometry at ten year intervals (Figures 5.22 – 5.24)

Figures 5.22 – 5.24 do not represent all the topics in the Matriculation examinations. If one was to add up the percentages in Figure 5.22 the Senior Public examination would total 100%, however the matriculation was only 35%, so what happened to the remaining 65%? In order to maintain consistency only four main topics were shown, namely *definitions, triangle- proof, circle-proof* and *polygon-proof*. The following Matriculation topics were not included, however on closer analysis of the data they did not impact on the overall results:

1881 – locus 15%, parabola & conics 50%

1891 – parabola & conics 30%

1901 – linear-proof (Senior Public – 10%) and (Matriculation – 35%)

Topics that were left out of all the charts to maintain overall consistency will be discussed in the conclusion (Chapter 10).

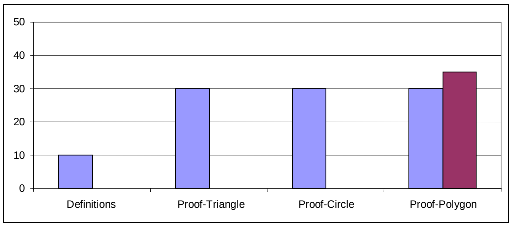


Figure 5.22 Content in 1881

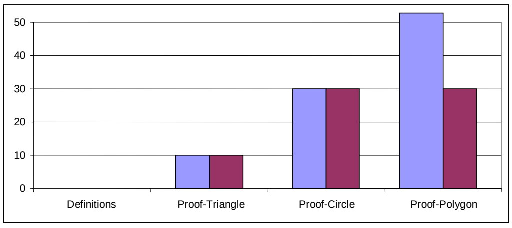


Figure 5.23 Content in 1891

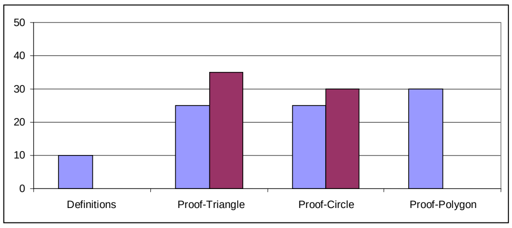


Figure 5.24 Content in 1901

5.4.1.1.7 Trigonometry by topics (Figures 5.25 – 5.27)

Proofs, sine & cosine rule, functions and compound angles represented 75% of the content and were common in both sets of examinations. The remaining 25% of the topics was made up of *logarithms, 3 dimensional trigonometry, graphs* and *de Moivre's theorem*. These topics collectively were not examined consistently, although there were always some questions related to some of the topics and overall they contributed 5-10% of any examination, hence these topics were not included in the figures below. Note the steady growth in the questions on *compound angles* (Figure 5.27).

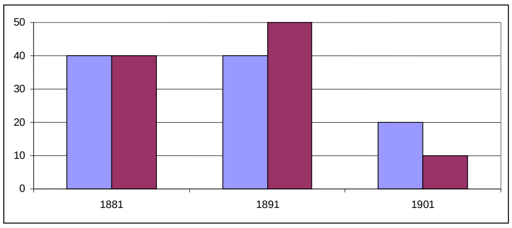


Figure 5.25 Content: Proof

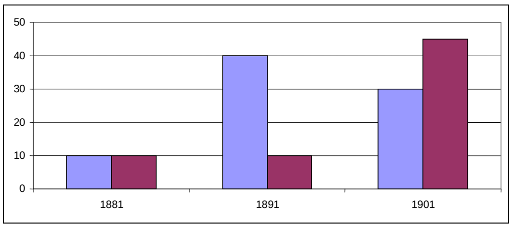


Figure 5.26 Content: Functions and sine & cosine rule

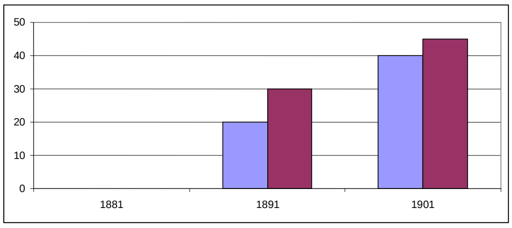


Figure 5.27 Content: Compound angles

5.4.1.1.8 Trigonometry at ten year intervals (Figures 5.28 – 5.30)

As the figures below indicate the two sets of trigonometry examinations had similar content namely, *proof*, *sine & cosine rule* and *compound angles.*

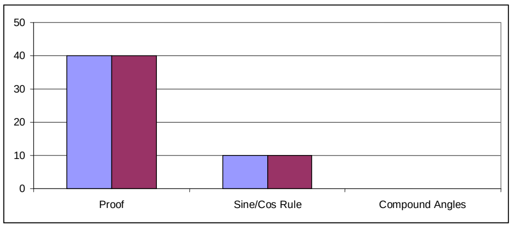


Figure 5.28 Content in 1881

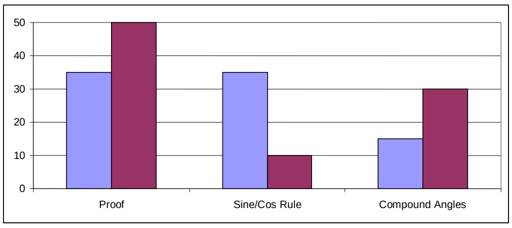


Figure 5.29 Content in 1891

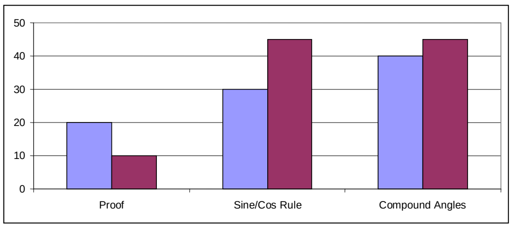


Figure 5.30 Content in 1901

5.4.1.2 Instructions

The instructions described below were used across the range of all the examinations, therefore it was decided to combine and show the results together in one set of figures. *Simplify, what, solve, prove, define, find, how, calculate* and *show* represented 92% of all the instructions, of these *prove* and *find* represented nearly 70% as listed in Figures 5.31 – 5.39. The remaining 8% (not shown) used instructions such as *define, describe, state* and *construct*.

5.4.1.2.1 Higher level (Figures 5.31 – 5.39)

The style of questions appeared to be similar between the two sets of examinations because the relative percentages closely compared with one another. According to Figure 5.34 almost 40% of the questions used the instruction *prove* from the selection list, this would indicate that a significant component of the questions required rote learning.

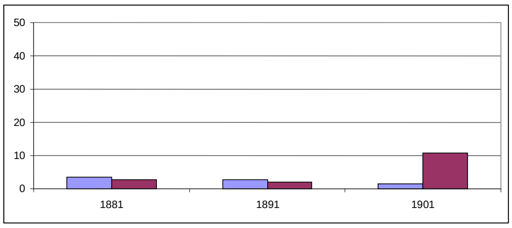


Figure 5.31 Instructions using Simplify

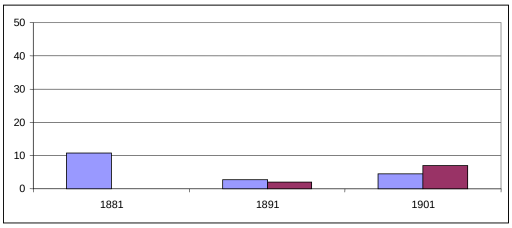


Figure 5.32 Instructions using What is

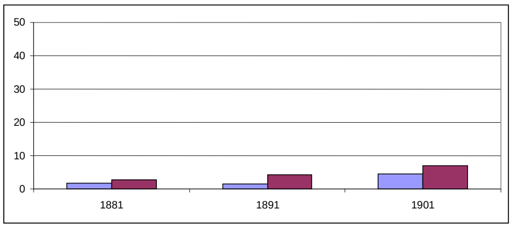


Figure 5.33 Instructions using Solve

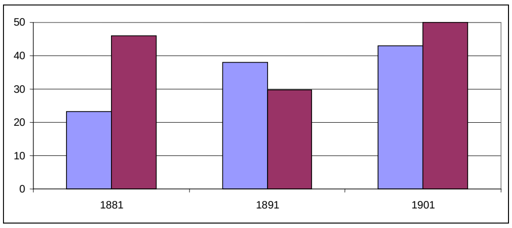


Figure 5.34 Instructions using Prove

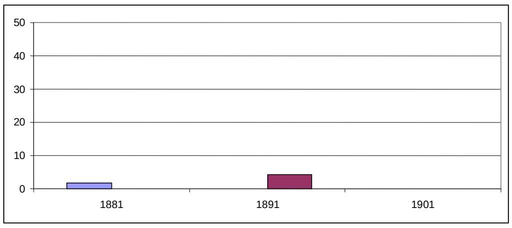


Figure 5.35 Instructions using Define

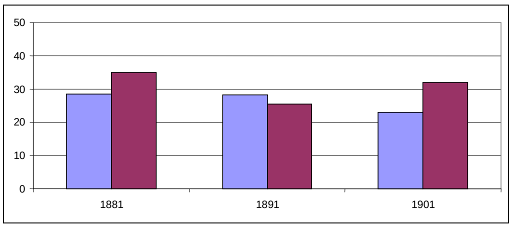


Figure 5.36 Instructions using Find

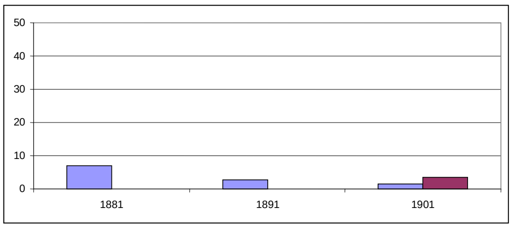


Figure 5.37 Instructions using How

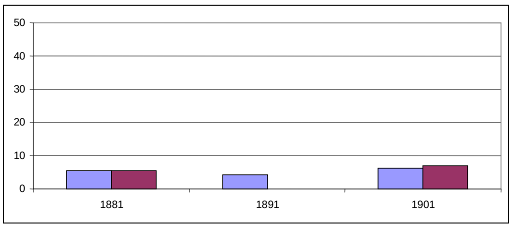


Figure 5.38 Instructions using Calculate

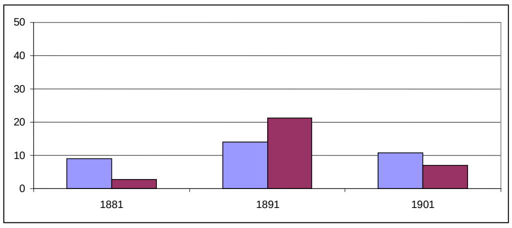


Figure 5.39 Instructions using Show

5.4.1.2.2 Higher level at ten year intervals (Figures 5.40 – 5.42)

The instructions shown in the charts were *simplify*, *what*, *solve*, *prove*, *define*, *find*, *how*, *calculate* and *show*. A snapshot of Figures 5.40 – 5.42 would indicate that not a great deal of change had taken place in the way the instructions were asked, which might imply that there was not a lot of change during 1881 and 1901.

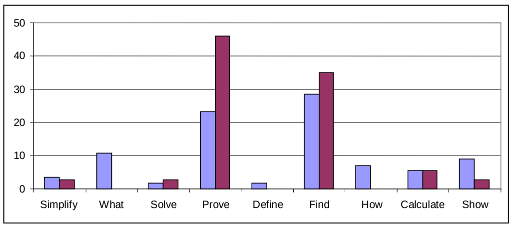


Figure 5.40 Instructions used in 1881

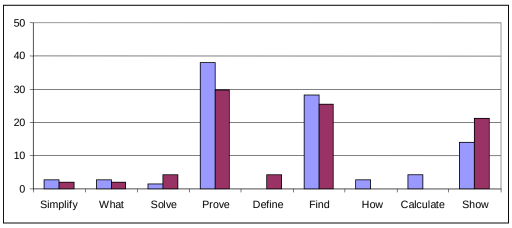


Figure 5.41 Instructions used in 1891

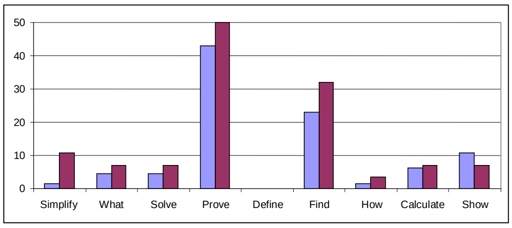


Figure 5.42 Instructions used in 1901

5.4.2 Lower level - Junior Public and Matriculation

This was the entry level matriculation examination and there were three separate 3 hour examinations in arithmetic, algebra and geometry for both subjects.

5.4.2.1 Content

5.4.2.1.1 Arithmetic by topics (Figures 5.43 – 5.45)

The arithmetic examination was in roughly three equal parts, namely: calculation, mensuration and finance (including simple and compound interest). As Figures 5.43 – 5.45 indicate, both the Junior Public and the Matriculation examinations had a similar content and format.

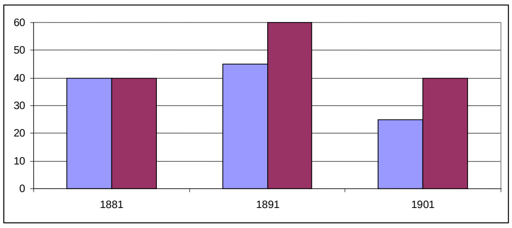


Figure 5.43 Content: Calculation

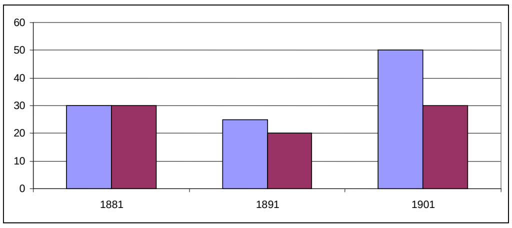


Figure 5.44 Content: Mensuration

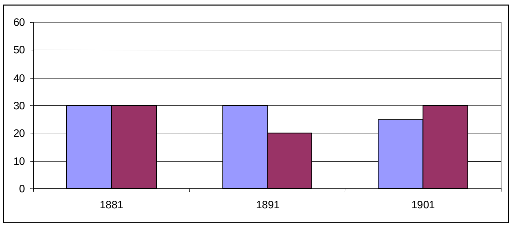


Figure 5.45 Content: Finance

5.4.2.1.2 Arithmetic at ten year intervals (Figures 5.46 – 5.48)

As Figures 5.46 – 5.48 indicate, there was very little change in the calculation, mensuration and finance content of the examinations during this thirty-year period which might indicate that there were little (if any) changes in the curriculum.

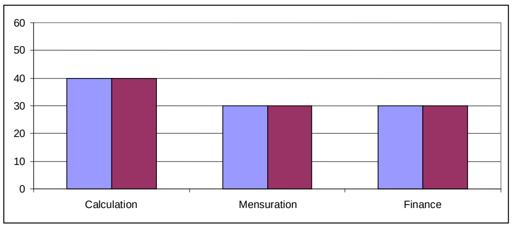


Figure 5.46 Content in 1881

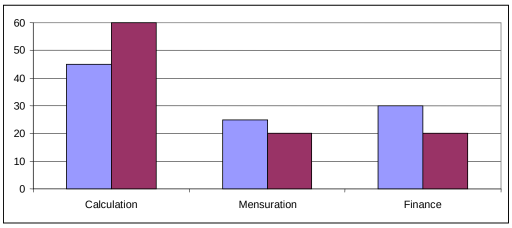


Figure 5.47 Content in 1891

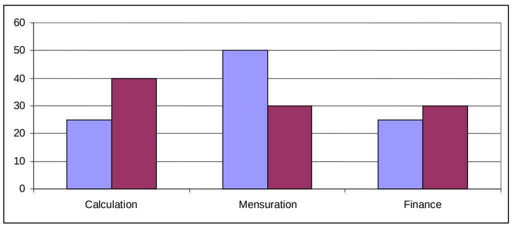


Figure 5.48 Content in 1901

5.4.2.1.3 Algebra by topics (Figures 5.49 – 5.52)

As shown below in Figures 5.49 – 5.52 the main questions in algebra were to simplify and factorize expressions, solve equations and provide proofs. By 1901 there were also questions on series and indices (not shown). Questions on simplifying decreased from 40% to 15% in the Junior Public examinations and from 50% to 10% in the Matriculation examinations. At the same time much of this decrease was taken up by an increase in questions on equations and later with additional questions on indices and series. Both sets of examinations followed the same pattern, indicating that they both had a similar syllabus.

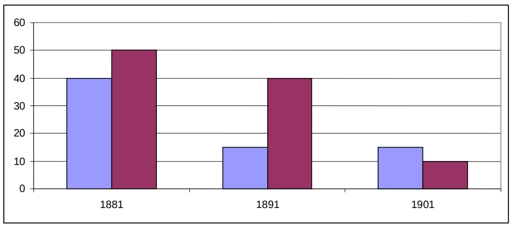


Figure 5.49 Content: Simplify

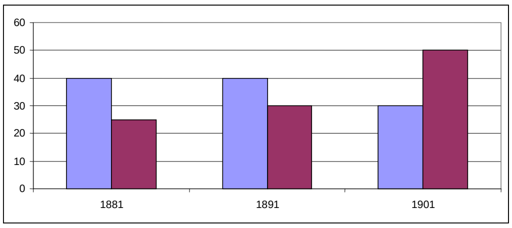


Figure 5.50 Content: Equations

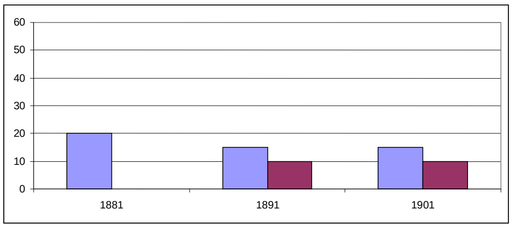


Figure 5.51 Content: Proof

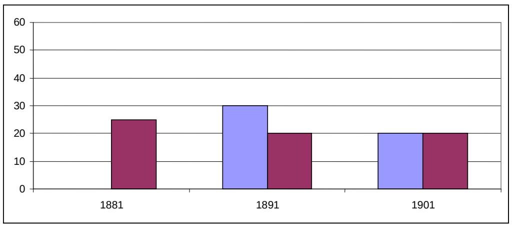


Figure 5.52 Content: Factorize

5.4.2.1.4 Algebra at ten year intervals (Figures 5.53 – 5.55)

Although the examinations continued to test the same four topics, the emphasis had changed significantly from one decade to the next. A possible explanation will be provided in the Section 5.5.

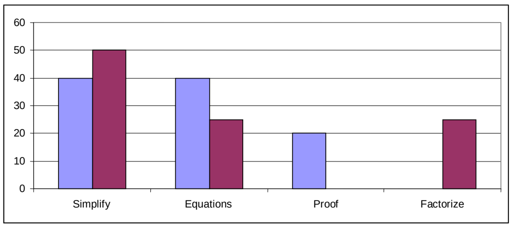


Figure 5.53 Content in 1881

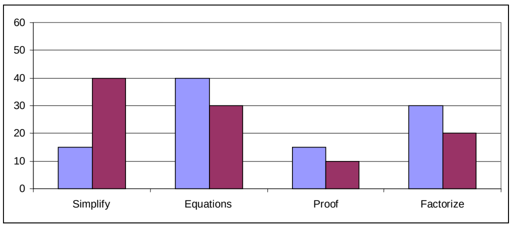


Figure 5.54 Content in 1891

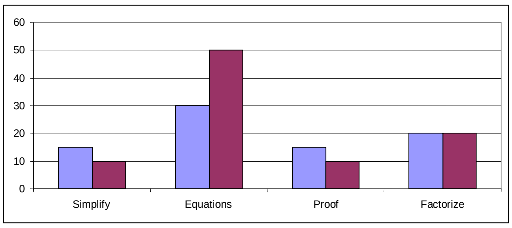


Figure 5.55 Content used 1901

5.4.2.1.5 Geometry by topics (Figures 5.56 – 5.59)

The main topics tested by both sets of examinations were definitions and proofs for triangle, circle and polygon. By 1901 the Junior Public examination had also included a 15% segment on proofs of linear functions (not shown). Almost the entire examination was based on memorizing theorems and proofs which had to be rote learned. Both examinations had a similar format, an indication that they both followed a similar syllabus.

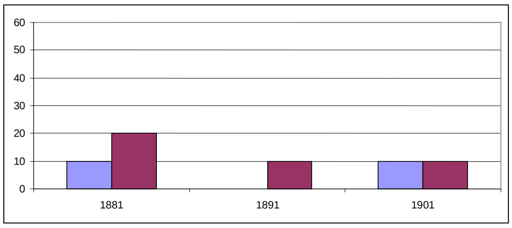


Figure 5.56 Content: Definitions

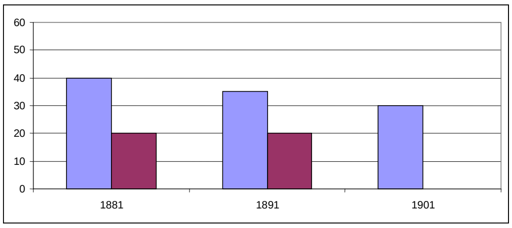


Figure 5.57 Content: Triangle proof

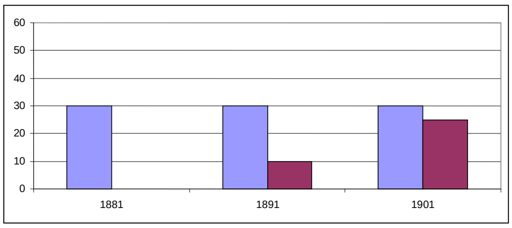


Figure 5.58 Content: Circle proof

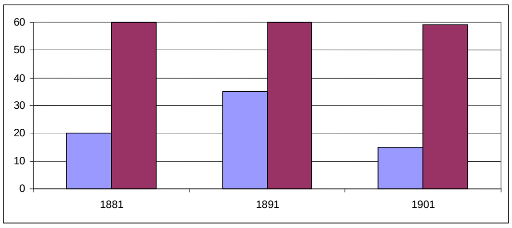


Figure 5.59 Content: Polygon proof

5.4.2.1.6 Geometry at ten year intervals (Figures 5.60 – 5.62)

As indicated by Figures 5.60 – 5.62 there was very little change in the format for both sets of examinations over the three decades, explanation in Section 5.5.

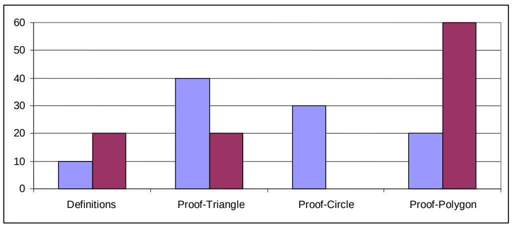


Figure 5.60 Content in 1881

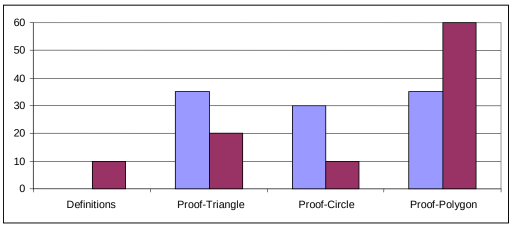


Figure 5.61 Content in 1891

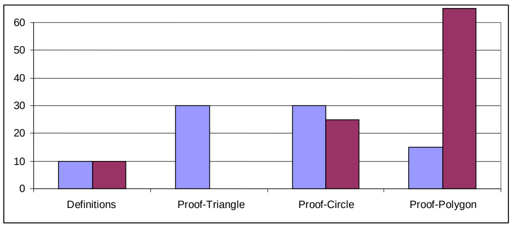


Figure 5.62 Content in 1901

5.4.2.2 Instructions

The instructions described in this section were used across the range of all the examinations, therefore it was decided to combine and show the results together in one set of figures. *Simplify, what, solve, prove, define, find, how* and *calculate* represented 87% of all the instructions, of these *prove* and *find* represented 58% as listed in Figures 8.63 – 8.70. The remaining 13% (not shown) used a combination of the instructions *show, define, describe, state* and *construct.*

5.4.2.2.1 Lower level (Figures 5.63 – 5.70)

The style of questions appeared to be similar between the two sets of examinations because the relative percentages closely compared with one another. According to Figure 5.66 almost 30% of the questions used the instruction *prove* from the selection list. This would indicate that a significant component of the questions required rote learning. The instruction *find* had an overall increase in usage from 10% to 40%.

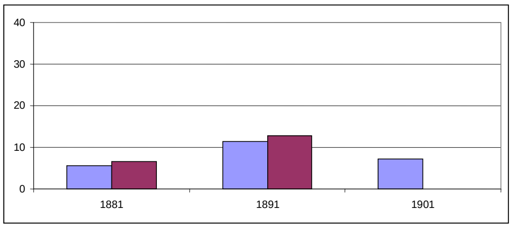


Figure 5.63 Instructions using Simplify

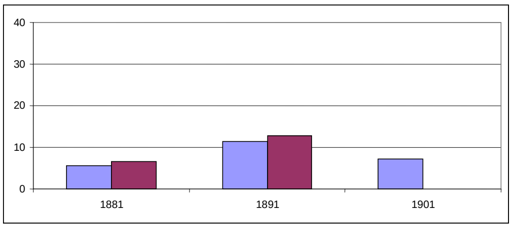


Figure 5.64 Instructions using What

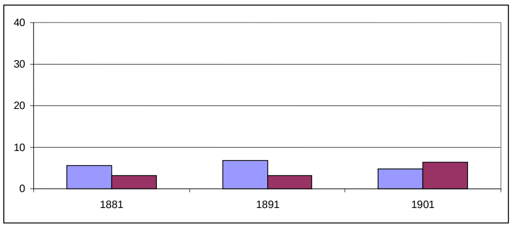


Figure 5.65 Instructions using Solve

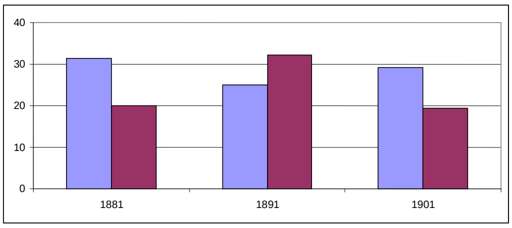


Figure 5.66 Instructions using Prove

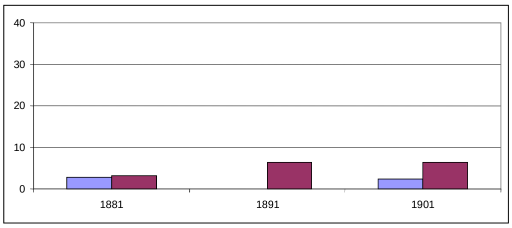


Figure 5.67 Instructions using Define

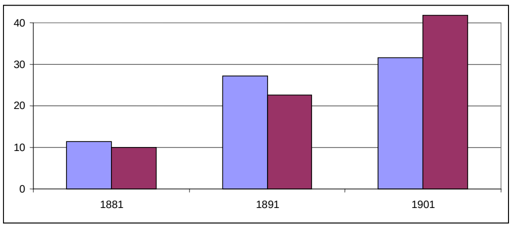


Figure 5.68 Instructions using Find

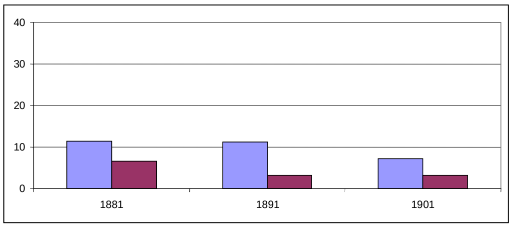


Figure 5.69 Instructions using How

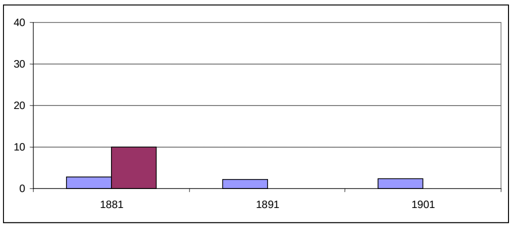


Figure 5.70 Instructions using Calculate

5.4.2.2.2 Lower level ten year intervals (Figures 5.71 – 5.73)

Although the content of the examinations remained fairly constant, as shown in the previous sections on the content at ten year intervals, there were some changes to the instructions *simplify, what, solve, prove, define, find, how* and *calculate.* In particular *what* has decreased, while *find* has increased and the other instructions stayed the same, with explanations provided in Section 5.5.

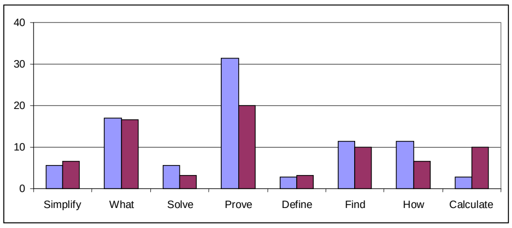


Figure 5.71 Instructions in 1881

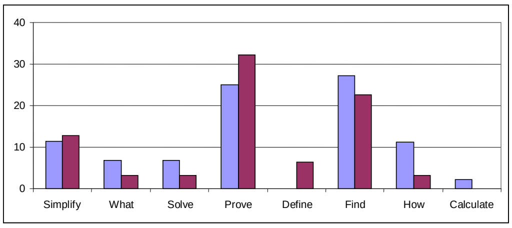


Figure 5.72 Instructions in 1891

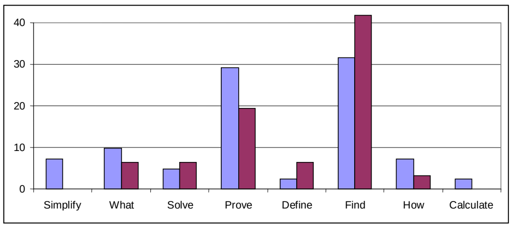


Figure 5.73 Instructions in 1901

5.4.3 Matriculation versus Public examinations

The Public examinations were introduced to reduce the influence of the Matriculation examinations and also because not all the students attempting these examinations wished to go to university. All four examinations had ten questions in each of the papers. By analysing the content of all the examinations, it was decided that not all the questions were of equal value. This conclusion was made on the basis of comparing the questions with one another based on:

- Assessing the time it would take to complete each question
- Difficulty of the topics tested
- Depth of knowledge required to answer the question

In the early examinations there were no indications provided as to how the marks may have been distributed within the examination papers. This would have made it more difficult for the students to decide on how much time to allocate for each question.

All four examinations were set and marked by the University of Sydney. As such there were no clear distinctions between the Junior Public and the Matriculation Pass examinations. However the Matriculation Honours paper contained additional questions on harder topics such as the binomial theorem as well as the parabola and conics, which were not included in the Senior Public examinations. This provided a clear distinction between the two sets of harder examinations.

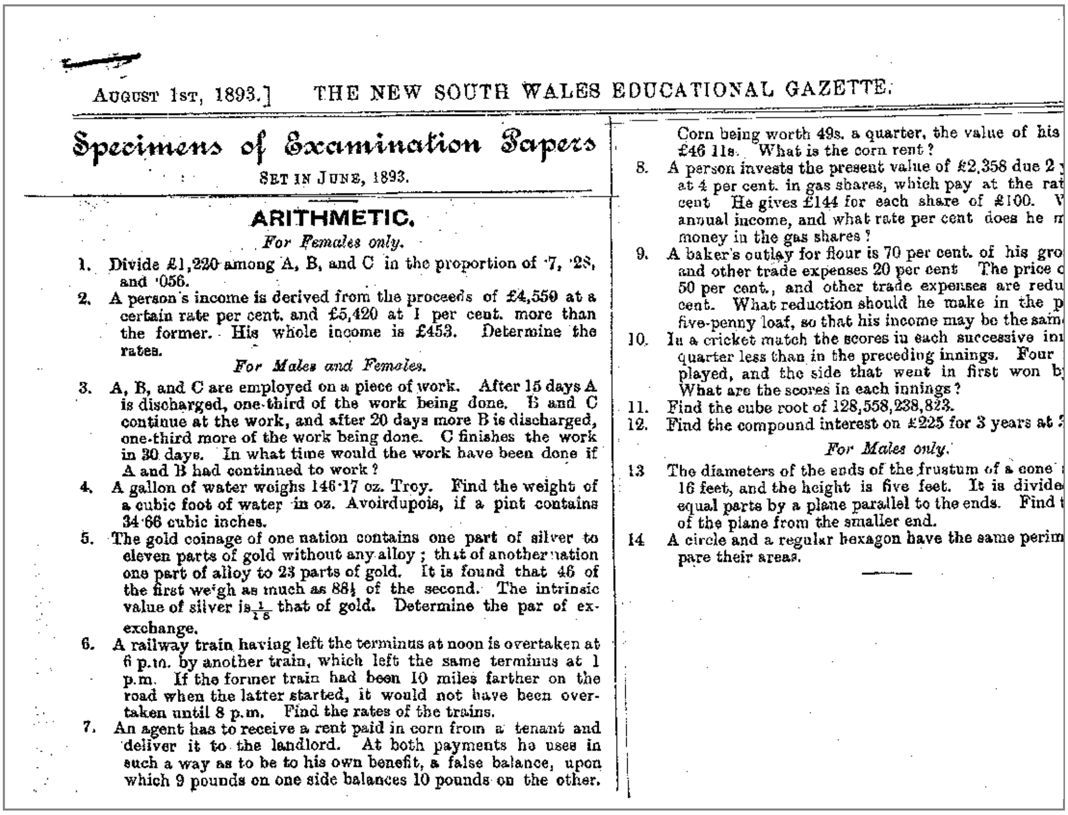
5.5 Review

The framework for denominational and public sectarian education in New South Wales in the twentieth century was established during the period 1850 – 1904. The foundation of the University of Sydney was considered a major catalyst to highlight the importance of education in that all children were given schooling until at least the age of fourteen. The University was also credited with establishing a formal examination system by introducing the Junior and Senior Public examinations. These examinations were also instrumental in the growth of the number of students' matriculations which was necessary for the survival of this institution. Initially there was no formal curriculum, however the Junior and Senior Public examinations as well as the Matriculation examinations set the requirements for entry to university, hence most schools set their curriculum and teaching programs based on these examinations.

The introduction of the Junior and Senior Public examinations to some extent reduced the control of the University of Sydney over the teaching curriculum by allowing school, industry and various stakeholders to influence the teaching curriculum (Section 5.4.3). Many people outside the university and the professions would have seen the University of Sydney as "high brow" and superior and this was probably true. However it should be noted that for the University to maintain its international credibility and standing it had to set standards similar to that of Oxford and Cambridge universities, thereby raising the standard of general education of the State.

The main reason for allowing women to enter the University in 1883 was to boost student numbers. Even though the reasons may not have been altruistic, it was still a giant step forward towards gender equity. Kamperos (2001) investigated the high school performance of girls and boys between 1884 and 1995 and according to her research, in 17 subjects girls' performance was equal to their male counterparts. In a male dominated high school environment, boys performed better in algebra and geometry, possibly due to gender specific questions (Kamperos, 2001).
It is beyond the scope of this study to analyze the social and political aspects of gender issues, which Kamperos (2001) dealt with in detail.

Figure 5.74 Sample examination, June 1893



AUGUST 1ST, 1893.] THE NEW SOUTH WALES EDUCATIONAL GAZETTE.

Specimens of Examination Papers

SET IN JUNE, 1893.

ARITHMETIC.

For Females only.

1. Divide £1,220 among A, B, and C in the proportion of ·7, ·28, and ·056.
2. A person's income is derived from the proceeds of £4,550 at a certain rate per cent. and £5,420 at 1 per cent. more than the former. His whole income is £453. Determine the rates.

For Males and Females.

3. A, B, and C are employed on a piece of work. After 15 days A is discharged, one-third of the work being done. B and C continue at the work, and after 20 days more B is discharged, one-third more of the work being done. C finishes the work in 30 days. In what time would the work have been done if A and B had continued to work?
4. A gallon of water weighs 146·17 oz. Troy. Find the weight of a cubic foot of water in oz. Avoirdupois, if a pint contains 34·66 cubic inches.
5. The gold coinage of one nation contains one part of silver to eleven parts of gold without any alloy; that of another nation one part of alloy to 23 parts of gold. It is found that 46 of the first weigh as much as 88½ of the second. The intrinsic value of silver is $\frac{1}{15}$ that of gold. Determine the par of exchange.
6. A railway train having left the terminus at noon is overtaken at 6 p.m. by another train, which left the same terminus at 1 p.m. If the former train had been 10 miles farther on the road when the latter started, it would not have been overtaken until 8 p.m. Find the rates of the trains.
7. An agent has to receive a rent paid in corn from a tenant and deliver it to the landlord. At both payments he uses in such a way as to be to his own benefit, a false balance, upon which 9 pounds on one side balances 10 pounds on the other. Corn being worth 49s. a quarter, the value of his £46 11s. What is the corn rent?
8. A person invests the present value of £2,358 due 2 y at 4 per cent. in gas shares, which pay at the rat cent. He gives £144 for each share of £100. V annual income, and what rate per cent does he m money in the gas shares?
9. A baker's outlay for flour is 70 per cent. of his gro and other trade expenses 20 per cent. The price c 50 per cent., and other trade expenses are redu cent. What reduction should he make in the p five-penny loaf, so that his income may be the sam
10. In a cricket match the scores in each successive in quarter less than in the preceding innings. Four played, and the side that went in first won b What are the scores in each innings?
11. Find the cube root of 128,558,238,823.
12. Find the compound interest on £225 for 3 years at 3

For Males only.

13. The diameters of the ends of the frustum of a cone 16 feet, and the height is five feet. It is divide equal parts by a plane parallel to the ends. Find t of the plane from the smaller end.
14. A circle and a regular hexagon have the same perim pare their areas.

Looking at a snapshot of the mathematics examinations, one can generally conclude the following:

- Papers were not gender neutral, as there were specific separate questions for both females and males. Figure 5.74 shows a sample examination paper produced in June, 1893 in which Questions 1 & 2 "*for Females only*", Questions 13 & 14 "*for Males only*" and Questions 3 – 12 "*for Males and Females*".
- The examination process was long and tedious. The Junior Public examination in mathematics consisted of three sets of three hour examinations, nine hours in total. The Senior Public examination in mathematics consisted of four sets of three hour examinations, twelve hours in total. The Matriculation examinations were also similarly lengthy.
- There was not a great deal of variety in the type of questions asked and on any one subject only 3 – 4 topics were tested.
- The questions were probably not of equal value, however this information was not provided on the examination papers.
- In order for students to successfully complete the examination, they had to pass all the subjects in one session.

Some of the more specific comments were:

- Between 1881 and 1891 questions on simplifying had decreased, while factorizing had increased (Section 5.4.2.1.4). This might indicate that the examiners were reacting to the demands of schools, parent, industry groups and other stakeholders as they started to exert their influence.
- Geometry stayed the same (Section 5.4.2.1.6) indicating that the university academics continued to maintain a strong control over the curriculum.
- Changes in the instructions (Section 5.4.2.2.2) might indicate changes in social trends and customs as to the way in which questions were phrased.

In all, the examination process was a particularly arduous and a painstaking exercise for both students and teachers.

Godfrey (1987) in his doctoral dissertation concluded that changes to examinations, go hand in hand with both changes to society and the education system. As a consequence this study has explored changes to our society and the effect this may have on the education system at the end of secondary schooling. Furthermore Godfrey (1987) concluded that examination reform is a systematic process over time by linking various events, individuals, organizations and social factors. According to a study carried out by Net Industries (2010, p.1) *"National testing of elementary and secondary students exists in most industrialized countries. Each country's national examinations are based on national curricula and content standards. The difference in weight and consequence of the exams varies tremendously from country to country, as does the use of exams at various levels of education".* The original hypothesis of this thesis was that changes in examinations goes hand in hand with changes in the curriculum, Godfreys (1987) and Net Industries (2010) go some way to support this hypotheis. This study has also analyzed historical, political and social events in relation to their impact on the high stakes examination process. The next chapter will consider the changes that took place between 1904 and 1939 with Peter Board becoming the Director General of Education. Under his leadership a revolution in education took place over the next 15 years.

Chapter 6

CALCULUS, A NEW BEGINNING 1904 - 1939

6.1 Background

By 1904 New South Wales had an established education system from primary through to university. There was a clearly defined path for students wishing to enter university by attempting the Junior and Senior Public examinations and/or the Matriculation examination. Public interest in education became more prominent for a variety of reasons discussed below:

1. *Social changes* were at hand, even though division in classes was less obvious in New South Wales than in England, the upper class students attended Anglican schools with a relatively low pupil-teacher ratio. On the other hand lower class and poorer parents wanted a better deal for their children. These students largely attended either Catholic or public schools for primary education where the pupil-teacher ratio was high.
2. *A declining birthrate* meant that parents had more money available for their children's education.
3. *Disorganized examinations* and the increasing number of subjects such as history and geography reflected social changes which caused confusion amongst schools, pupils and parents.
4. *Reforming education* following the financial crisis of the 1890s.
5. *Overseas trends* influenced the curriculum as well as the method of teaching and the general structure of education (Barcan, 1988).
6. *Politically,* the Federation of Australia took away much of the States' formal powers. However education was retained by the states so they could focus on issues such as simplifying the curriculum, reducing class sizes, reforming the examination system and improving teacher training.

Expanding on the report submitted by the Knibbs-Turner Commission (Section 5.2), a number of major defects were identified in the New South Wales education system (Barcan, 1988), namely:

- Inadequate ideals or aims of the system: The Commissioners made the recommendation for a combination of humanistic aims and mental training to round off the educational objectives because the curriculum lacked subjects such as ethics and civics.
- Treatment of subjects was narrow and bookish, partly due to the limited knowledge of the pupil-teacher. Pupil-teachers were promising 13-16 year old students who were placed under the supervision of experienced teachers, much like an apprentice. At first they observed and assisted the experienced teacher and eventually were placed in charge of teaching a class. This was not a satisfactory method in that the pupil-teachers were only as good as their supervisors. By 1906 the practice of recruiting students as pupil-teachers was abandoned. Instead at about age fifteen Probationary Students were selected by examination, given an allowance from the department to complete a further two years of secondary schooling before they sat the College Entrance Examination. On completion the better students went to Teachers College while the weaker students were appointed as a Junior Assistant to the school (Browne, 1927).

Both school buildings and administration were defective: The Commissioners recommended that the Department of Education be placed under the control of a Director of Education to oversee and manage the administration system.

The Commissioner's report of 1902 also suggested that secondary education lacked organization because no printed curricula existed in both private and State schools. Furthermore, teaching was predominantly aimed at preparing students for various examinations such as the Matriculation examination. Unfortunately this system encouraged "cramming". Peter Board proposed a new balanced curriculum to include English, mathematics, natural knowledge, morals and civics. These subjects were ranked in order of importance with the majority of the time allocated to English and mathematics. Board also proposed that each class should take one year to complete and progression was dependent on adequate academic progress. Students were generally expected to complete the final primary class (fifth class) by the age of 11 or 12 years. In larger schools each class had a separate classroom, instead of being taught in a hall-like environment and dual desks started to replace long benches. Provisions were also made to accommodate students who lived far from school and in isolated areas (Wyndham, 1957).

In 1905 “district schools” were established and manual arts, physical science and agriculture were added to the academic subjects. Peter Board as Director of Education insisted that the university was not necessarily an authority on the highest form of education represented by the secondary school (Barcan, 1988).

The Free Education Act of 1906 abolished fees in primary schools and shortly after secondary school fees were also abolished in State schools. This encouraged students to stay at school longer, placing additional pressures on the cost of education and the need to find suitably qualified teachers to cope with the increased number of students. Peter Board’s concern was that too many young people were moving into clerical or professional education and he recommended that high schools should offer both academic and vocational courses (Barcan, 1988). By 1910 extra high schools were opened and the examination system was overhauled with the establishment of the Qualifying Certificate at the end of primary school, an Intermediate Certificate examination after two years of secondary schooling and a Leaving Certificate two years later replacing the Junior and Senior Public Examinations. Nevertheless the non-state secondary schools continued to operate in much the same way as they did in the nineteenth century, possibly because they continued to use the pupil-teachers. In the long term this had the effect of reducing the quality of education because there was no formal training given to the teachers. Since the Junior and Senior Public Examinations did not offer a broad academic curriculum the University of Sydney agreed to accept the Leaving Certificate (started in 1913) as an alternative to the Matriculation examination, which continued to be administered by the University (Barcan, 1988). In the early stages students attending State schools sat for the Leaving Certificate, while others attending private schools tended to sit for the

Matriculation examination. As student numbers grew, more students attended State schools and many more private schools started to teach the State curriculum. Consequently the Leaving Certificate numbers continued to grow at the expense of the Matriculation examination. Eventually the Matriculation examination was only attempted by mature age students who were not at school and those who failed the Leaving Certificate.

Following Australia's entry into World War I a significant number of male teachers enlisted, thus women took over teaching the senior classes previously taught by male teachers. Later, during the course of the war, the Commonwealth government became temporarily involved in teacher education when the Department of Repatriation arranged vocational training for soldiers who were no longer able to continue their previous occupation. A scheme also provided teacher training at universities and technical colleges (Barcan, 1988).

At the start of the twentieth century, the University of Sydney had less than 1000 students with about half the students taking Arts courses and a quarter of the students studying Medicine. It was a very formal environment in which students were required to wear an academic gown. A large bequest in 1919 from Sir Samuel McCaughey, who was a pastoralist, philanthropist and highly successful sheep breeder, enabled considerable expansion in the number of faculties by the appointment of new Professors and Associate Professors in Arts, Engineering, Agriculture, Veterinary Science, Economics, Architecture, Dentistry and Medicine (Wyndham, 1957).

In New South Wales by the 1920s students could matriculate to university or teachers college via the newly created Leaving Certificate, as well as through advanced courses offered by technical colleges. Immediately following the war university enrolments increased disproportionately because of students who earlier had deferred their studies. This high enrolment was later corrected as university enrolments dropped (with the exception of Science) and there was a further fall in student numbers due to increased student fees. A lack of funding during the 1929 Depression severely restricted the number of trainee teachers (Wyndham, 1957). Student enrolments also decreased due to a general fall in the birthrate. On the other hand the Depression encouraged an increased interest in technical education and vocational training thereby helping employment figures because better educated people were able to find work more easily.

After the Depression, as high schools and superior public schools (these were an extension to primary schools with a two year “top up” for students wishing to enter the workforce) continued to increase in numbers. There was a serious concern amongst teachers about the influence and interference of the University in high school education (Price, 1959).

In 1933 a committee was set up to address the problems associated with secondary education and in 1936 the Board of Secondary School Studies was established. In addition to the university representation, this new Board's membership also included teaching groups from schools and technical education as well as representatives from industry, commerce, women's organizations and the Federation of Parents and Citizens Associations (Wyndham, 1957).

In order to reduce the University’s academic influence, the Board of Secondary School Studies was established in 1936. This replaced the original Board of Examiners earlier set up by the universities in 1912. The amendments to university legislation and the State Education Act became necessary to ensure that the States and teachers would have a say in the secondary school curriculum.

The Board consisted of:
(a) Five members nominated by the Senate of the University of Sydney;
(b) Five officers of the Department of Public Instruction including the Director of Education, the Chief Inspector of Schools, and the Superintendent of Technical Education;
(c) A principal teacher of a secondary school (other than Roman Catholic) registered under the Bursary Act, 1912;

(d) A person to represent Roman Catholic Schools registered under the Bursary Act, 1912; and
(e) One headmaster and one headmistress of State Secondary Schools.

The functions of the Board were to:
(a) make recommendations to the Minister in matters relating to the Leaving Certificate and Higher Leaving Certificate which was starting in 1913;
(b) make arrangements for the conduct of the Leaving Certificate and Higher Leaving Certificate Examinations which served as the new Matriculation to gain entry to university (Wyndham, 1957);
(c) determine curricula for secondary schools; and
(d) appoint Committees for each subject of the school curriculum for the purpose of recommending content (NSW Government Gazette, 1997).

By the late 1930s there was also a significant change in public attitudes towards general acceptance of secondary education. However the low birthrate resulting from the Depression led to the Child Welfare Act of 1939 which lowered the compulsory age for starting school from 7 to 6 years of age, possibly to fill up empty school seats in order to maintain student numbers (Barcan, 1988). Lowering the school starting age for students also allowed more women to enter (or re-enter) the work force. By 1939 war had already started in Europe and the likelihood of Australia entering the war became imminent. This meant that a significant portion of the male workforce would join the war effort. Lowering the school age allowed more women to replace these men in the work place.

Following the Depression and improved economic conditions, educational reforms became feasible (Barcan, 1988). The Youth Welfare Act of 1940 raised the number of years of study for the Intermediate Certificate from two years to a three year program. This change was prompted by the belief that a higher school leaving age would lessen unemployment after the war. Keeping the students in school for an extra year would reduce the supply of labour. The Minister further argued that based on studies conducted by social demographers an extra year in school might increase vocational preparedness.

6.1.1 Changing society

Social demographers like the Australian Bureau of Statistics (2010b) and McCrindle (2010) have been studying the characteristics of the human population to identify changing patterns of social behavior, attitudes to life style, food as well as education.

6.1.1.1 Oldest generation

This generation was born before 1926, as young adults many experienced interrupted employment and family formation during the Great Depression. Many of the men served in the armed forces during World War II. Members of the Oldest Generation (Section 2.2) had limited formal educational opportunities. According to reports 39% left school at Year 8 or below or never attended school. (McCrindle & Wolfinger, 2009)

6.1.1.2 Lucky generation/Builders

Born between 1926 and 1946, just prior to and during the Great Depression and World War II, they are referred to as the Lucky Generation because they generally perceived that they had an easier time than their parents. They did not live through World War I or have to make ends meet during the Depression, and as young adults they experienced full employment and prosperity during the post-World War II economic boom. This generation has also been referred to as the Austerity Generation; affected by the hardships resulting from the Great Depression in their formative years, they are often regarded as a hardworking and stoic generation who seek stability and security. The Lucky Generation was a relatively small group compared to successive generations, partly due to low birth rates during the Depression and World War II and recent deaths. This cohort also experienced higher rates of infectious diseases (such as polio, diphtheria and rubella), cancer and heart disease during their lifetime than subsequent generations (McCrindle & Wolfinger, 2009).

Having reviewed the historical, social and demographic developments since the beginning of the 20th century, this study will now look at curriculum developments for the same period.

6.2 Curriculum changes

In 1909 Peter Board declared that in secondary schools he expected thoroughness, not a mastery of comprehensive detail while placing focus on English, history, mathematics and science. The syllabus provided for a four-year program of four courses including a general course leading to matriculation as well as commercial, technical and domestic courses. The first syllabus for high schools “Courses of Study for High Schools” was issued in 1911 by the lecturers of Sydney Teachers’ College (Barcan, 1988). Peter Board expected high schools to assist students to acquire knowledge, skills, and conduct that should form the foundation of their private and public responsibilities of adult age.

The main implications of the 1911 reform were that all courses of study up to university became the responsibility of the Department of Education. The Department established three types of vocational secondary schools as well as additional high schools. A significant effect of this new syllabus was the forced integration of the various branches of mathematics within one or two sets of examination papers (Carslaw, 1914). A higher level Mathematics Honours subject incorporating a new field of mathematics called calculus was also offered. Around 1700, Newton and Leibniz were formally credited with recognizing calculus as a new separate field of mathematics (Dunham, 2004). However it took almost two hundred years before calculus questions started to appear in the Oxford and Cambridge scholarship papers and another 30 years, before they started to appear in New South Wales examinations. The questions were basic differential and integral calculus, predominantly based on manipulation of terms with little emphasis on the geometrical or physical significance of calculus (Grimison, 1990). The examination process will all be discussed in Section 6.3.

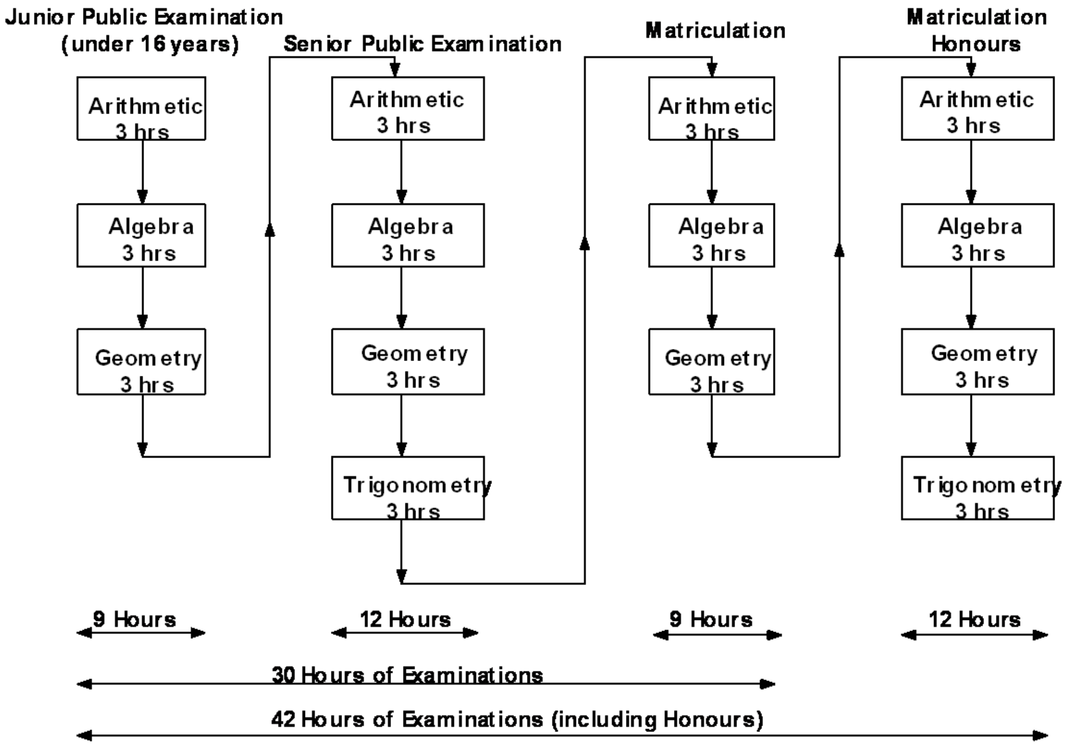
Following the British trends reflected in the Cambridge and Oxford local examinations, calculus appeared in the first 1913 Leaving Certificate examinations and continued thereafter. After the 1911 reorganization, the differentiation and integration of trigonometrical expressions were added to the Honours calculus course in 1927 (NSW Department of Education, 1927). No other significant changes occurred in the mathematics curriculum and examination process until after World War II; this will be discussed in the following Chapter 7.

Greater equity in educational opportunities allowed access to higher education with the establishment of State run post-primary (vocational/trade courses) and high schools (academic courses). History, literature and science were introduced according to a liberal-humanist curriculum based on Neo-Herbartian theory. The Herbartians were keen to promote the moral, character-building quality of education and make it the central focus of education. Herbart was a German philosopher and educational theorist (Keeves, 1987). His theory of five formal steps of teaching was widely known and applied. According to Herbart the formation of the mind was achieved from within, and the ideal model of education was built-up from a wide "*circle of knowledge*", based on moral development (Barcan, 1988).

6.3 Examination Process

By 1900 the Junior and Senior Public examinations were held each year (Section 5.3). Alternatively, students who did not attempt either the Junior or Senior Public examinations were accepted into university by obtaining a satisfactory pass in the relevant subjects at the Matriculation examination (Table 6.1) set by the University of Sydney (Turney, 1975). A student had to complete the Junior and Senior Public Examinations (21 hours) as well as the Matriculation examination (minimum 9 hours plus an additional 12 hours for Honours). Thus a student had to sit for a staggering 30 to 42 hours of examination (Table 6.1) – this was just for Mathematics.

Table 6.1 Prior to 1913 - Pathway to university before the Leaving Certificate

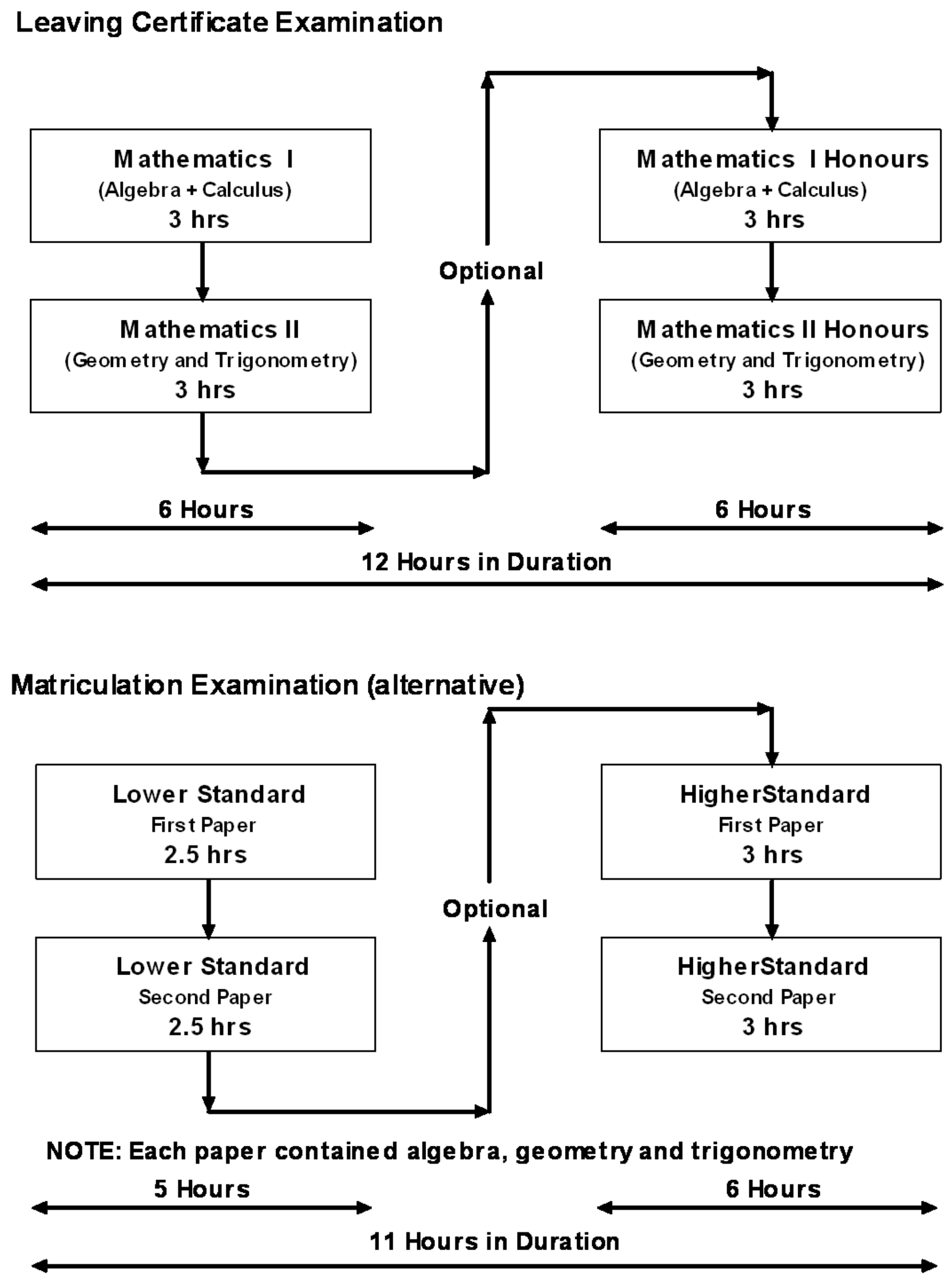


As most students had to attempt at least five to six subjects, this would indicate that an average student probably had 150 hours of examinations compared with 15 – 20 hours in 2010. Furthermore all subjects had to be attempted and passed in one examination session. In 1909 Peter Board traveled abroad to the United States and following his return he published a detailed report. His findings resulted in the University Amendment Act of 1912 (Board, 1909, as cited in Barcan 1988, p.186). This led to the creation of the Leaving Certificate as an alternative to the Matriculation examination. The syllabus of the newly established Leaving Certificate completely revised the subject allocations for mathematics by combining the previous four individual subjects, namely Arithmetic, Algebra, Geometry and Trigonometry into just two new subjects, namely Mathematics I and Mathematics II, thereby also halving the examination time. This also meant that students were accepted into University by passing Mathematics I and II in two sets of three hour examinations (Table 6.2). Some students chose to extend their mathematical knowledge by also taking the Honours course which added a further six hours of examinations.

By 1910 the Junior Public examinations had added mental arithmetic and a commerce component while the Senior Public examination added an extra paper on geometry and conics. At the same time the Matriculation examination was streamlined into Lower Mathematics 1 & 2 with each paper two and half hours long and Higher Mathematics 1 & 2 with each paper three hours long. The time taken for the university entrance examination was further reduced with the introduction of the Leaving Certificate in 1913, it was now sufficient for students to obtain a pass in Mathematics I & II, thus the time was reduced from 30 hours to just six hours. Clearly the content could not be examined in the same detail as before but nevertheless the examinations still retained rigor and variety.

The reform of the University of Sydney was prompted by a growing desire for a closer relationship to exist between the secondary schools and the University because many more students were considering advanced studies. The University Amendment Act of 1912 allowed a pass in appropriate subjects at the new Leaving Certificate to be recognized as qualifying for matriculation. The University soon abandoned the Junior and Senior Public Examinations, thereafter sharing the responsibilities for academic secondary courses between the Department of Public Instruction and the University of Sydney (Barcan, 1988). Students in high schools were now able to sit for the Intermediate Certificate and this became the only examination pupils completed after three years of secondary schooling. Students with higher aspirations completed the Leaving Certificate (Grimison, 1990).

Table 6.2 From 1913 - Pathway to university after the Leaving Certificate



6.4 Description of Examination Papers

The list of examinations are shown in Table 6.3 with Public and Leaving Certificate examinations using the darker colour (black) and Matriculation examinations in the lighter colour (red).

Table 6.3 List of courses from 1901 - 1942

Year	Course	with Calculus	Higher	Lower
1901	Public Matriculation		Senior Honours	Junior Pass
1911	Public Matriculation		Senior Higher Standard	Junior Lower Standard
1922	Leaving Matriculation	Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass Higher Standard	Mathematics Lower Standard
1932	Leaving Matriculation	Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass Higher Standard	Mathematics Lower Standard
1942	Leaving Matriculation	Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass Higher Standard	Mathematics Lower Standard

Until the introduction of the Leaving Certificate in 1913 there was little change in the style, format and content of the mathematics examinations at the end of secondary schooling.

6.4.1 Junior Public

The Junior Public examination was attempted by students less than sixteen years of age and contained three separate mathematics examinations in arithmetic, algebra and geometry (see Table 6.1). These examinations were administered by the University of Sydney (see Section 5.3.1.1). To matriculate each student had to pass all three separate examinations in the same examination session and this allowed them into a limited number of university courses. The only obvious change that occurred after 1900 was the reduction in time from three hours to two and a half hours for each paper and the addition of mental arithmetic.

6.4.2 Senior Public

The subjects for the Senior Public examinations in mathematics included the three Junior Public examination examinations (unless holding certificates of having passed the Junior examinations) as well as further arithmetic, algebra, logarithms, analytical geometry, trigonometry and conics sections (Table 6.1). These examinations of secondary schooling were also administered by the University of Sydney. To matriculate each student had to have already passed all three separate mathematics papers of the Junior Public examinations and, depending on the university course they chose to study, they were also required to pass the mathematics Senior examination papers. For example, students wanting to study engineering had to pass all four Senior mathematics examinations.

After 1900 the Senior Public examinations were also reduced in length from three hours to two and a half hours for each paper and following the appointment of Horatio Carslaw changes appeared in the examination process along the lines of the Oxford and Cambridge Examinations (Crane & Walker, 1957). By 1910 additional papers were introduced to accommodate commerce students, while a conics section was added to the Senior Public examinations. All these examinations were replaced by the Leaving Certificate in 1913.

6.4.3 Leaving Certificate

Following the 1912 University Amendment Act which was partly set up to reduce the influence of the University of Sydney on the curriculum (Barcan 1988), the Leaving Certificate was created as an alternative to the Matriculation examination. In its first year 156 candidates presented themselves for the examination and eighty percent obtained a Certificate (Barcan, 1988). Initially there were four separate mathematics examination papers see Section 6.3 and Table 6.2

By 1922 an additional (lower end) mathematics paper was added to cater for the students who had not planned to go to university but still wanted to study some mathematics. Calculus questions were first introduced in the Leaving Certificate Honours papers in 1913; however it took almost another thirty years to 1950 before calculus questions first appeared in the University of Sydney Matriculation examinations.

6.4.4 Matriculation

The Matriculation examinations also changed in 1911. The existing separate papers for each subject with a total duration of nine hours (see Section 5.3.1.2) were replaced by the Lower Standard Papers 1 and 2 with duration of two and a half hours each (five hours in total). The Matriculation Honours papers were also replaced by the corresponding Higher Standard papers 1 and 2 and the duration of each was reduced to three hours each (six hours in total). The duration of the lower standard papers was clearly stated on the paper but there was no such statement on the higher standard paper. Therefore it was assumed that the higher standard papers had the same duration or possibly an additional half hour, making it three hours in total.

Extract from the University of Sydney By-Laws (The University of Sydney, 1911, p.105).

> *1. In all subjects, except Science and Mechanics, there shall be a higher and lower standard.*
> *2. A pass at a lower standard shall be deemed sufficient, except in the cases where the provisions for admission …. state that the higher standard is required.*
> *3. The lower standard (matriculation) in each subject corresponds to the pass standard of the Junior Public examination and the higher standard (matriculation) to that of the Senior Public examination.*
> *4. Candidates must pass in all the subjects of the examination at one and the same examination.*
>
> *Details of mathematics subjects*
>
> *Lower standard - The examination will consist of two papers comprising questions in arithmetic, algebra and geometry.*
> *Higher standard - The papers in mathematics will be papers in algebra, geometry, trigonometry, mechanics or conic sections.*

As with the Junior and Senior Public examinations, the Matriculation examination became less important as the Leaving Certificate became better established.

6.5 Results

The new Leaving Certificate introduced major changes to the examination process (see Section 6.4.3). Instead of having two courses, namely Junior and Senior Public examinations, there were three courses available, the Honours, Pass and just Mathematics. Throughout this period the University of Sydney Matriculation continued to offer two courses, renamed as the Higher Standard (previously Honours) and the Lower Standard (previously Pass). To compare courses similar to one another the examinations were split into three groups namely, highest level with calculus and the two non-calculus courses the higher and lower standard. The Matriculation examinations were matched to the corresponding Leaving Certificate or Public examinations based on details printed in the University of Sydney By-Laws (see Section 6.4.4).

The courses were separated into three groups as shown in Table 6.3 below:

- Leaving Certificate Mathematics I & II Honours with calculus for 1922, 1932 and 1942, for completeness also included the 1916 (first available) examination;
- Senior Public examinations or Leaving Certificate Mathematics I & II (after 1916) and Matriculation Higher Standard (from 1911) or Matriculation Honours (for 1901) as specified in the University of Sydney By-Laws 1911 (see Section 6.4.4); and
- Junior Public examinations or Leaving Certificate Mathematics (after 1916) and Matriculation Lower Standard (from 1911) and Matriculation Pass (for 1901) as specified in the University of Sydney By-Laws 1911 (see Section 6.4.4).

This chapter covers the period from 1904 to 1939. In order to provide a more detailed comparison the 1901 and 1942 examinations were also included (Table 6.3).

To directly compare two or more sets of different examinations, all the examinations were treated as if they were a single two and half or three hour examination. This needed to be done to accommodate papers, such as the 1901 Junior Public examination with 3 separate 3 hour papers in arithmetic, algebra and geometry. This was compared with the 1932 Mathematics examination being a single 2.5 hour paper covering algebra, geometry and trigonometry.

Both the Leaving Certificate and Matriculation examinations within each group were analyzed longitudinally over time as well as compared with each other during the same period according to:

- Topics examined as a relative percentage
- Commonly used instructions as a relative percentage

Data were arranged in such a way that it was also possible to make certain comparisons between two different sets of standard of examinations by comparing the Senior Public examination with the Junior Public examination.
In Figures 6.1 – 6.59 the Leaving Certificate, Senior Public and Junior Public examinations are shown using the lighter colour (blue), while the Matriculation examinations are in the darker colour (red).

6.5.1 Leaving Certificate Honours (with calculus)

The Leaving Certificate, Mathematics I and II Honours papers were the most academically challenging examinations available at the end of secondary schooling and for the first time they also included calculus (see Section 6.2). The Matriculation papers were not included in this section because calculus was not examined in this course until 1946. To provide as much detail as possible, this section also included the 1916 (earliest available) Leaving Certificate examination.

6.5.1.1 Content (Figures 6.1 – 6.10)

There was little change in the style and content of the Honours examination papers until the mid 1940s, indicated by the similar size column graphs from one decade to the next. Algebra, geometry, trigonometry and calculus accounted for 85 – 90 percent of the content, while the rest of the papers were divided between questions on series, logarithms, probability and the Binomial theorem. It would appear that questions on series replaced the Binomial theorem (Figures 6.2 and 6.6). There was little variation in the mix of topics examined.

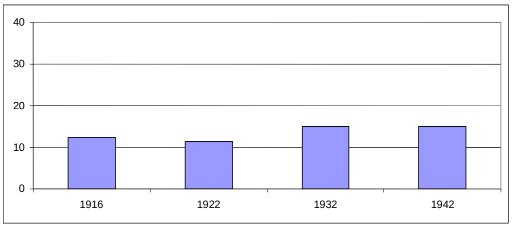


Figure 6.1 Content: Harder algebra

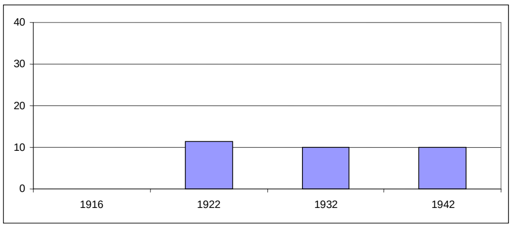


Figure 6.2 Content: Series

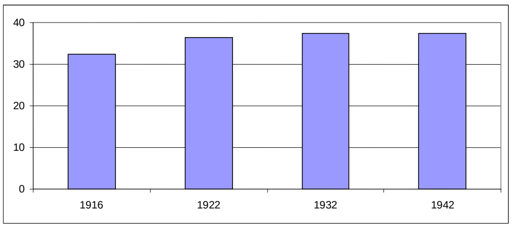


Figure 6.3 Content: Geometry

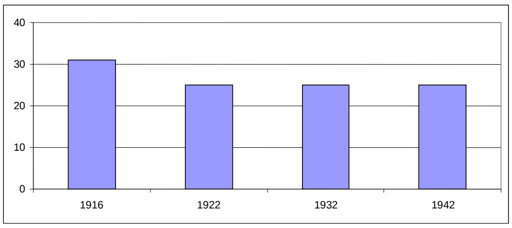


Figure 6.4 Content: Trigonometry

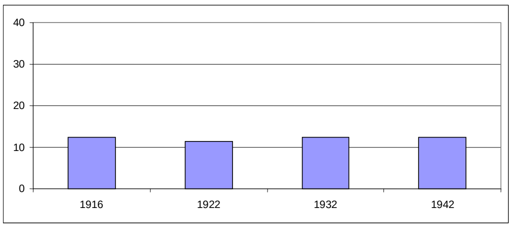


Figure 6.5 Content: Calculus

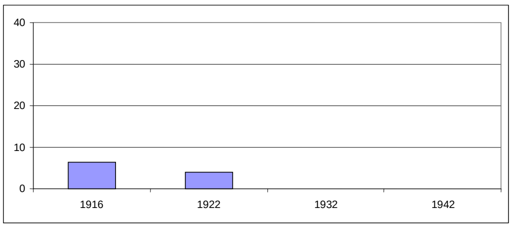


Figure 6.6 Content: Binomial theorem

The Figures 6.7 – 6.10 lists the topics at ten year intervals showing that during this period geometry and trigonometry clearly dominated the examinations, consistently taking up 62% of the content.

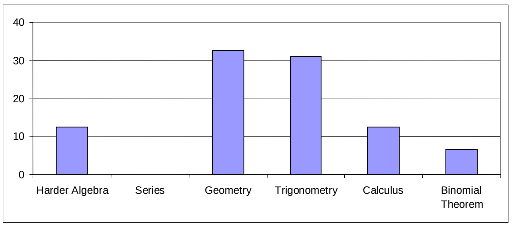


Figure 6.7 Content in 1916

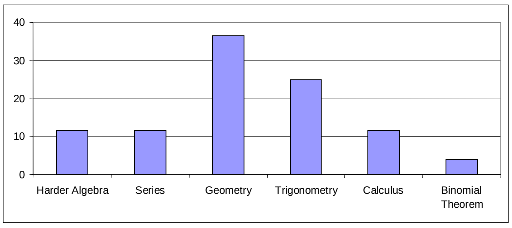


Figure 6.8 Content in 1922

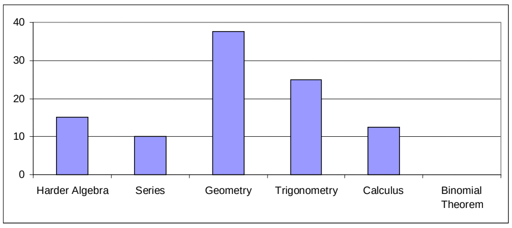


Figure 6.9 Content in 1932

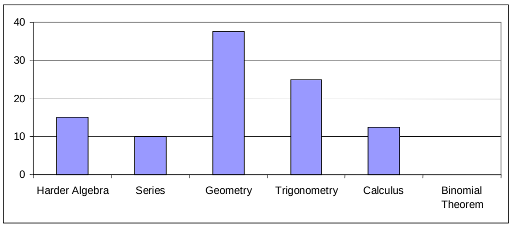


Figure 6.10 Content in 1942

6.5.1.2 Instructions (Figures 6.11 – 6.20)

About 85% of all instructions were either *find*, *prove* or *show* (Figures 6.11 – 6.13) with a further 10% taken up by *write down*, *what is* and *discuss* (Figures 6.14 – 6.16). The remaining 5% (approximately) used terms like *deduce, solve, state*, *calculate*, *evaluate*, *verify*, *describe, explain, describe*, *draw* and *establish.* As verified by analyzing the questions, students were mainly asked to reproduce rote learned theory, there was little if any analytical discussion required or expected. Over a relatively short period of 26 years, the term *find* decreased from over 40% to just 10%, while the term *prove* doubled from 21% to over 40% (see Section 6.6 for an explanation).

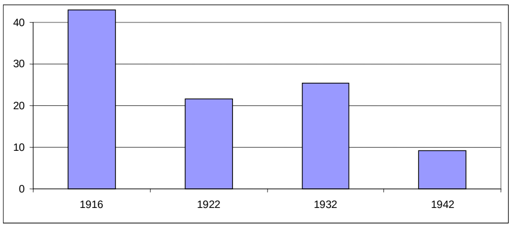


Figure 6.11 Instructions using Find

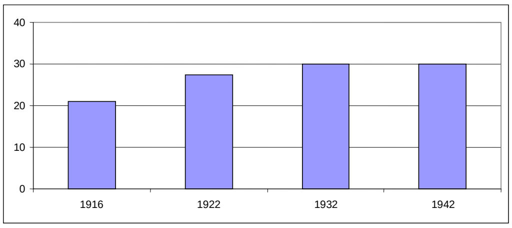


Figure 6.12 Instructions using Show

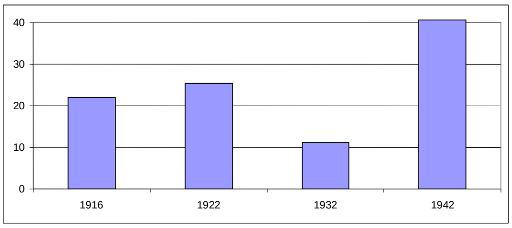


Figure 6.13 Instructions using Prove

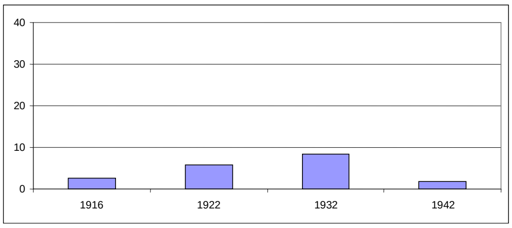


Figure 6.14 Instructions using What is

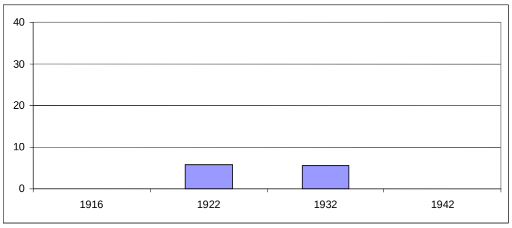


Figure 6.15 Instructions using Write down

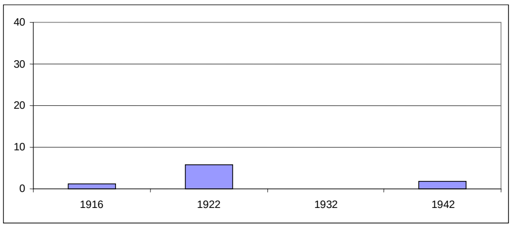


Figure 6.16 Instructions using Discuss

Figures 6.17 – 6.20 clearly demonstrated that the commonly used instructions were *find, show and prove* while the instructions *what is, write down* and *discuss* were generally below 5%. For no apparent reason the relative mix between the three kept changing, possibly to create superficial changes from one examination period to another. The use of the term *prove,* significantly increased in 1942, a possible explanation will be provided in Section 6.6.

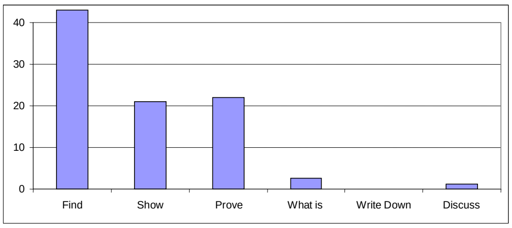


Figure 6.17 Instructions used in 1916

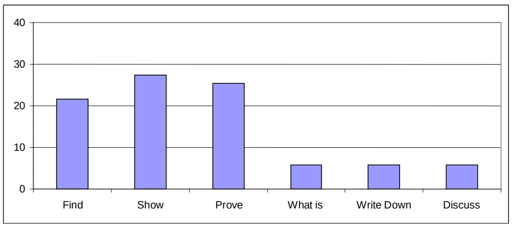


Figure 6.18 Instructions used in 1922

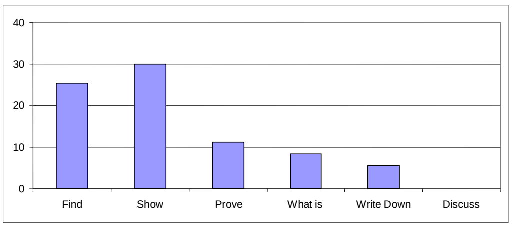


Figure 6.19 Instructions used in 1932

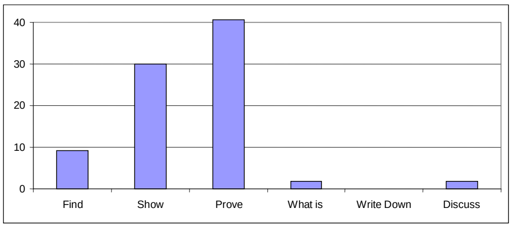


Figure 6.20 Instructions used in 1942

6.5.2 Higher standard (non-calculus)

This section includes the Leaving Certificate Mathematics I Pass and Leaving Certificate Mathematics II for 1922, 1932 and 1942, Senior Public examinations (1901 & 1911), all shown in lighter colour (blue), Matriculation Higher Standard (from 1911) and Matriculation Honours (for 1901), and all in darker colour (red). None of these examinations contain any calculus.

6.5.2.1 Content (Figures 6.21 – 6.31)

In the Senior Public/Leaving Certificate examinations the geometry and trigonometry accounted for 70% of the examinations, while algebra represented a further 20% and the remaining 10% was made up of questions on series, logarithms, quadratic functions, financial mathematics, locus and the occasional binomial theorem questions. The charts show that virtually no changes occurred in the style and format of these examination papers between 1901 and 1942.

The points of interest were the gradual and steady increase of algebra in the Matriculation Higher Standard paper from 10% to 35%. While the Matriculation papers increased the algebra content, the Leaving Certificate introduced new topics such as: series, logarithms, quadratic functions, locus and the Binomial theorem.

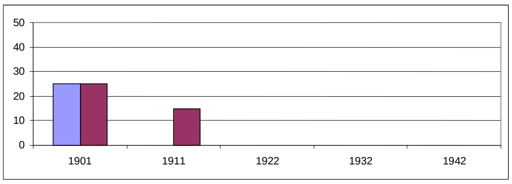


Figure 6.21 Content: Arithmetic

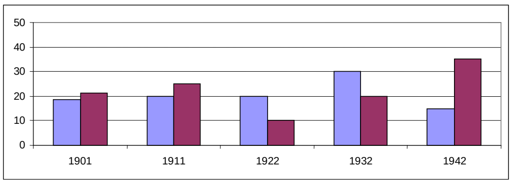


Figure 6.22 Content: Algebra

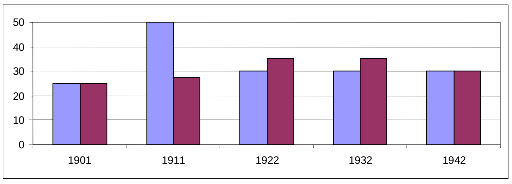


Figure 6.23 Content: Geometry

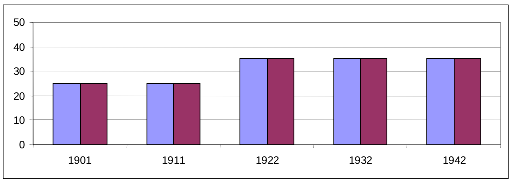


Figure 6.24 Content: Trigonometry

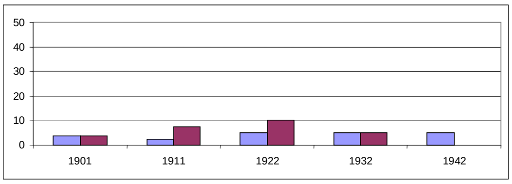


Figure 6.25 Content: Series

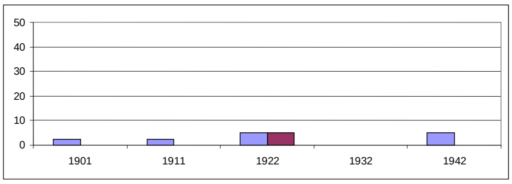


Figure 6.26 Content: Binomial theorem

Looking at the content of the two sets of examinations at ten year intervals (Figures 6.27 – 6.31), they appear very similar apart from the changes in algebra and the increase in the geometry content of the 1911 Senior Public examination.

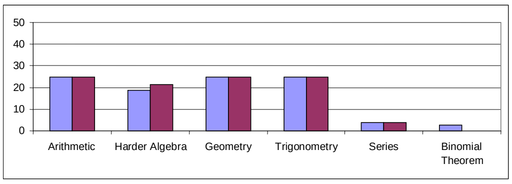


Figure 6.27 Content in 1901

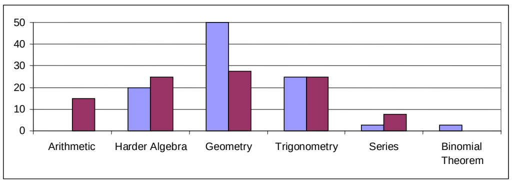


Figure 6.28 Content in 1911

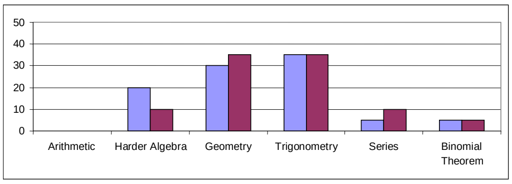


Figure 6.29 Content in 1922

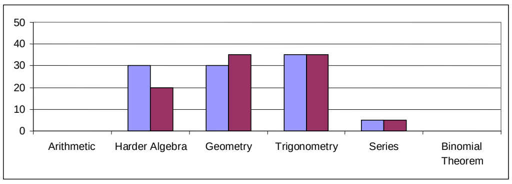


Figure 6.30 Content in 1932

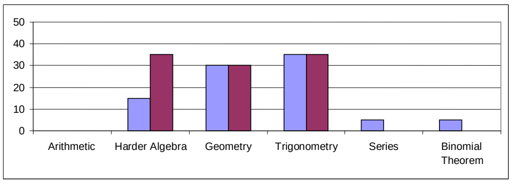


Figure 6.31 Content in 1942

6.5.2.2 Instructions (Figures 6.32 – 6.40)

In the higher standard examinations, the terms *solve, prove, find* and *show* represented 75% - 85% of all instructions except for the 1922 examinations (to be discussed in Section 6.6). The most popular instruction was *prove* (Figure 6.33) followed by *find* and *show* (Figures 6.34 & 6.35). From the instructions *how, calculate, show, state, simplify, define, resolve, describe, draw* and so forth, only a few were ever used together because a typical examination paper would have approximately 8 instructions out of a possible list of 20 - 25 (representing just 40%).

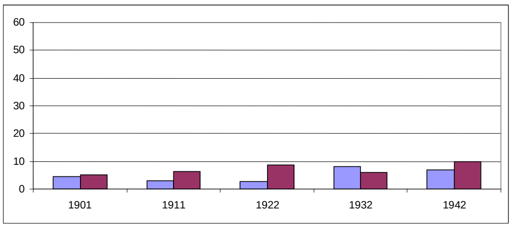


Figure 6.32 Instructions using Solve

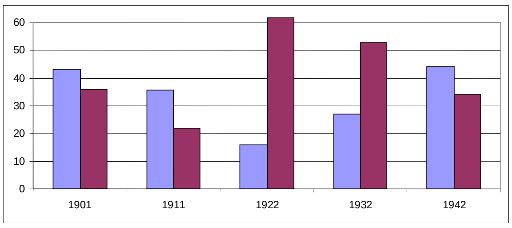


Figure 6.33 Instructions using Prove

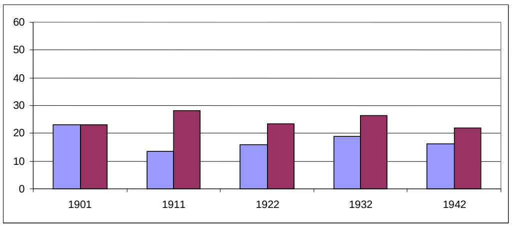


Figure 6.34 Instructions using Find

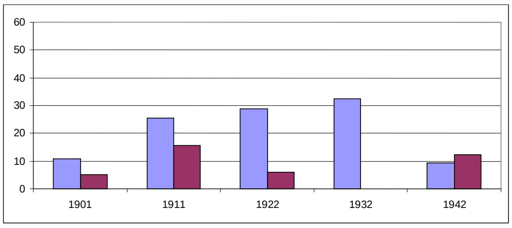


Figure 6.35 Instructions using Show

Figures 6.36 – 6.39 describe data ten years apart and include four additional instructions namely: *what is, how, calculate* and *state*. These eight instructions together made up 90% of a typical examination.

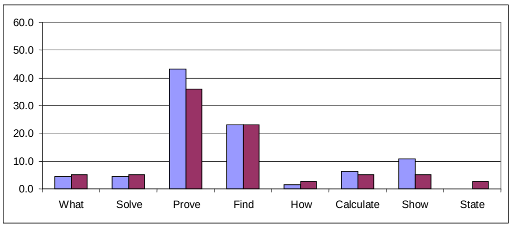


Figure 6.36 Instructions used in 1901

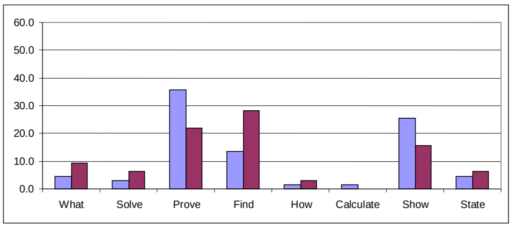


Figure 6.37 Instructions used in 1911

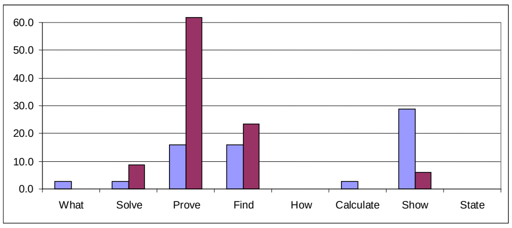


Figure 6.38 Instructions used in 1922

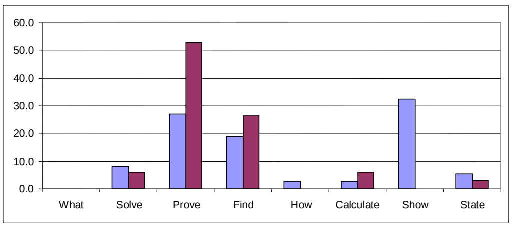


Figure 6.39 Instructions used in 1932

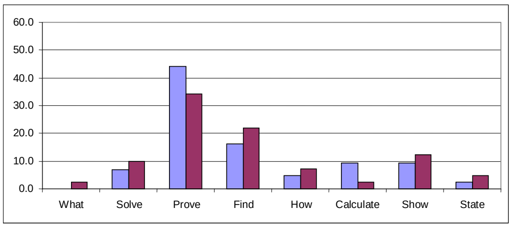


Figure 6.40 Instructions used in 1942

6.5.3 Lower standard (non-calculus)

These include the Leaving Certificate mathematics (from 1913), Junior Public examinations (1901 & 1911), Matriculation Lower Standard (from 1911) and Matriculation Pass (for 1901). None of these examinations contained any calculus.

6.5.3.1 Content (Figures 6.41 – 6.50)

These examination papers changed considerably in that arithmetic and simple algebra were replaced at the start of the Leaving Certificate by harder algebra (see Figures 6.41 & 6.43). Questions on algebraic equations (Figure 6.42) disappeared almost completely, trigonometry (previously in the higher standard) now appeared in the lower standard (Figure 6.45). Geometry (Figure 6.44) was the only topic that remained constant throughout this period.

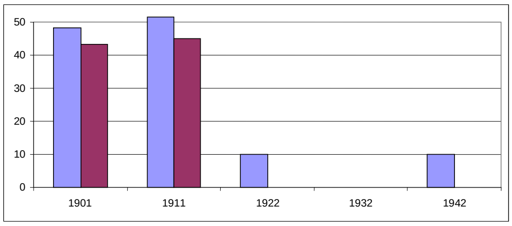


Figure 6.41 Content: Arithmetic/Algebra

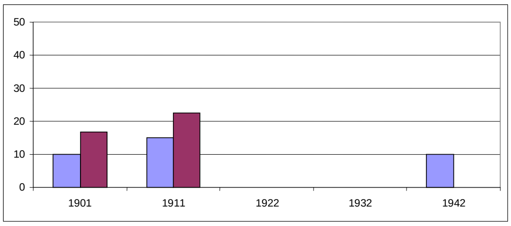


Figure 6.42 Content: Equations

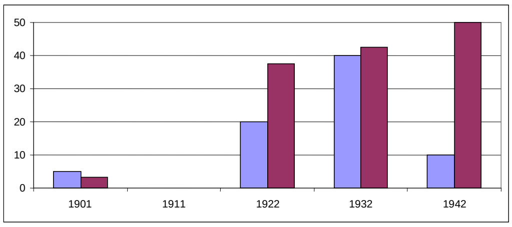


Figure 6.43 Content: Harder algebra

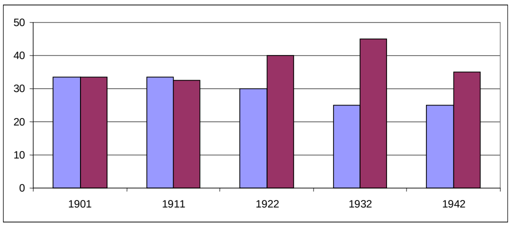


Figure 6.44 Content: Geometry

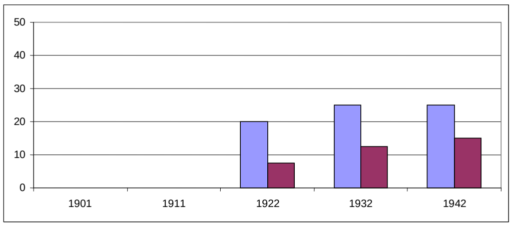


Figure 6.45 Content: Trigonometry

The Junior Public and Matriculation Pass examinations were closely aligned (Figures 6.46 & 6.4) before 1913, however this gap had widened with the introduction of the Leaving Certificate. The distribution of topics also changed significantly by 1942 (Figure 6.50). While the Junior Public examination was testing all five topics, the Matriculation only examined algebra, geometry and trigonometry with algebra taking up 50% of the examination.

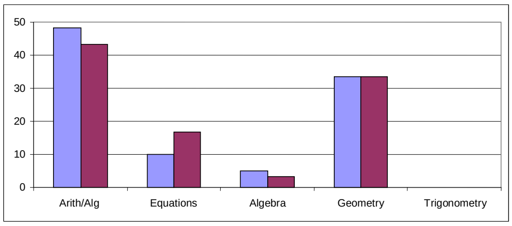


Figure 6.46 Content in 1901

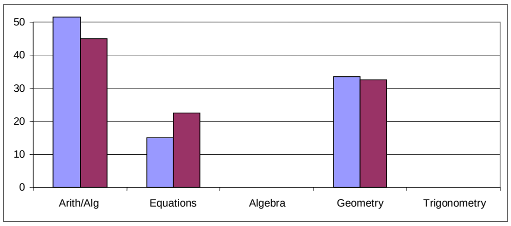


Figure 6.47 Content in 1911

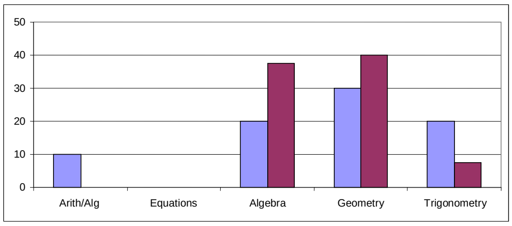


Figure 6.48 Content in 1922

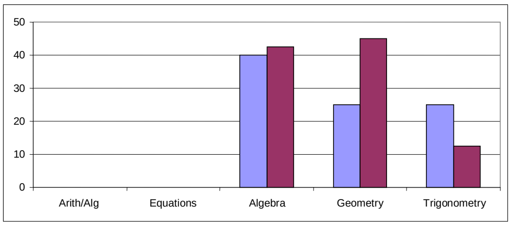


Figure 6.49 Content in 1932

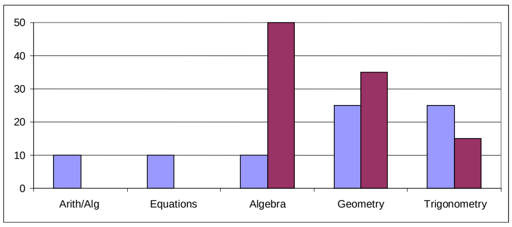


Figure 6.50 Content in 1942

6.5.3.2 Instructions (Figures 6.51 – 6.59)

The instructions *solve, prove, find* and *show* (with the exception of 1922) represented 50% - 65% of the Leaving Certificate or the Junior Public examinations. In the 1922 Leaving Certificate examination these instructions represented almost 90% of the paper (see Section 6.6). The same instructions represented 70% - 85% of the Matriculation lower standard/pass examinations.

As with the higher standard examinations, over twenty different instructions were used but individually this would account for only 2% - 3% of the total. *Prove* (Figure 6.52) was used more frequently in the Matriculation examinations whereas *show* was used more often in the Leaving/Junior examinations (see section 6.6).

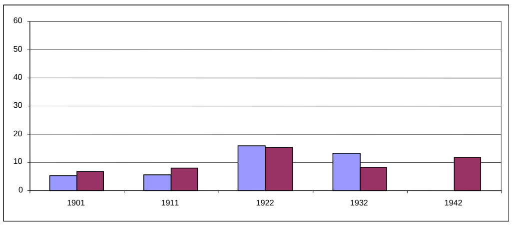


Figure 6.51 Instructions using Solve

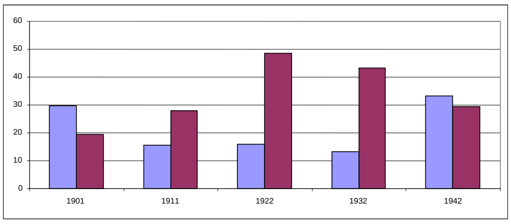


Figure 6.52 Instructions using Prove

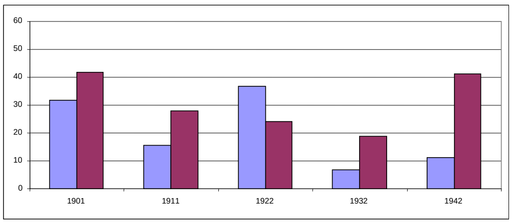


Figure 6.53 Instructions using Find

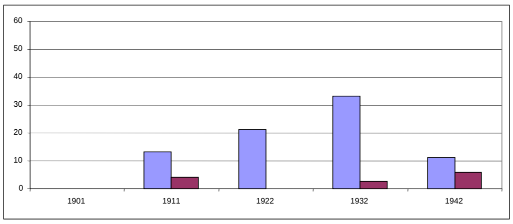


Figure 6.54 Instructions using Show

The Figures 6.55 – 6.59 represent instructions ten years apart with eight of the most commonly used terms *what is, how, calculate* and *state* plus the four from Figures 6.51 – 6.54. On average they represent 85% of all the examinations. Before 1913 as Figures 6.55 – 6.59 indicate the style of the Junior Public and the Matriculation examinations were similar. After the start of the Leaving Certificate, there was less similarity between the Matriculation examinations and the corresponding Leaving Certificate papers.

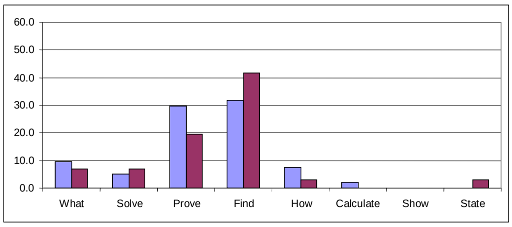


Figure 6.55 Instructions used in 1901

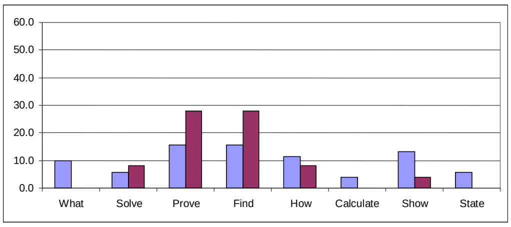


Figure 6.56 Instructions used in 1911

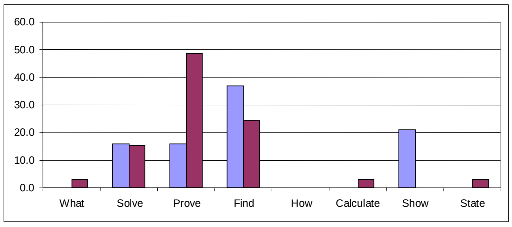


Figure 6.57 Instructions used in 1922

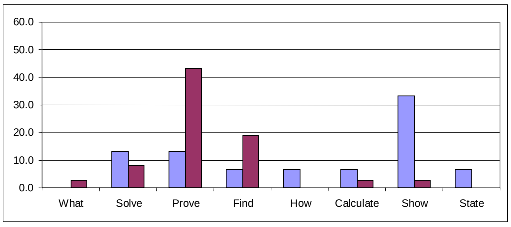


Figure 6.58 Instructions used in 1932

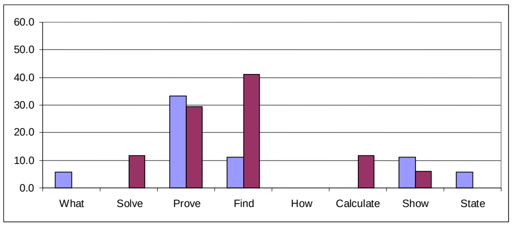


Figure 6.59 Instructions used in 1942

6.6 Review

A snapshot of all the mathematics examinations at the end of secondary schooling from 1900 to 1940 indicated that most of the changes were brought about by the introduction of the Leaving Certificate. This led to fewer examination papers, which resulted in significant reductions in the time necessary to complete the examinations. According to the information published in the Calendar of the University of Sydney, in 1900 over 100 students passed their Matriculation. By 1940 this number had more than doubled to over 240 students. At the same time Leaving Certificate numbers increased from 156 (in 1913) to about 3700 by 1940. Fewer examinations would have saved time, effort and cost in both the setting and the marking of papers.

The Leaving Certificate introduced a new era in education, helping to rationalize the examination process as well as reduce the influence of the University on the curriculum. As the results (Section 6.5) indicate, there were certainly changes during the transition from the 1911 to the 1922, but not as many as may have been expected and these changes were mainly to the instructions rather than the content of the examinations. In the 1922 higher standard Matriculation examination over 60% of the questions used *prove* as an instruction. Perhaps the examiners just wanted to make a distinction, separating them from the corresponding Leaving Certificate examination.

After the introduction of the Leaving Certificate one may have had the impression that the University and the examination board lived in some sort of a cocoon. Between 1913 and 1939 Australia had World War I, the Roaring 20s and the Great Depression followed by the start of World War II – yet very little changed in the examination process. The assumption is that the examinations reflected the curriculum. So it appears that these results confirm there was little change in curriculum taught in schools as discussed in Section 6.2.

In the Mathematics I & II Honours examinations, the recently introduced calculus topics maintained a constant 10% - 15% throughout this period. However the Matriculation examinations did not offer an equivalent subject until 1946, even though the Matriculation examinations were running in parallel with the Leaving Certificate and were also set by the University of Sydney.

During this period Carslaw was Professor of Mathematics at the University of Sydney and he was responsible for both the Matriculation and the Leaving Certificate examinations. Therefore it is hard to understand why calculus was not included in the matriculation curriculum until much later. There may be a couple of possible explanations, keeping in mind that student numbers for the Matriculation examinations were dwindling. As stated earlier, in 1940 approximately 250 students attempted the Matriculation examinations compared with 3700 for the Leaving Certificate (Barcan, 1988).

At that time calculus was only examined at the most advanced level. As the student numbers for the Matriculation were small (compared with the Leaving Certificate), Carslaw might have been concerned that there were not enough academically capable students who would be interested in taking advanced mathematics. Furthermore due to lack of student numbers, Carslaw had already foreseen the demise of the Matriculation examination and he was working towards building up the Leaving Certificate as the premier examination system.

In 1939 as New South Wales was coming out of the Depression and facing the likelihood of Australia entering World War II, there were great challenges ahead politically, economically and socially. All these would have an impact on education and the examination system and these issues will be considered in the next chapter.

Chapter 7

CHANGING WORLD, 1939 - 1962

7.1 Background

This period was largely dominated by Australia's involvement in World War II, followed by economic prosperity. Full employment and industrial growth led to a demand for educational reform. Technical training also became a matter of national importance but the State government had difficulty in meeting the demand for places in education because of the lack of adequately trained teachers, a legacy of the Depression.

External factors such as Australia's entry in World War II in September 1939 and the subsequent national mobilization in 1942 had a significant impact on the education system. The number of male secondary school teachers reduced as they joined the armed forces leading to staff shortages. To resolve this crisis more women, as well as retired teachers were employed to teach in schools. (Barcan, 1988).

While retaining the High School Entrance examination in metropolitan and Newcastle areas, in 1938 the government decided to abolish the external examinations at the end of primary school in country districts, because it was easy to implement. Country students who wanted to study further were selected on a composite assessment mark based on their sixth class work together with an intelligence test (Barcan, 1988). The Youth Welfare Act of 1940 was instrumental in raising the minimum school age from 14 to 15 years, in anticipation that a higher leaving age would lessen unemployment by reducing the number of people looking for work. Furthermore it was thought that the extra year in school might increase vocational preparedness (Barcan, 1988). The Leaving Certificate continued to grow in popularity and it was used for Matriculation as well as to enter the labor market. In 1941 the number of subjects taken for the Leaving Certificate was reduced from 10 to 8 papers, made up of a combination of standard and honours level subjects. In 1943 the Higher School Entrance component of the Primary Final examination followed the assessment used in country districts since 1938. The importance of the Leaving Certificate became more significant after 1944 when the Intermediate Certificate lost some of its credibility, as it was decided to move from total external assessment to partly internally assessment and part external assessment (Barcan,1988).

In 1939 the existing examination system was not coping adequately because of the large number of candidates (Chapter 6.3). Many students had little academic interest, possibly due to the boom in economic times and full employment in the non-academic areas (Barcan, 1988). There was a general tendency by students to relax the intensity of study and defer acquisition of academic skills to a later stage (Wyndham, 1957). Australia's involvement in World War II renewed interest in overseas affairs leading to the introduction of social studies in 1944, but when the University of Sydney did not accept it as a matriculation subject, it was replaced with history and geography. Concerned with the diminishing number of students going onto university, government funding was increased to encourage enrolment. Coupled with the idealism and enthusiasm of the post war period, student numbers at universities doubled during the period 1944 – 1951. Possibly in an effort to increase student numbers after the war the University removed mathematics as a matriculation requirement in 1944.

In March 1944 the Commonwealth Reconstruction Training Scheme (CRTS) was introduced in order to provide educational and vocational training to those who had served in Australia's armed services during World War II. The Scheme provided training for ex-servicemen and women necessary for them to be re-established in suitable civilian occupations. By the middle of 1951 when the Scheme had closed, over 300 000 people had been assisted, making it one of the most significant strategies for social change in Australia. In order to be eligible for assistance under the Scheme, servicemen and servicewomen were required to have had a minimum of six months service and to have been honourably discharged. Training was available in one of three categories – professional, vocational or rural – and could be undertaken either full time or on a part time basis. Individuals embarking on full time training had tuition and other fees paid and received living allowances (National Archives of Australia, 2010).

During the boom years between 1950 and 1965, education in New South Wales experienced significant changes. A significant increase in immigration, particularly from central European countries as well as students remaining longer at school, led to an expansion in secondary education (Newcastle Morning Herald, 1957). Post war prosperity allowed parents to keep their children in school longer and employers were also demanding better educated employees. The pressure of extra student numbers, a shortage of teachers and a shortage of funding for teacher training once again led to a crisis in education (Barcan, 1988). As a consequence, comprehensive secondary schools, as distinct from selective schools were introduced by the 1950s, to cater for the extra students (Hughes, 1999).

By the early 1950s, due to inadequate teacher training, declining primary standards had a flow-on effect by lowering the standards of secondary schools. This was brought about by a shortage of primary school teachers, the raising of the minimum age for leaving school and the removal of the external assessment of the School Certificate at the end of primary school (Farrell, 1952). Shortly after the appointment of Harold Wyndham as Director-General of Education in 1952, the Wyndham Committee was established in 1953 in an effort to restore lagging educational standards. The Committee immediately re-established an externally set Intermediate Certificate (Barcan, 1988).

The universities were also experiencing an academic crisis as the quality of students declined after the post-war renaissance. This was due to the earlier influx of students funded by the Commonwealth Reconstruction Training Scheme (CRTS) which was introduced in 1944 (National Archives of Australia, 2010). The scheme finished in 1950, had earlier provided educational and vocational training to those who served in Australia's armed services during World War II. To support this scheme, the number of academic staff increased and the range of courses grew. The teaching load of lecturers was high, class sizes were large and above all the University was short of funds (Barcan, 1988).

In 1956 to investigate the problems with tertiary education the Commonwealth government appointed the Murray Committee. As a result of the *Report of the Committee on Australian Universities* (Murray Report) in 1957, the government decided to increase their influence in the area of higher education and provided additional funding to establish a large number of new universities. The Murray Report also recommended that tertiary institutions be classified into three categories - universities, institutes or colleges and boards of teacher education (Murray Report, 1957). Later in the Wyndham Report it was suggested that the Murray Report was a confusing and unclear document. Consequently almost all of its recommendations were rejected. However a decade later Wyndham followed the original recommendations of the Murray Report and the Colleges of Advanced Education were established (Barcan, 1988).

The Wyndham Report, introduced in 1957, led to the 1961 Education Act and the establishment of the Secondary Schools Board. The Board was to conduct the new School Certificate after four years of secondary schooling and the Higher School Certificate after a further two years, thereby extending high school education from five to six years. After a hasty introduction, the Wyndham Scheme began in 1962 and the first School Certificate was held at the end of 1965 followed by the first Higher School Certificate at the end of 1967.

The 1965 *Report of the Committee of Economic Enquiry* (Vernon Report) presented the Commonwealth a ten year outlook of demographic issues, education, public health, physical infrastructure, natural resources, and industry productivity. This report found that between 1947 and 1961 there was an expansion in the proportion of the workforce in the professional and technical and other 'white collar' functions (Marginson, 1997a).

The introduction of the Wyndham Scheme recognised the needs of the Baby Boomers and confirmed the trend towards comprehensive, co-educational high schools which had been occurring in New South Wales. It also re-introduced State aid to Church schools to fund the growing need for science equipment, text books and teaching aids (Centre for Learning Innovation, 2010).

7.1.1 Changing society

7.1.1.1 Baby boomers

The Australian Bureau of Statistics (2010c) defines the baby boomers as "*those who were born in Australia or overseas during the years 1946 to 1964*". The key event that formed the social marker of the generations in the western world was the end of the Second World War. The years after the war were the opposite of the war years: the Depression and war period were replaced by economic growth and full employment. Austerity was overtaken by technological advancement and increasing freedom. Yet, even more significantly in the years after the war there was an unparalleled baby boom and immigration program and this 19 year population boom literally rejuvenated the nation.

Combined with an increase in European migration to Australia, the baby boomers changed Australia in the second half of the 20th century. Initially, baby boomers represented a new market whose needs were quickly met due to wartime advances in technology and a new economic optimism. Comic books became the literature of youth. Politics was also changing with the baby boomers. It forced the Liberal-National government into a referendum in 1967 that changed the constitution to give Aboriginal people the vote.

Between 1962 and 1972, Australia's adult population leapt by almost three million as the baby boomers reached voting age. When Gough Whitlam was elected Prime Minister in 1972 it was the first change of government in twenty-three years. His Program of reforms (International Marxist Tendency, 2000) introduced changes across every field of government including the establishment of a Schools Commission, the National Training & Education Scheme and the abolition of university tuition fees.

According to the Australian Government (2010) through the 1980s, baby boomers settled down to enjoy the wealth and comfort of their middle age years, with many boomers represented in the higher income bracket. Today, baby boomers represent an even bigger economic challenge. As they grow older, this group has started to distort Australia's non-working population. Just as they increased its working population throughout the 1960s and 1970s, now this older non-working population is placing a greater strain on Australia's hospitals, aged-care services and pensions.

The impact of the baby boomers also had a significant effect on the education system and the curriculum in New South Wales. This will be addressed in the following section.

7.2 Curriculum changes

During the early part of the 1900s, Dewey's social philosophy of education started to gain more attention and by the 1940s the idea of "*social reconstruction*" was taken up by educationalists in New South Wales (Chapter 2.2). It briefly stirred up the prevailing inactivity and complacency in educational matters as a new social class of white collar employee class continued to grow to affect the process of formal education (Barcan, 1988; Cunningham & Radford, 1938).

By 1951 an alternative curriculum was devised introducing General Mathematics, to cater for the "average student", as these students were less likely to progress beyond the Intermediate Certificate (Year 10). In the late 1950s, Caleb Gattegno an Egyptian/British mathematics educator promoted the Cuisenaire Movement for the teaching of primary school mathematics (Grimison, 1978). Gattegno suggested that learning takes place in four stages which can be described in stages of awareness. He believed that using special teaching techniques with the Cuisenaire coloured rods developed unexploited intellectual ability in young children. He also realized that this teaching method provided teachers with the means for making the lesson a personal investigation of mathematics for every pupil. Although not all schools and teachers used Gattegno's method, it was the likely catalyst for developing a revised curriculum which included self learning and awareness.

Between 1950 and 1960 the overall tendency was to embrace the core curriculum based on liberal, concerned and social democracy (Kalantzis, Cope, & Hughes, 1983). Changing attitudes in social awareness meant that new mathematics courses were beginning to place more emphasis on “self-evidence” in calculations and the discovery of mathematics principles by means of class activities involving both inductive and deductive thinking (Grimison, 1978).

To bridge the gap between theory and practice many teachers argued for curriculum assessment and reporting to be clearer and to correspond with classroom practices (Withers, 1941). Social changes led educators to consider different methods of assessment. According to Nuttall (1986) the Universities and tertiary institutions had not quite given up the idea that they should determine senior secondary curriculum through control of its assessments. The curriculum was also substantially affected by education becoming a social and political issue with the appointment of Dr Wyndham as Director General of Education in 1952. He was asked to completely review the education system in New South Wales and make recommendations for improvements to be implemented.

Changes to the curriculum were also influenced by the geography and politics of region as well as the need for an understanding of the different languages and cultures of our neighbors in the Pacific Rim (Beare, 1989). Furthermore there was a reorientation of thinking by both the educational and wider community towards the emergence of new trends, such as decreasing the emphasis on restrictive subject specialization and the need for vocational training, leading to less rigorous and more practically oriented courses. Often this practice was colloquially called the “dumbing down” effect where “general” subjects were replacing the more academic and challenging subjects (Nuttall, 1986; Barrington, 2006).

The successful launch of the Sputnik satellite by the USSR in 1957 provided a wake up call to the Western nations USA in particular to increase awareness and focus on technology and scientific subjects including mathematics. Consequently the calculus content of the mathematics syllabus continued to grow and this increase was seen in the content of the examination papers (Section 7.4). In October 1960 a revised General Mathematics syllabus was introduced reflecting the downward trend in geometry.

7.3 Examination process

During this period there was a steady increase in calculus in the Leaving Certificate mathematics examinations. In the 1940s only one set of examinations contained calculus, two sets by the 1950s and there were three sets of examinations containing calculus by the 1960s. At the same time examination papers without calculus decreased from two subjects to one.

The Leaving Certificate always had at least three academic levels of examinations plus an additional level by the 1960s, compared with the Matriculation examinations which had just two levels of examinations (higher and lower standard) throughout this period. Calculus questions first appeared in the 1946 Matriculation examinations 33 years after they appeared in the Leaving Certificate, at that time the subject names were also changed to correspond to the Leaving Certificate (Table 7.1)

The Matriculation examinations were always held in January at least two months after the Leaving Certificate and they were predominantly used as a "back-up" for students who either failed or did not do well enough in the Leaving Certificate to gain entry into university.

7.4 Description of examination papers

Between 1939 and 1962 both the Leaving Certificate and the Matriculation examinations (with the exception of the lowest level) were taught and examined in two parts. Students studying Mathematics I also had to attempt Mathematics II. Both papers were each 2.5 – 3 hour examinations. Furthermore, students taking Honours courses also had to attempt all the Pass papers.

Prior to 1950 there was no clear distinction regarding the topics examined in each of the papers. However by the 1950s a clear distinction was made in that

Mathematics I contained the topics algebra and calculus while Mathematics II contained geometry and trigonometry. At the same time a series of General Courses was developed as a consequence of the “appreciation movement” replacing the previous (non-calculus) mathematics course with a new subject called General Mathematics (Price, 1959) (Chapter 2.2).

Table 7.1 below lists all the examinations that were produced in 1932, 1942, 1952 and 1962. The review of this period began from 1939 and the first set of examinations representing this period were in 1942. To provide a better overview it was decided to also include the data from the 1932 examinations.

Table 7.1 Summary of mathematics examination papers 1932 – 1962

Course	with Calculus			without Calculus	
Year	1st Level	2nd Level	3rd Level	Higher	Lower
Leaving 1932 *Matriculation*			Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Higher Standard 1st & 2nd Papers*	Mathematics *Lower Standard*
Leaving 1942 *Matriculation*			Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Higher Standard 1st & 2nd Papers*	Mathematics *Lower Standard*
Leaving 1952 *Matriculation*		Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Mathematics I* *Mathematics II*	General Mathematics *General Mathematics*	
Leaving 1962 *Matriculation*	Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass *Mathematics I* *Mathematics II*	Mathematics III Pass	General Mathematics *General Mathematics*	

During 1939 - 1962 individual Leaving Certificate examination papers were 3 hours long, while Matriculation papers were 2.5 - 3 hours in duration. Depending on the course they chose to take at university, it may have taken as long as 12 hours by attempting the Honours course, which also includes the Pass course, a total of four subjects.

7.5 Results

The examination papers in this chapter were analyzed according to Table 7.1. First separated into calculus and non-calculus sections, the calculus section is in three parts, namely: 1st, 2nd and 3rd level. The 1st level was most academically challenging followed by an easier 2nd level and finishing with the least difficult 3rd level course. The non-calculus section was separated into higher and lower level. In any one time period there were only two Matriculation examination sets compared with at least three sets of Leaving Certificate examinations, these were matched to the corresponding Leaving Certificate examination. Both sets of examinations had the same name *Mathematics I & II* and *General Mathematics,* so there was no ambiguity in matching the two sets of papers.

7.5.1 Examinations with calculus

In 1942, 2 in 8 papers had calculus, while in 1962, 7 in 9 had calculus a 50% increase and as the figures will indicate this increasing trend was at the expense and demise of geometry and to some extent trigonometry.

7.5.1.1 First Level

There was no equivalent Matriculation examination to compare the Leaving Certificate Mathematics I and II Honours at this highest academic level, hence comparisons cannot be made. Students attempting first level also had to attempt the second level course, a total of four separate 3 hour papers equivalent to four subjects.

7.5.1.1.1 Content

The topics: algebra, geometry, trigonometry, calculus, logarithms/exponentials and complex numbers in Figure 7.1 represent about 85% of the areas examined. The remaining 15% (not shown) was made up of a combination of questions on graphs, conics and determinants. Students attempting the two Honours papers (6 hours duration) also had to attempt Mathematics I and II (further 6 hours). This lower level examination also tested many of same topics as the Honours papers, only easier questions were used. Except for conics, matrices and complex numbers which appeared only in the Honours papers and represent about 30% of the content. This was the first instance that matrices and complex numbers were examined at the end of secondary schooling (conics first appeared in 1952). Previously these topics were only taught at university. This clearly demonstrated the trend that the Leaving Certificate had well and truly taken over as the premier examination at the end of secondary schooling because new topics were introduced and Matriculation had not produced an equivalent examination

7.5.1.1.2 Instructions

Figure 7.2 represent 90% of the instructions: *what is, solve, prove, find, how, calculate, show, state* and *sketch.* Almost 60% of the questions three instructions *prove, find* and *state*. It was interesting to note that terms such as *solve, how* and *calculate* – used extensively in less academic examinations did not appear, possibly due to the theoretical style of questioning. The remaining 10% were made up of terms such as *deduce, differentiate, evaluate, discuss* and *explain*. Terms such as *deduce, discuss* and *explain* reflect social change and changes in the curriculum in that students are now asked to justify their answers instead of simply stating rote learned information. This only represented a small percentage, nevertheless it was a start.

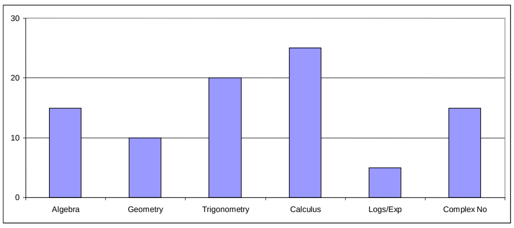


Figure 7.1 Content in 1962

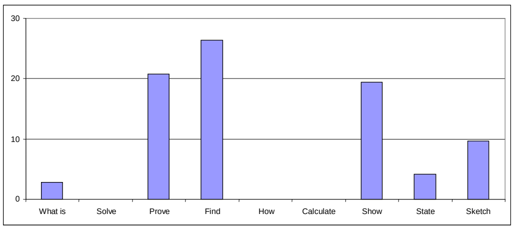


Figure 7.2 Instructions used in 1962

7.5.1.2 Second level

In 1962 there were two sets of examinations, namely the Leaving Certificate Mathematics I and II Pass as well as the Matriculation I and II. Students attempting the second level Leaving Certificate also had to attempt the entry (third) level course, a total of four subjects. In 1952 there was only one set of examinations, namely the Mathematics I and II Honours. Students attempting the Honours also had to take Pass course. These examinations were in fact the highest level for that time period. Each examination paper was 3 hours in duration and each paper counted as one subject. However if a student chose Mathematics I then they had to also attempt Mathematics II or vise versa. In 1932 and 1942 there were no subjects in mathematics at this level.

7.5.1.2.1 Content

Figures 7.3 and 7.4 shows the content for topics: algebra, series, geometry, trigonometry, probability, calculus, logarithms/exponential and the binomial theorem. In the 1952 Leaving Certificate paper 45% of the content was geometry while algebra, series trigonometry and calculus in roughly equal parts represented another 45% (Figure 7.3). The remaining 10% was made up of questions on logarithms, exponential functions, induction, binomial theorem and conics. Ten years later in 1962 the geometry content was halved to 23% while calculus had doubled to 25% (Figure 7.4). While questions on series almost disappeared, the remaining topics were almost equally balanced to take up 90% of the examination. The remaining 10% was made up of probability (a new topic), logarithms and exponential functions. The corresponding matriculation examinations closely mirrored the Leaving Certificate examination. The content changes in geometry and calculus reflected social changes towards a technologically driven world.

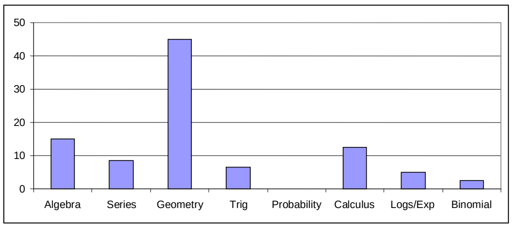


Figure 7.3 Content in 1952

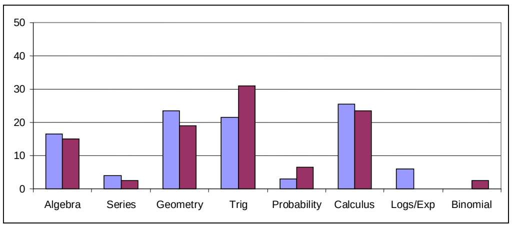


Figure 7.4 Content in 1962

7.5.1.2.2 Instructions

Figures 7.5 and 7.6 shows the instructions: *find, prove, show, solve, state, deduce, calculate, what is, write* and *sketch.* In the 1952 Leaving Certificate paper 50% of the questions asked the students to *prove* or *state*. Ten years later in 1962 only 10% of the questions asked students to *prove* a concept and *state* disappeared all together (Figures 7.5 & 7.6). This 40% change represents a significant trend away from rote learning. Instead students were asked to answer questions using a much wider range of instructions. In the 1962 examinations the term *find* was by far the most frequently used instruction. Once again as with the content, the style of the Matriculation examination closely mirrored the Leaving Certificate (Figure 7.6).

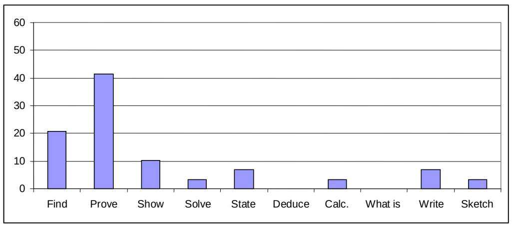


Figure 7.5 Instructions used in 1952

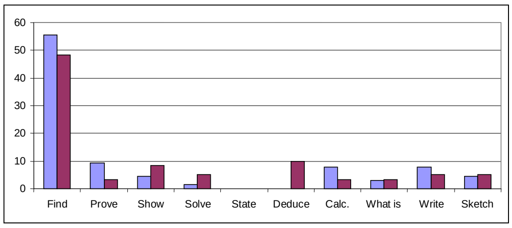


Figure 7.6 Instructions used in 1962

7.5.1.3 Third level

This was the entry level calculus examinations in the Leaving Certificate and during this period there was only one equivalent matriculation examination in 1952. During the 1930s, 40s and 50s the third level Leaving Certificate consisted of two separate 3 hour examinations, as student numbers increased due to post war prosperity and birth rate a new subject called Mathematics III was developed. This "in theory" had the same rigor as Mathematics I and II, however it was aimed to attract the students who did not plan to continue on to university.

7.5.1.3.1 Content

Figures 7.7 and 7.8 show the content for: algebra, series, logarithms/exponential, geometry, trigonometry, probability, calculus and the binomial theorem. Comparing Mathematics I & II (Figure 7.7) with Mathematics III (Figure 7.8) it was evident that probability was included in the second level examinations while the binomial theorem was left out. However in the third level examinations it was the other way around (see Section 7.5.1.1). Note that Figure 7.7 represents the combination of two examinations, each 3 hours long, where as Figure 7.8 was a single 3 hour examination. Percentage wise both examinations had roughly the same algebra, series and trigonometry content, however geometry had almost completely disappeared from Mathematics III and this was replaced by calculus which represented 45% of the examination compared with 26% calculus content in the second level examination. Although the Mathematics III was considered the least rigorous examination, overall this paper had a greater percentage of calculus then the combined Mathematics I and II papers. It had appeared that the 3 hour Mathematics III was in fact more rigorous than the 6 hour Mathematics I & II paper because it had double the calculus content as well questions on the Binomial theorem.

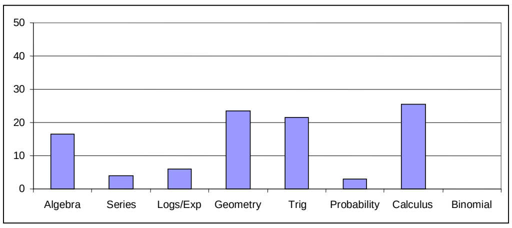


Figure 7.7 Second level content in 1962

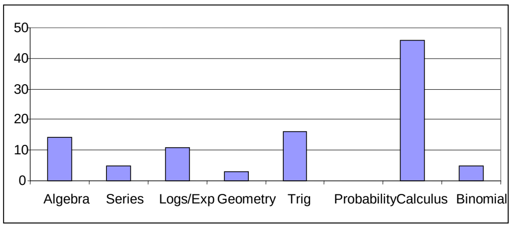


Figure 7.8 Third level content in 1962

In the Leaving Certificate Between 1939 and 1962 the number of questions examining topics such as basic arithmetic and algebra, quadratic functions, series, logarithms, and the binomial theorem had remained relatively constant. However the percentage of topics such as geometry and to some extent trigonometry significantly reduced in number and even disappeared from the examinations being replaced by calculus.

The style of the entry-level calculus questions remained constant, because the topics examined generally remained unchanged and continued to be based on the gradient function; rules for differentiation; equations of tangents; maximum and minimum turning points. This suggests that the entry-level calculus syllabus taught in secondary schools had not altered during this time period. However the percentage of the calculus content as well as the number of individual papers that contained calculus questions had increased significantly due to the introduction of additional calculus based topics.

By 1962 calculus had been gradually increasing in content to include almost 50% of the examination for university entrance (Figure 7.12). Geometry had slipped from 40% to less than 5% by the 1960s (Figure 7.13). Advancements in technology, particularly in the USA following the launching of the Russian Sputnik in 1957 placed a much greater emphasis on scientific areas and even commerce, hence the need for more advanced mathematics. As evident by the charts, topics such as algebra, series, logarithms/exponential, trigonometry and the binomial theorem has remained constant, indicating that there was little if any change in the curriculum.

Content by topics, Figures 7.9 – 7.15

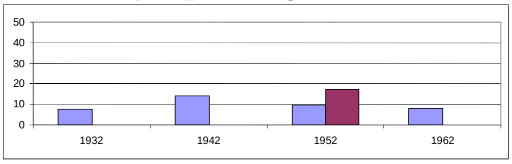


Figure 7.9 Content: Algebra

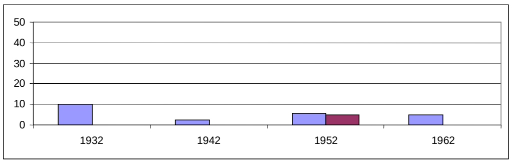


Figure 7.10 Content: Series

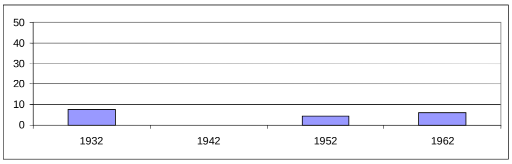


Figure 7.11 Content: Logs/Exp

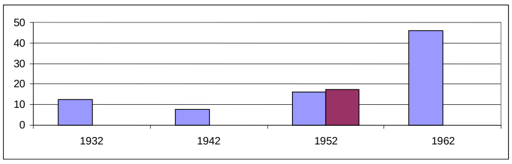


Figure 7.12 Content: Calculus

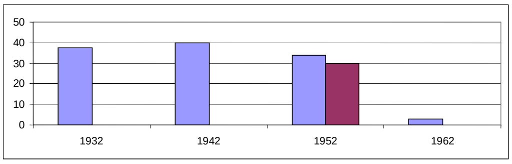


Figure 7.13 Content: Geometry

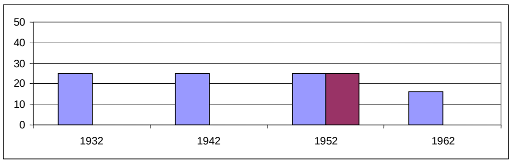


Figure 7.14 Content: Trigonometry

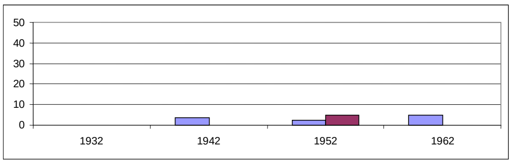


Figure 7.15 Content: Binomial theorem

The 1952 Matriculation examination (the only set available for comparison) was similar in style and format to the corresponding Leaving Certificate examination (Figure 7.18). Furthermore Figures 7.16 – 7.18 show a lot of similarity between 1932 and 1952. Calculus clearly dominated the 1962 examination (Figure 7.19).

Content at ten year intervals, Figures 7.16 – 7.19

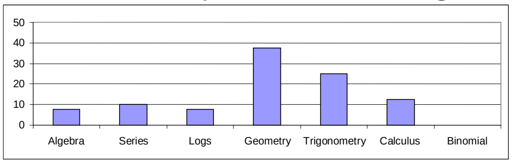


Figure 7.16 Content in 1932

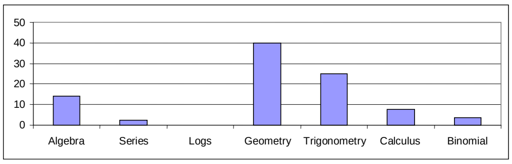


Figure 7.17 Content in 1942

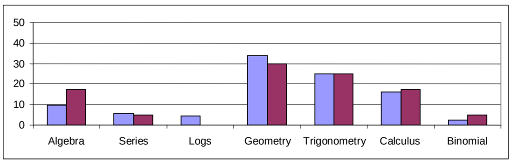


Figure 7.18 Content in 1952

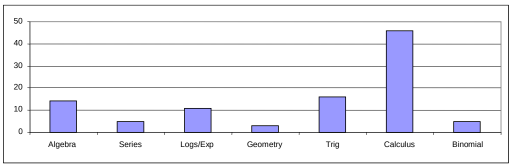


Figure 7.19 Content in 1962

7.5.1.3.2 Instructions

The school curriculum prior to WWII was largely controlled by the State Government, the Board of Examiners and the University of Sydney (Price, 1959). However after WWII parents, teachers, industry and community groups were showing interest in curriculum reforms based on cultural, personal, vocational, social and economic changes in the community (Brady & Kennedy, 1999).

Mathematics examination papers from 1932 to 1952 largely requested students to express their declarative (factual) knowledge because the majority of the questions asked the students to *find*, *prove* or *show* (Figures 7.22 – 7.24). By 1962, 35% of questions were using terminology such as *calculate*, *verify* and *what if* replacing the more conventional term - *prove*. The style of the examinations had changed by asking students to think about *what if* (Figure 7.20) and provide logical reasoning for solutions, instead of regurgitating rote-learned facts. The terms solve and state (Figures 7.21 and 7.25) were either not used at all or accounted for less than 10% of the questions.

Instructions, Figures 7.20 – 7.25

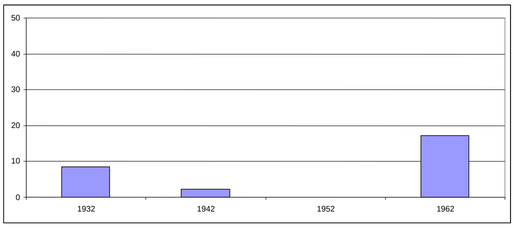


Figure 7.20 Instruction using What is

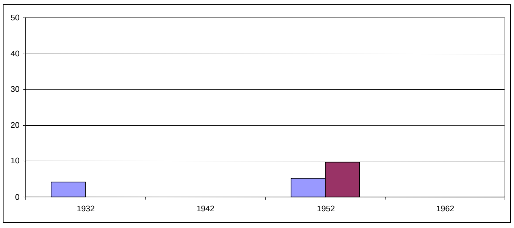


Figure 7.21 Instruction using Solve

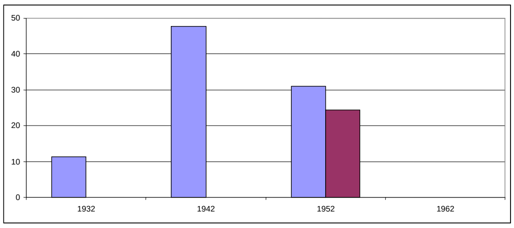


Figure 7.22 Instruction using Prove

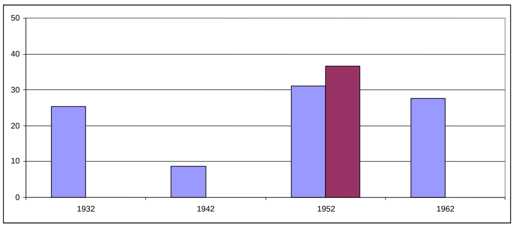


Figure 7.23 Instruction using Find

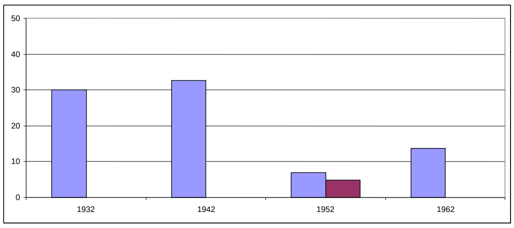


Figure 7.24 Instruction using Show

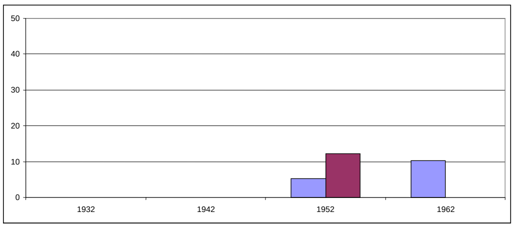


Figure 7.25 Instruction using State

Figure 7.28 indicates the similarity in the style of questioning between the 1952 Leaving Certificate and Matriculation examination. Furthermore in the 1952 examination the combination of *what is* and *show* were about 8%, by 1962 this had increased to over 30% reflecting social changes in the community.

Instructions at ten year intervals, Figures 7.26 – 7.29

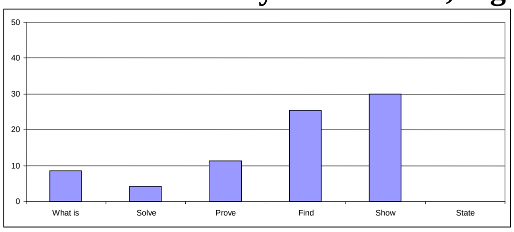


Figure 7.26 Instructions used in 1932

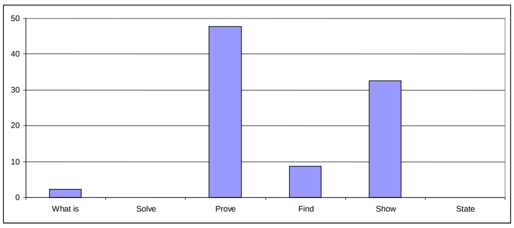


Figure 7.27 Instructions used in 1942

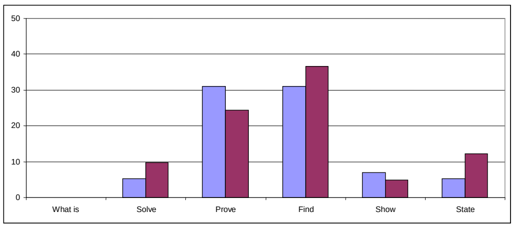


Figure 7.28 Instructions used in 1952

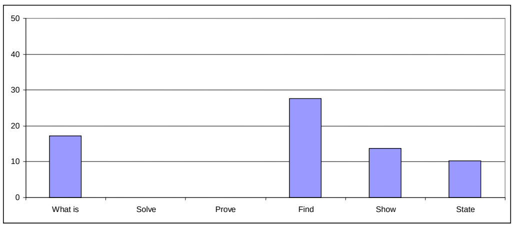


Figure 7.29 Instructions used in 1962

7.5.2 Examinations without calculus

Ten separate examination papers over two academic levels representing 40% of all papers contained non-calculus questions. In 1942, 6 out of 8 had no calculus. By 1962 this was reduced to 2 out of 9, a decrease of 50%. In 1942 there were two levels of non-calculus papers, after the 1950s only one set of non-calculus examinations were produced. At each level there were also corresponding Matriculation examinations offered by the University of Sydney.

7.5.2.1 Higher level

During this period the number of non-calculus papers decreased in both the Leaving Certificate and the Matriculation examinations. As shown in Table 7.1, prior to 1950s non-calculus papers were two separate 3 hour (Leaving Certificate) and 2.5 hour (Matriculation) examinations. After the 1950s there was only one set of examinations called General Mathematics.

7.5.2.1.1 Content

The Leaving Certificate examinations had a greater variety of topics examined including graphs, statistics, measurements and linear functions, not shown in the diagrams because in total they represented less than 10% of the examinations. There were significant differences in 1962 between some areas of the Leaving Certificate and the Matriculation examinations, particularly in geometry (Figure 7.31). With the introduction of the new Leaving Certificate syllabus in October 1960 geometry almost disappeared from the examinations. On the other hand the geometry content in the Matriculation examination jumped to over 40% (Figure 7.31). There was a gradual decline in trigonometry in all examinations (Figure

7.32) and while questions on series were few, in the Leaving Certificate they suddenly jumped to almost 15% in the 1962 Matriculation examination, however not shown to maintain consistency.

Content by topics, Figures 7.30 – 7.32

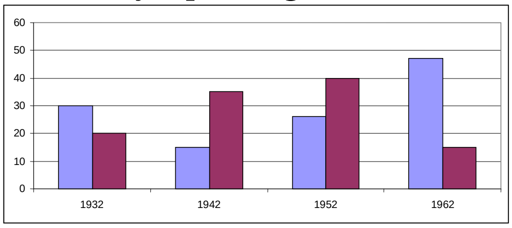


Figure 7.30 Content: Harder algebra

Figure 7.31 Content: Geometry

Figure 7.32 Content: Trigonometry

Figures 7.33 – 7.35 shows that the content of harder algebra, geometry and trigonometry for 1932, 1942 and 1952 Leaving Certificate and Matriculation examinations were both very similar. Figure 7.36 for 1962 clearly shows a distinctive change, an explanation to be provided in Section 7.6.

Content at ten year intervals, Figures 7.33 – 7.36

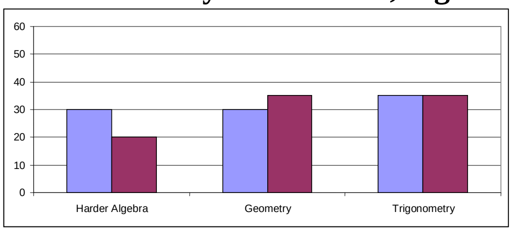


Figure 7.33 Content in 1932

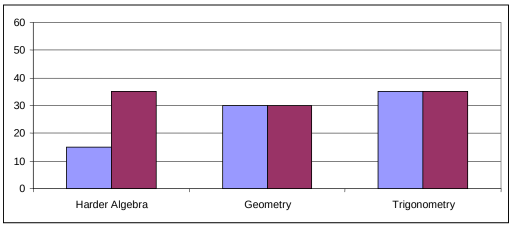


Figure 7.34 Content in 1942

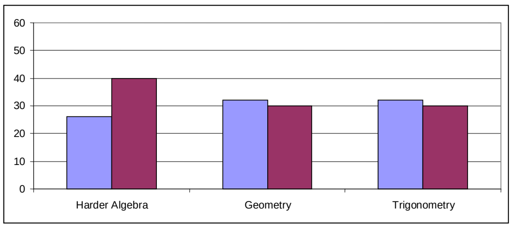


Figure 7.35 Content in 1952

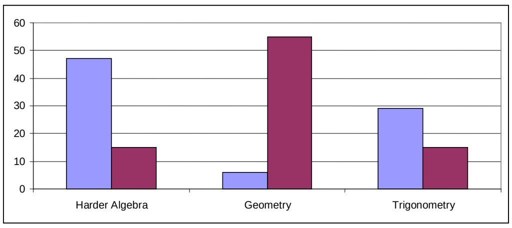


Figure 7.36 Content in 1962

7.5.2.1.2 Instructions

Comparing the commonly used instructions the Leaving Certificate had more questions using instructions such as *what is*, *how* and *sketch* requiring greater analysis in answering questions compared with the Matriculation examination. In the Leaving Certificate the use of *what is* increase from 2% to 18% and it also started to appear in the Matriculation examination (Figure 7.38). The term *prove* was used in almost 50% of Leaving Certificate questions in 1942 (Figure 7.42), but completely disappeared by 1962. During the same period in the Matriculation examination *prove* decreased slightly from 28% to 18%, indicating that rote learning techniques were still needed to answer questions. Instructions for *write* started to appear in 1952 (Figure 7.43).

Instructions, Figures 7.37 – 7.43

Figure 7.37 Instructions using Find

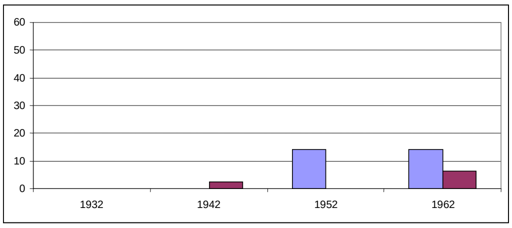


Figure 7.38 Instructions using What

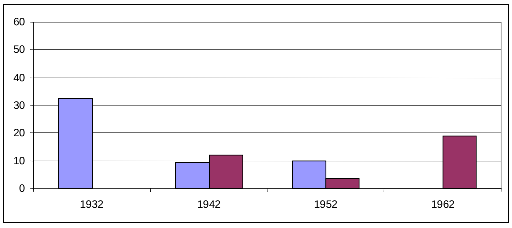


Figure 7.39 Instructions using Show

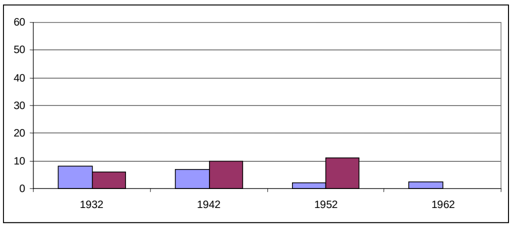


Figure 7.40 Instructions using Solve

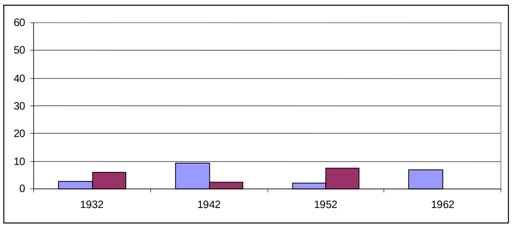


Figure 7.41 Instructions using Calculate

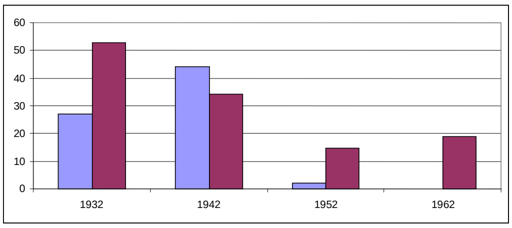


Figure 7.42 Instructions using Prove

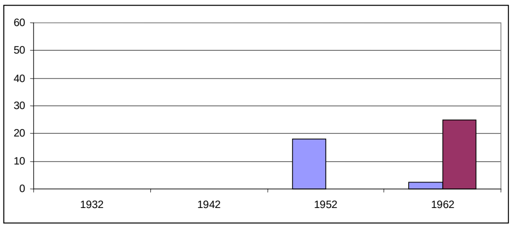


Figure 7.43 Instructions using Write

Instructions using *find, what is, show, solve, calculate, prove* and *write down* stayed relatively constant for the 1932, 1942 and 1952 examinations. The 1962 examinations (Figure 7.47) demonstrate the difference in the style of questions between the two examinations.

Instructions at ten year intervals, Figures 7.44 – 7.47

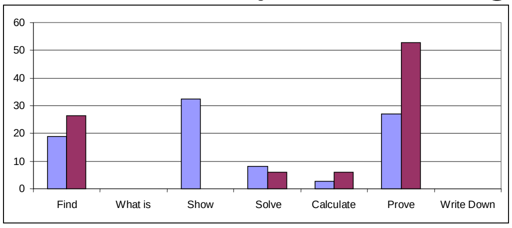


Figure 7.44 Instructions used in 1932

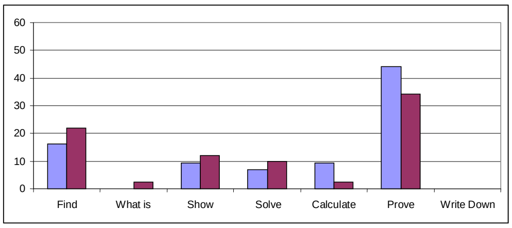


Figure 7.45 Instructions used in 1942

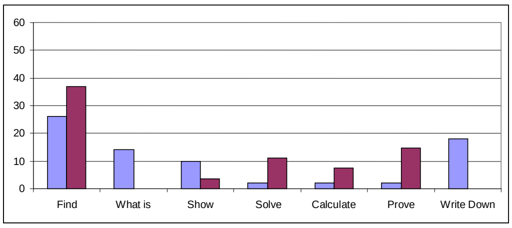


Figure 7.46 Instructions used in 1952

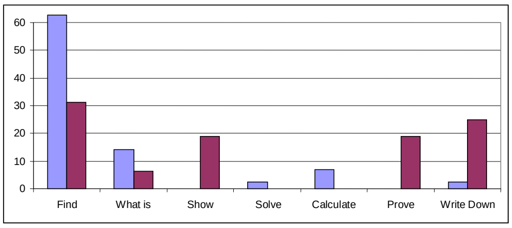


Figure 7.47 Instructions used in 1962

7.5.2.2 Lower level

In Figures 7.48, and 7.50 the extensions "L" and "M" after the dates refer to the Leaving Certificate (L) and the Matriculation (M) examinations. The first two bar charts show the results for 1932, the second set for 1942.

Figure 7.48 – shows the content for algebra, geometry and trigonometry.

Figure 7.49 – shows the content in Figure 7.48 in 1932 and 1942

Figure 7.50 – *shows the instructions using simplify, solve, prove, find, calculate* and *show*

Figure 7.51 – shows the instructions in Figure 7.50 in 1932 and 1942

Up until the 1940s there were always two sets of non-calculus examinations set for the Matriculation and the Leaving Certificate (before 1913 by the Senior and Junior Public examinations). In 1942 there were two examinations, the Leaving Certificate Mathematics and the Lower Standard Matriculation examinations.

7.5.2.2.1 Content

As Figures 7.48 and 7.49 indicate, both examined much the same subjects with algebra, geometry and trigonometry taking up 80% of the Leaving Certificate and 90% of the Matriculation examination. The Leaving Certificate was again leading the way with additional questions on Financial Mathematics (10% of the paper) to cater for the social necessities of life by teaching "survival mathematics". In 1942 the Leaving Certificate gave equal weighting to algebra, geometry and trigonometry, whereas the Matriculation allocated 50% to algebra, 35% to geometry and 15% to trigonometry (Figure 7.48).

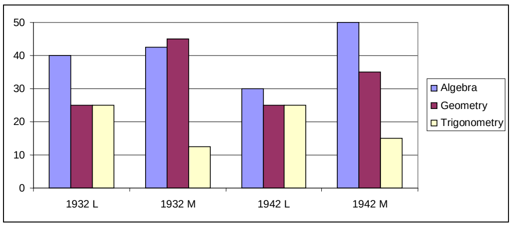


Figure 7.48 Content by examinations

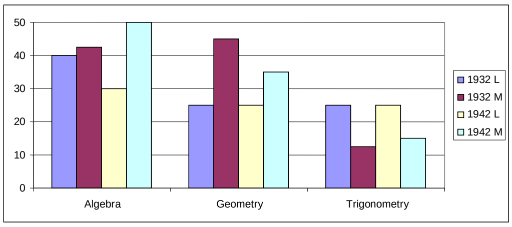


Figure 7.49 Examinations by content

7.5.2.2.2 Instructions

Both the Leaving and the Matriculation sets of examinations had the same number of questions, however the Leaving Certificate (L) used more instructions such as *what is, describe, draw* and *state*, making the questions more varied. As in most cases these instructions were used only 5% of the time, for overall consistency they were not included. In the 1942 examinations (Figure 7.50) 30% of the examination used the rote learning instruction, *prove*. *Prove, find* and *show* were the three most commonly used instructions representing 75% of the 1942 Matriculation (M) examination.

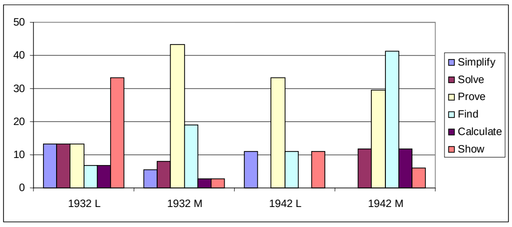


Figure 7.50 Instructions by examinations

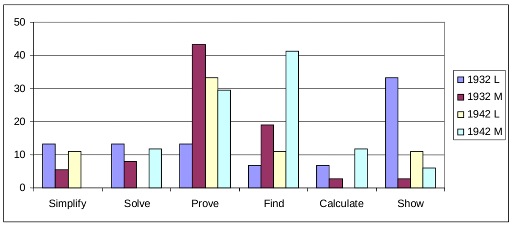


Figure 7.51 Examination by instructions

7.6 Review

According to Barcan (1988) social education became a school issue, because many fathers were away with the armed forces and more mothers had to join the workforce. Thus students were less supervised, which led to their anti-social behavior, delinquency and truancy (Section 7.1) Truancy jumped from 500 in 1941-2 to 1700 in 1942-3 and 2200 in 1943-4 (Barcan, 1988).

During the period between 1939 and 1962 the duration of the examination papers was reduced but additional subjects such as social studies were added reflecting social changes and population growth. As part of social changes, examinations at the end of secondary schooling became more important to the parents of the baby boomers. As not all students wanted to progress onto university it was important to recognize that different levels of mathematics were needed to accommodate the extra students. Calculus became a dominant component of mathematics spurred on by technological advancements. The Leaving Certificate was leading the way and setting the standards for university entrance with Matriculation becoming a less important examination. The Matriculation examination had differentiated itself from the Leaving Certificate by significantly increasing the geometry content. This change in the syllabus would have made it harder for those students who originally sat for the Leaving Certificate (and failed) to now pass the Matriculation examination.

In 1944 the technological revolution began, followed by an increase in Australia’s population due to post-war immigration and childbirth. These events brought changes in the Australian way of life, its social structure and values, influencing more students to attempt the Leaving Certificate. By the end of the war the population of New South Wales was 2.9 million and increased to almost 4 million by 1962. It is likely that the increased student numbers became a political and financial consideration in relation to the production costs and the timely marking of examination papers. This eventually led to shorter examinations whereby Mathematics I and II were combined and examined as a single subject. Changes to the examinations were also reflected in the appearance, content and style of the mathematics papers used for the Leaving Certificate. As the spread of the ability of students became more apparent, the three levels of mathematics examinations were extended to four levels by the 1960s.

In 1965 the Vernon Report (Section 7.1) presented the Commonwealth with a ten year forecast to identify some of the emerging education and economic issues. An outcome of this Report was reflected in the growth of what was then regarded as a more technologically relevant area of mathematics, namely calculus. In order to increase the content of calculus, other topics had to be sacrificed and geometry became the main loser.

As mentioned earlier, the curriculum (Section 7.2) was also substantially affected as education became a social and political issue with the appointment of Dr Wyndham as Director General of Education in 1952. Furthermore there was a reorientation of thinking by both the educational and wider community towards the emergence of new trends, such as decreasing the emphasis on restrictive subject specialization and the need for vocational training. This justification was used to introduce vocational training and other less rigorous and more practically oriented courses including Mathematics III (Nuttall, 1986). On a closer inspection it appeared that in fact the new 3 hour Mathematics III was more rigorous than the previous and ongoing 6 hour Mathematics I & II papers. This was demonstrated by the fact that Mathematics III had double the calculus content than Mathematics I and II as well as including questions on the binomial theorem. It is possible that this changing focus may well have been attributed to Wyndham who was about to introduce the new Higher School Certificate to replace the Leaving Certificate.

As part of our social evolution we tend to question more, rather than accept, information that has been given to us (NSW Ministry of Education and Youth Affairs, 1989). Hagan (1977) suggested that this trend was influenced by social changes such as the development of multicultural society; changing attitudes towards work; the changing status of women; the increase in leisure time; the changing market for job skills and the increasing demand for further education. Consequently the proposed changes to the curriculum include *"Specific outcomes include the abilities to plan, to interpret, to apply findings, to assess impacts of design decisions and to respond to design and technology through acceptance of responsibility for the consequences of decisions, to appreciate the value of individual thought and to develop critical judgments about the impact of creativity, enterprise and innovation on society."* (Peacock, 1994, p.103). This in turn has changed the style of the questions, as students are expected to explain their answers and draw conclusions from the results obtained (Genovese, 2002).

Looking towards the next 40 – 50 years we might expect to cover a similar range of issues as addressed in the original Vernon Report in 1965. The next chapter will look at the changes from 1962 to 2010. During this period the growth in computing technology, mobile phones and miniaturization changed the way we live and the way we do business. In light of these trends Chapter 8 will review any changes and effects on education, mathematics and the examination system between 1962 and 2010.

Chapter 8

THE WYNDHAM LEGACY 1962 – 2010

The technological revolution of the 1950s together with population growth due to post-war immigration and the increase in birth rate changed the Australian way of life and its social values. More students decided to continue their schooling and attempt the Leaving Certificate and new leadership was needed to meet the growing educational needs of New South Wales.

To appreciate Wyndham's achievement it is important to understand the administrative and political battles which were fought behind the sedate facade of administrative life. As Director-General, Wyndham was a very secure man and he was sure of his facts, by virtue of his wide experience. Wyndham knew what questions to ask and had an excellent background against which to interpret the answers (Hughes, 1999). Wyndham often cited Peter Board, as one role model he sought to emulate and had a liberal approach to curriculum development and pedagogy. Wyndham's education philosophies included that:

- teaching should be more scientific;
- school was not just served by teachers but also other professionals such as psychologists;
- education should offer a key means of moderate social reform; and
- school life ought to be a happy as well as profitable learning experience (Hughes, 1999).

Following the 1961 Education Act, the Wyndham Scheme was implemented in 1962 ending the five year secondary school program of the Intermediate Certificate and the Leaving Certificate (Barcan, 1988).

8.1 Background

After World War II over 2.5 million immigrants arrived in Australia from Europe with many settling in New South Wales, increasing the population from 3.2 million in 1950 to 4.5 million by 1970. The additional 1.3 million people changed the ethnic mix of New South Wales leading to major changes in the education system (Section 7.1). During this same period, school enrolments also doubled and the retention rate at the end of secondary school sharply increased, stretching the education system even further as the economy moved from great prosperity to serious recession (Crittenden, 1987).

The dominant theme in the history of Australian education has been the changing balance of control between church and State as student numbers attending independent schools continued to grow at the expense of State schools. In 1900 most of the education was provided by church schools (Carrick, 1989). According to figures published by the Australian Bureau of Statistics, 23% of students in 1970 attended independent schools (Auditor General 2009). Thirty years later in the year 2000 this number had increased to over 30%. In actual numbers this increase was very significant because the population of New South Wales had increased from 4.5 million to about 6.5 million people. By the 1960s the liberal/progressive curriculum aimed to prepare students for life rather than a vocation. It started to change towards the social/critical orientation which was more interested in educating students to be more caring about society on the whole instead of the academic rigor required for jobs in industry (Kemmis, Cole & Suggett, 1983).

Attempts by Wyndham to formulate a revised educational philosophy encountered difficulties due to social changes of the greater community. These changes were reflected in school attitudes because it was in conflict with the middle class beliefs, morals and ethics. As teachers were part of the salaried, white collar middle class group they were also looking for change because of confusion about new and more modern values of adult society. The attitude of students had also changed, influenced by media and peer pressure groups as they were caught up in their own “sub-culture”. Consequently the post war immigration boom meant that secondary school curriculum no longer satisfied the needs of community attitudes and ideas which had existed prior to the changing face of multiculturalism.

The Wyndham Report presented in 1957 explained the proposed four-plus-two examination structure as …*the School Certificate is designed to recognise the completion of a satisfactory secondary education. For those students who may aspire to some form of tertiary education, a further stage of two years of secondary education will be provided.*

Thus the three year Intermediate Certificate and two year Leaving Certificate program was replaced with a four year School Certificate program followed by a further two years of study to obtain the Higher School Certificate. Within this secondary school structure, a variety of new courses in Years 11 and 12 became available. Within most subjects a number of different levels were offered to suit various outcomes. The "more academic" courses were aimed towards further study at tertiary level while other "less academic" and more practical towards a vocational orientation. The proposal added an extra year to the length of secondary schooling, particularly for the minority of pupils who wished to continue onto university.

The quality of teachers had been declining for many years (see Section 7.1) so Wyndham wanted to maintain or even raise academic standards by improving teacher education. According to Hughes (1999), Wyndham was admittedly an admirable and conscious collector of schemes for the improvement of schools. His method of developing his philosophy was by accretion: each successive edition enriched and strengthened the original version. It was the way he pursued his goals, rather than the manner in which he formed them, that distinguished Wyndham.

Unlike England which had a clearly defined class structure, Australia was typically devoid of a dominant social group. However by the 1960s the salaried white collar, middle class people became the largest entity with strong egalitarian points of view. This was a view also supported by Wyndham and helped to structure the curriculum for the new Higher School Certificate (Hughes, 1999).

When Wyndham retired in 1968 he left a legacy to be envied as school enrolments had expanded from 455,000 to 747,000. In 1953, 15,500 teachers were employed in government schools. This number increased to 32,500 by 1968. In 1953 there was an average 29.3 students per teacher but only 23.1 in 1968 The number of students in teacher training in that period rose from 2,680 to 9,030 and two new teachers colleges were established (Hughes, 1999). Regardless the public had doubts concerning the academic and the social aspects of education because it was in conflict with their generally accepted egalitarian values. The comprehensive school concept owed much to the egalitarian principles of society, and to the growth of the white-collar middle class with aspirations for a full secondary education for their children. The debate was linked to the perceived lower standards of the comprehensive schools but Wyndham claimed that standards would be lifted with an extension of the secondary course to six years (Hughes, 1999).

Following the Wyndham era many factors curtailed the influence of the Director General of Education as the senior adviser to the government. Lobby groups proliferated and became quite sophisticated in bypassing Departmental officers and gaining direct access to the Minister and Government, a situation that did not happen while Wyndham was in charge. The growing number of militant teachers formed part of the new industrial unionism and made politicians acutely conscious of their power. As an influential lobby group the union organized the first teachers' strike in New South Wales in 1968. This was hailed a new era of political influence for the Teachers Federation and it subsequently demonstrated that it could excite sufficient professional and community sympathy to deliver votes at elections (Hughes, 1999).

Taking a more active role in Australian education and curriculum, in 1973 the Federal Government established a series of statutory bodies. These organizations included the Schools Commission, then the Curriculum Development Centre and in 1975 the Australian Advisory Committee for Research and Development in Education (previously known as the Education Research and Development

Committee) (Rosier, 1980). In the early 1970s, educational disadvantage was seen as something for which compensation should be made but it could not be eliminated. Today we have higher expectations, although disadvantaged schools are still part of a landscape. Unfortunately the disadvantaged pupils are not likely to escape their surroundings (Teese, 2006).

The first Karmel Report on educational inputs was released in 1973 and a follow up report on educational outcomes was released in 1985. Four years later followed recommendations made in the Carrick Report in 1989. A White Paper was issued by Terry Metherell MP, Minister for Education and Youth Affairs called, *Excellence and equity: New South Wales curriculum reform,* (see Section 8.2).

According to John Aquilina, MP Minister for Education and Training:

> *"It is three and a half decades since the decision was taken to restructure New South Wales secondary education and establish the Higher School Certificate. Thirty-five years on, a number of problems have emerged. The Government is now reforming the Higher School Certificate to enhance its intellectual rigor, fairness and relevance to the needs, interests and capacities of senior school students. This will ensure its continuing quality and standing into the twenty-first century…"* (McGaw, 1997, p.1)

In 1997 to overhaul the now "aging" Higher School Certificate Professor Barry McGaw prepared a report titled *Shaping Their Future* with twenty-six recommendations (McGaw, 1997), including:

- The purpose of the HSC was to provide a curriculum structure which encouraged students to complete secondary education and provide formal assessment and certification of students' achievements.
- Removal of the use of the Key Learning Area structure (previously established by Terry Metherell in his White Paper on *Excellence and Equity*) and adoption of a common curriculum structure with 2-Unit courses in each subject for courses within subjects.
- All syllabus documents should explicitly identify the ways in which particular Key Competencies were expected to be developed. In order to qualify for the HSC, students must have completed a minimum of 12 units of study, including at least two units of Board developed English. It was

recommended that the School Certificate be abolished and replaced by a Statement of Achievement for students wishing to leave school at any time prior to sitting for the HSC.

- Statistical moderation of school-based assessment against external assessment should be maintained and a standard-referenced approach to assessment be adopted by developing achievement scales for each subject. It was further recommended that there be no use of categories of 'pass' or 'fail' or of other grades in the reporting of students' results.
- Courses for Vocational Education and Training should be developed.

As a result of the McGaw review the new HSC started in 2001 with many of the original twenty-six recommendations implemented, except for the abolition of Key Learning Areas which continued to remain (see Section 8.2). Many people thought that with the rapid changes in society identified by the social demographers as Generation X, Y and Z (Section 8.1) and the technological advancement such as computers would be most relevant to mathematics teaching. However according to Simpkins and Miller (1972) there is a basic weakness in this line of reasoning. Unless the length of schooling is increased, additional topics can only be included at the expense of existing material.

8.1.1 Changing society

A “generation” is usually considered to be about 30 years however world wide changes in society became so rapid that a much shorter time span was identified as being relevant to describe the children of the baby boomers.

8.1.1.1 Generation X (1965 – 1979)

In a presentation to the Institution of Surveyors Australia 50th Birthday celebrations in May 2002, Dean Wallington defined Generation X as more global, culturally diverse and technology orientated then the generations before them. Generation X existed when a life long career path with the one firm was virtually non-existent, the average income was falling, affordability of the lifestyle was non-existent and change and corporate restructure was the way of life

(Wallington, 2002). He also believed that there were two major factors that shaped the thoughts and attitudes of Generation X.

- Parents
- Corporate world and the changing workforce

Parents - In their quest for a good life, which was better than their parents had. Baby Boomers (1946 – 1964) chose to work, leaving children at home alone to be entertained by the television. As an example, one of the many consequences was that the divorce rates skyrocketed; the family unit broke down leaving many children with only one parent.

Corporate world and the changing workforce - The globalization of the world markets meant that corporate takeovers, downsizing and economic rationalization became common place. It meant that the corporate world not only made baby boomers redundant, but also had a far greater impact on Generation X than the Boomers themselves. This also added to breakdown of the family unit and scared Generation X. This generation can now be looked at as both pupils and parents. As pupils they are generally better educated then their Baby Boomer parents. As parents they have higher expectations of those who educate and care for their children than parents of past generations (Grose, 2006). The result was the generation X employee did not see a job as one for life because job security was no longer guaranteed. Every job was seen as a temporary one and every employer as a stepping stone to something bigger and better or something else. The Generation X employee expected to be valued immediately for his/her skills. They saw job security as the transferability of one's skills to other tasks, rather than for job advancement within the organizational structure.

Generation X was generally educated to the tertiary level with the numbers of people holding tertiary degrees now higher than ever before. However many academics and professionals stated that a tertiary degree had a shelf life of about three years before retraining or further education was required (Wallington, 2002).

8.1.1.2 Generation Y (1980 – 1994)

The Dusseldorp Skills Forum (2006) commissioned research from Irving Saulwick and Denis Muller and from Newspoll to find out what young people, those aged 16 to 24 were thinking about education, work and the future. The research showed that Generation Y had adjusted fully to the globalized world. In that way they were dramatically different from their parents, and represented a point of change in Australian social and economic history.

In summary Generation Y:

- Have grown up understanding and accepting that the future of work is all about mobility, adaptability and change;
- Have little or no expectations of a "*job for life*", thinking it a form of imprisonment;
- Do not understand the social and economic changes wrought by globalization and the information revolution over the past 20 years;
- Regard the changed social and economic landscape as completely normal;
- Have no fear of an economic downturn; and
- Robustly believe their future is in their own hands.

The contrast with the attitudes of their parents' generation could not be starker.

8.1.1.3 Generation Z (1995 – 2009)

The Australian Bureau of Statistics (2010c) on their website refer to Generation Z – as the "*'iGeneration' or 'Internet generation', but what exactly is the 'iGeneration'? Some people will know them as 'Generation Z'. Others will have heard them referred to as 'KIPPERS' (Kids in Parents' Pockets Eroding Retirement Savings)".* The concern and challenge for today's educators is to develop a curriculum suitable and applicable for the Generation Z population. This generation, born since 1995 are largely the children of Generation X parents, Gen Zeds are beginning their transition from Primary to Secondary school and in 2020 they will comprise 9% of the workforce. Often referred to as the digital natives, the dot-com kids or Generation Media, they personify the 21st Century (McCrindle Research, 2010). The point being that Generation Z is clearly very

different from the Baby Boomers. Has there been a corresponding change in the curriculum as reflected in the examination process?
Looking ten years ahead, the class of 2020 started school five years ago. When they graduate, Australia's median age is expected to be 40 (it was just 29 in 1980). The class of 2020 should live longer (life expectancy at birth will exceed 85 years). The class of 2020 will enter the workforce in a time of massive succession planning and according to McCrindle Research (2010) many Boomers will have retired, creating employment shortages.

In light of the constant changes to our demography, one might expect that the mathematics curriculum, assessment and examination process should have catered for Generation X, Y and Z students. Has this really happened?

8.2 Curriculum Changes

Following the rapid expansion of secondary education after World War II, it took 20 years for a number of government policy decisions on curriculum change to be implemented to address the inequalities of students from different social and economic background. As a consequence:

- the number of external examinations was reduced;
- curriculum content began to focus on knowledge and experience of those students who were previously marginalized or excluded by the previous curriculum; and
- the compulsory school leaving age was raised to 15 years.

These changes however still failed to dislodge the competitive academic curriculum and the mechanism used to sort and select students (Reid & Thomson, 2003). Traditional mathematics courses were thought to encourage logical thinking, but whether logical operations of mathematics could be transferred to other areas of living was being questioned. The technology boom and the advent of electronic calculators and computers clearly assisted with complex calculations. However people were still expected to understand number relations, measurements, learning about money, time as well as buying and selling (Simpkins & Miller, 1972).

A world wide social and cultural upheaval began towards the late 1960s and this was also reflected in the Australian society. All classes of people, including minority groups, were seeking the “equality” of the dominant white collar middle class and this had important effects on the curriculum, leading to the collapse of the humanist-realist ideas (Barcan, 1988). The new ideology and the new morality shifted the balance of personal and social aims towards individual development, feelings, creativity, mental skills, investigational skills, personal and moral autonomy (Barcan, 1988).

After 1970, additional courses were offered reducing the popularity of core subjects like mathematics. The curriculum narrowed because the Board of Studies decided to count mathematics and science as three subjects each if they were taken as full courses. There was also an increase in the popularity in social science subjects and it was further decided in 1973 to make the School Certificate an internally (school) set examination (Carrick, 1989).

Professor Peter Karmel was commissioned to review education in Australia and he later released the Karmel Report in 1973 which addressed and made recommendations in three broad areas:

- the lack of human and material resources;
- the gross inequalities in resources and opportunities among schools; and
- the inadequate quality of teaching, curriculum and administration.

The Report recommended substantial additional Commonwealth expenditure as well as the reallocation of resources.

While the 1973 Karmel report looked at educational inputs, the second Karmel report in 1985 focused on educational outcomes. The 1985 Report noted that public sector expenditure on education had not kept up with inflation and strongly recommended an increase in equality of educational opportunities. The committee saw teacher training as a high priority and further recommended that funding be limited to four main areas, namely:

- Improving student competencies in primary schools;
- Improving disadvantaged groups by raising their participation in Years 11 and 12;
- Improving outcomes for girls; and
- Enhancing teacher competence (Carrick, 1989).

Teese (2006) was critical of the way in which success was measured, saying that the government of the time had failed to deliver the recommendations of the second Karmel Report in helping the disadvantaged.

> *"Real innovation would be about breaking the link between social position and learning outcomes so clearly evident in the map of achievement. It would be about depth of learning, about intrinsic learning satisfaction, about interactive teaching styles that fully engage learners, about transparency of learning objectives, evaluation of programs from a pedagogical perspective, about freedom of choice based on interest and enjoyment of learning".* (Teese, 2006, p.8)

Teese believed that real innovation did not come from the academic end of schooling instead they should have looked at disadvantaged schools where everything depends on relationships between individuals.

The Labor governments in the 1980s again attempted to address the marginalized and socially disadvantaged students by reducing the university's domination over the Higher School Certificate (HSC) (Reid & Thomson, 2003). In 1986 the HSC and the system of certification in upper secondary was reformed.

A change in government in New South Wales in 1988 was accompanied by a massive revision of curriculum including a wide ranging review known as The Carrick Report (1989). This Report was based on the Hobart Declaration on Schooling which included the State, Territory and Commonwealth Ministers of Education. Conscious that the schooling of Australia's children was the foundation on which to build our future as a nation, the Council agreed to act jointly to assist Australian schools in meeting the challenges of our times. They made an historic commitment to improving Australian Schooling within a framework of national collaboration in areas such as National Collaboration in Curriculum Development and Establishment of Curriculum Corporation of Australia (MCEECDYA, 2009)

In 1989 Metherell, the Minister for Education and Youth Affairs released a White Paper on *Excellence and Equity: New South Wales curriculum reform.* This was Dr Metherell's election promise to improve education services for people in the disadvantaged suburbs of Western Sydney, to provide greater choice to parents and to promote reward for excellence in students. It was also to develop new scope for teacher promotion and to open schools to the community (Crump, 1991). The White Paper identified the areas of curriculum as Key Learning Areas (KLA) in English, Mathematics, Science, Technology and Applied Studies (TAS), Human Society and its Environment (HSIE), Community and Family Studies (CAFS), Visual Arts, Vocational Education and Training (VET) and Languages other than English (LOTE). Each Key Learning Area was to have a number of mandated hours of study. Schools retained the freedom to adjust these hours upward and to provide structures whereby students were allowed to select further study in an area through elective subjects (Peacock, 1994).

In 1990 the Board of Studies was established and charged with responsibility for curriculum development from Kindergarten to Year 12 and accreditation of the HSC. Three years later in 1993 the Board of Studies published *HSC Pathways: implementation Guidelines*, outlining new rules to apply to the HSC from 1995. This gave students greater flexibility to study individual subjects at their own pace, all counting towards the Higher School Certificate.

There was an ill-fated attempt in 1991 to establish a national curriculum to engineer national collaboration (Reid & Thomson, 2003). The election of the Liberal-National Party coalition in 1996 once again embraced neo-liberalism, stressing individual rights and consumer choice, instead of the social good that benefits everyone as well as the individual (Marginson, 1997b). Nevertheless the mathematics curriculum with the exception of the non-calculus course was largely unaffected by the political upheavals and their changing influence on education policies.

Later that same year the Department of Training and Education Co-ordination released a Green Paper, written by Professor Barry McGaw, *Their future: Options for reform of the Higher School Certificate*. The Green Paper was to address the disenchantment of students, parents and industry with the curriculum and schools in general (ACER, 2002).

The consistent theme from these reform projects suggested a new national curriculum with:

- Active student engagement with ideas and supportive classroom discourses;
- High conceptual expectations, across class lessons;
- Attention to the individual learning styles;
- Focus on higher order thinking skills and representation of scientific reasoning;
- Student autonomy and responsibility for learning; and
- Importance of collaborative teacher behaviors.

In 1997 the Department of Training and Education Co-ordination released the report commissioned to review the NSW HSC. The report, *Shaping their future: Recommendations for reform of the Higher School Certificate* (McGaw Report), identified problems with curriculum, assessment and reporting, and made a number of recommendations for reform of the HSC and shortly after the Board of Studies published *A Review of the HSC Assessment Program*. The review was undertaken following recommendations made in the McGaw Report.

According to the McGaw Report changes to the Higher School Certificate were necessary:

- to increase the rigor and quality of the HSC curriculum;

- to ensure HSC marks fairly reflect the standards achieved by students;
- to better equate the method of reporting achievement with concepts understood by the community and
- to enhance the chances for more equitable educational outcomes.

These changes were aimed to provide a future for young people in New South Wales.

Ten years after the 1989 Hobart Declaration on Schooling the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) sponsored the Adelaide Declaration on National Goals for Schooling in the 21st Century. According to their press release, the Ministers agreed to eight key learning areas to be a prime focus into the next century. These include the arts; English; health and physical education; languages other than English; mathematics; science; studies of society and environment and technology. Although they all agreed on numerous outcomes, there was no mention as to how these outcomes would be implemented and achieved.

In the meantime the McGaw Report meant sweeping changes for most HSC subjects. However calculus based mathematics subjects were not affected. A new method of assessment based on the standards-referenced approach was adopted and cosmetically the names of the subjects were changed from 3 Unit to Extension 1 and 4 Unit to Extension 2. The two non-calculus subjects namely, Mathematics in Society and Mathematics in Practice were replaced by a single more rigorous General Mathematics and graphics calculators were also allowed into this mathematics course alone. Otherwise the impact of technology was not reflected in the assessment of mathematics, because (apart form General Mathematics) the syllabus had basically remained unchanged.

In 2004 the Board of Studies set up committees and prepared writing briefs to replace the existing and as yet largely unchanged Mathematics 2 Unit, Mathematics Extension 1 and Mathematics Extension 2 subjects with the introduction of new courses. It was envisaged that they would be in schools by 2010 but this was later deferred to coincide with the National Curriculum.

According to a June 2008 press release from the Australian Curriculum, Assessment and Reporting Authority (ACARA):

> *"Professor Barry McGaw launched the National Curriculum Board's extensive consultation process today when he opened the Into the Future Forum in Melbourne with over 200 participants. - Today is the first of many consultation forums to inform the Board's task of developing national curriculum in English, mathematics, the sciences, and history."*

A final implementation date has not yet been announced.

8.3 Examination Process

In the period to 1960 the NSW Public Instruction Act was amended ten times. This followed the acceptance of proposals by the NSW Government for the reorganization of secondary education in New South Wales, as contained in the Report of the Committee on Secondary Education of 1957. This committee of ten, whose membership covered a broad range of educational and community interests, met over the period of five years during 1953-1957 under the Chairmanship of Dr H. S. Wyndham, who was at the time the Director-General of Education in New South Wales (Section 8.1).
Under Wyndham a new era in education began with the School Certificate (after 4 years of high school) and the Higher School Certificate (after 2 additional years) replacing the Intermediate and Leaving Certificates leading to university matriculation.

The Board of Studies records indicate that in 1965, 29 000 students sat for the Leaving Certificate. Two years later only 18 000 attempted the first Higher School Certificate. By 1970 this number increased by over 50% to 29 000 students. During subsequent decades the retention rate of student numbers in senior years continued to increase, well beyond the expectations of the Committee making the HSC almost universal with enrolments reaching over 69 000 students in 2009.

8.3.1 Higher School Certificate

In 1962 secondary education was completely transformed in New South Wales following the implementation of the Wyndham Report (Wyndham, 1957). The first group of students completed the new Higher School Certificate (HSC) in 1967.

Mathematics enrolment at all levels grew as the student population broadened. The key influence on enrolment in advanced courses (including mathematics) was the impact of scaling on results. The scaling was the means by which universities differentiated between less demanding and more demanding courses. In other words if a student received 60% in a "less demanding" subject, it was then scaled down. However if a student receiving 60% in a "more demanding" subject, it was scaled up, increasing their chances of gaining a place at university. The University Admissions Board used statistical analysis to determine the rating of each subject. According to the Board of Studies the scaling of marks conferred an unfair benefit on students studying at higher levels, so the Board decided not to use scaled marks for the Higher School Certificate and in 2002 in a HSC Newsletter it stated:

> *"In the new HSC marks are no longer scaled to fit a predetermined distribution. The distribution of marks in new HSC courses is aligned to the standards students have achieved. There are no longer any artificial restrictions placed on the number of students who can achieve in each mark range. Students who achieve high standards are now guaranteed high marks".* (BOS, 2002)

Throughout this earlier period assessment was by an external examination only, however after 1986 external assessment was equally combined with a school based assessment. The marks were moderated and expressed as a single number (between 1 and 100) called Tertiary Entrance Rank (TER) and in 2001 this was replaced by University Admissions Index (UAI) until June 2009 when Australian Tertiary Admission Rank (ATAR) replaced the Universities Admission Index (UAI) in NSW and the ACT. ATAR is being introduced across all states and territories (other than Queensland) over the next two years in an aim to move towards national consistency. Before ATAR conversion factors were used for students wishing to apply to interstate universities and vise versa.

At one time the Higher School Certificate was the only means of gaining a place at a university in New South Wales. With changing economic times as the universities were becoming self-funded to some extent, they started to recruit full fee paying overseas students from Asia and other parts of the world. Many of these recruited students enrolled in Foundation Courses set up by various universities as well as independent colleges. These colleges are aligned to different universities and on the successful completion of their program the students are guaranteed a place at a university of their choice, without having to pass the Higher School Certificate. Today there are a number of alternative paths available to gain entry to universities such as:

- International Baccalaureate examination – offered by about 15 schools in New South Wales;
- Tertiary Preparation Course (TPC) - offered by TAFE; and
- Mature age students, with or without an HSC.

Consequently in New South Wales (and other States) universities compete with each other for students as well as for funding.

8.3.2 Matriculation

The introduction of the Higher School Certificate clearly indicated the end of the Matriculation, with the last set of examinations held in 1978. The information in the University of Sydney Calendar for 1978 stated that:

> *"The (Matriculation) examination will have the same difficulty as the corresponding subject in the Higher School Certificate."*

In the following year's Calendar and thereafter, under the heading of Matriculation, the University had a note saying:

> *"The University of Sydney (Matriculation) examination has been suspended for the time being."*

It would appear that the University of Sydney Matriculation examination was only used by students who failed to gain university entry through either the Leaving Certificate (till 1967) or the Higher School Certificate. On passing the Matriculation, students were accepted in all tertiary institutions.

In 1967 according to the University Calendar, 900 students attempted the Matriculation examination. By 1974 this number had dropped to just 400 students, compared with 32 000 students who sat for the Higher School Certificate. One might suggest that the cost of producing and marking the Matriculation could well have been a catalyst in the demise of the Matriculation examination, particularly as additional paths opened to gain university entry (see Section 8.3.1).

8.4 Description of Examination Papers

8.4.1 Examinations in the 1960s

By 1960 the number of examination papers in mathematics had increased from three to four, recognizing the need for an extra level required to accommodate the wide ability of students. There was one non-calculus course for both the Leaving Certificate and Matriculation called *General Mathematics* and a further three academic levels with calculus offered by the Leaving Certificate. In the 1960s the corresponding Matriculation course offered just one subject with calculus (Table 8.1).

Table 8.1 Summary of examination papers 1962 – 2008

Year Course	with Calculus 1st Level	 2nd Level	 3rd Level	without Calculus
1962 Leaving	Mathematics I Honours Mathematics II Honours	Mathematics I Pass Mathematics II Pass	Mathematics III Pass	General Mathematics
1962 Matriculation		**Mathematics I Mathematics II**		**General Mathematics**
1973 HSC	1st Level Paper A	2nd Level Paper B	Paper C	3rd Level Paper D
1974 Matriculation		**Level 2F Paper B**	**Level 2F/S Paper C**	**Level 3 Paper D**
1982 HSC	Mathematics 4 Unit	Mathematics 3 Unit	Mathematics 2 Unit	Mathematics in Society
1992 HSC	Mathematics 4 Unit	Mathematics 3 Unit	Mathematics 2 Unit	Mathematics in Society
2002 HSC	Mathematics Extension 2	Mathematics Extension 1	Mathematics 2 Unit	General Mathematics
2008 HSC	Mathematics Extension 2	Mathematics Extension 1	Mathematics 2 Unit	General Mathematics

By the time the Matriculation examination ceased to exist in 1978, this had increased to two calculus courses and two separate sets of examinations.

8.4.2 Transition to the Higher School Certificate

The change from Leaving Certificate subjects to Higher School Certificate subjects meant that the separate Mathematics I & II and Mathematics I & II Honours papers, each three hours in duration, were replaced by a single Mathematics Paper A and B, thereby halving the examination times. The letters A, B, C and D did not have any particular significance apart from setting order of difficulty. The examination papers were replaced as shown in Table 8.2 below:

Table 8.2 Comparison between the Leaving Certificate and the HSC

Leaving Certificate (old)	**Higher School Certificate (new)**
General Mathematics (3 hrs)	Mathematics Paper D, 3rd. Level (3 hrs)
Mathematics III (3 hrs)	Mathematics Paper C, 2nd Level (3 hrs)
Mathematics I & II (6 hrs)	Mathematics Paper B, 1st/2nd Level (3 hrs)
Mathematics I & II Honours (6 hrs)	Mathematics Paper A, 1st Level (3 hrs)

Note: Students attempting Paper A (previously Mathematics I & II Honours) also had to sit for Paper B (previously Mathematics I & II)

8.4.3 Matriculation examination

With the introduction of the Higher School Certificate the corresponding number of Matriculation papers offered by the University of Sydney had increased from two to three examinations. However with the introduction of the Wyndham Scheme the Matriculation examination finally came to end in 1978 (Table 8.3).

Table 8.3 Matriculation comparison table

OLD – 1960s		**NEW – until 1978**	
Matriculation	***Leaving Certificate***	***Matriculation***	***HSC***
General Mathematics	General Mathematics	Mathematics Paper D Third Level	Mathematics Paper D Third Level
	Mathematics III	Level 2F/S Paper C	Mathematics Paper C Second Level Short
Mathematics I & II	Mathematics I & II	Level 2F Paper B	Mathematics Paper B Second Level
	Mathematics I & II Honours		Mathematics Paper A First Level

Between 1970 and 2008 the names of the examination papers containing calculus were changed (see Table 8.4), however the content and format basically remained much the same, except for some changes in 4 Unit/Extension 2 and the introduction of General Mathematics in 2002.

Table 8.4 Description of all HSC examinations

1970s	1980s	1990s	After 2002
Mathematics Paper D Third Level	Mathematics in Society	Mathematics in Practice Mathematics in Society	General Mathematics
Mathematics Paper C Second Level Short	Mathematics 2U	Mathematics 2U	Mathematics 2U
Mathematics Paper B Second Level	Mathematics 3U	Mathematics 3U	Mathematics Extension 1
Mathematics Paper A First Level	Mathematics 4U	Mathematics 4U	Mathematics Extension 2

Note: Students attempting Mathematics 3U/Ext 1 had to pass Mathematics 2U while students attempting Mathematics 4U/Ext 2 had to pass Mathematics 3U/Ext 1

During the 1990s for a relatively short time there was also a fifth non-calculus mathematics paper called Mathematics in Practice introduced in 1991 which was particularly aimed towards lower ability and vocation oriented students, Mathematics in Practice did not count towards a university entrance score. Following the McGaw Report and with the introduction of the new syllabus in 2002, Mathematics in Practice and Mathematics in Society were replaced with a new (more rigorous) subject called General Mathematics. This was seen by the Board of Studies to be equivalent to other 2 Unit courses including the Mathematics 2 Unit course but without the calculus content.

8.5 Results

The results are separated into two groups, namely examinations with and without calculus content. Wherever applicable the Matriculation (M) examination was included with either the corresponding Leaving Certificate (LC) or the Higher School Certificate (HSC). The majority of examinations were selected in the year ending in 2, such as 1932, 1942, 1952, 1962, etc. This (second year) was chosen because all the examinations (with the exception of 1972) were available. Instead of 1972 which was not available, it was decided instead to use the 1973 HSC. This was compared with the 1974 Matriculation examination as this was the latest set of examinations found in the Mitchell Library.

8.5.1 Explanation of examination papers

Table 8.1 shows all the examinations produced at ten year intervals from 1962, noting that the 1962 was part of the LC and all subsequent examinations were from the HSC. The calculus examination papers were placed in three groups, namely:

1st Level – highest (most academically demanding) standard, students also had to attempt the 2nd Level examination

2nd Level – higher standard, students also had to attempt the 3rd Level examination

3rd Level – entry standard

The corresponding Matriculation examinations were also included, noting that the last examination was produced in 1978 (Section 8.3.2).

8.5.2 Examinations with calculus

During this period 24 papers containing calculus were analyzed compared with 8 papers that did not contain calculus. In 1962 there were 7 examinations compared with 3 examinations in 2008.

8.5.2.1 First level

Students attempting the first level also had to study and attempt the second level. There was no Matriculation examination to correspond with either the Leaving Certificate or the Higher School Certificate. To improve the appearance of the Figures 8.11 – 8.16 the names of the following topics was abbreviated: Geom (Geometry), Trig (Trigonometry), Prob (Probability) and Complex (Complex Numbers).

8.5.2.1.1 Content

The main topics tested were algebra, geometry, trigonometry, complex numbers and various calculus based questions (see Figures 8.1 – 8.9). Other topics such as projectile motion, induction, binomial theorem and conics came and went as they moved from time to time between the first and second level. Calculus-based questions increased from 30% to 50% during the period 1970 – 1980 (Figure 8.2).

This was possibly due to the technology boom and the boost to science oriented subjects in the USA following the successful launch of the Russian Sputnik satellite in 1957. The ease of use of word processors changed the appearance of the papers with the increased use of diagrams (see Figure 8.10).

Figures 8.11 and 8.12 indicate that the transition from the LC to the HSC had little effect on the examinations, however during the next two decades the calculus content increased significantly (see Figures 8.13 and 8.14). There were changes to the syllabus in the 1990s and this is reflected in Figures 8.15 and 8.16. In the 1980s trigonometry disappeared and was replaced again by geometry, while matrices disappeared in the 1980s to be replaced with questions on induction (see Figure 8.7 and 8.8). Probability, complex numbers and conics continued to be part of the syllabus throughout this period (Figures 8.5, 8.6 and 8.9).

Content by topics, Figures 8.1 – 8.9

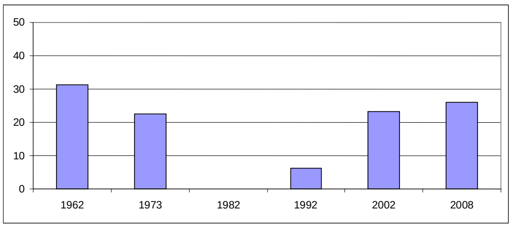


Figure 8.1 Content: Algebra

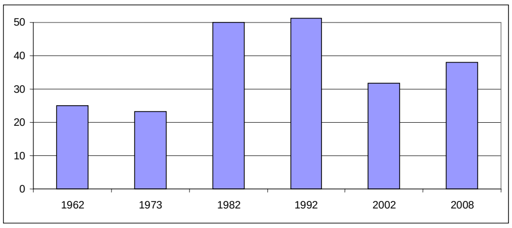


Figure 8.2 Content: Calculus

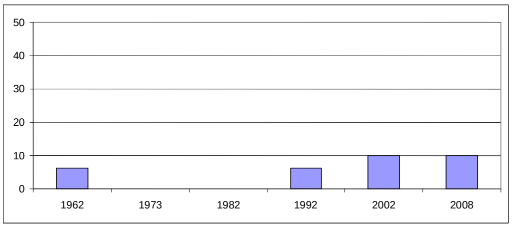


Figure 8.3 Content: Geometry

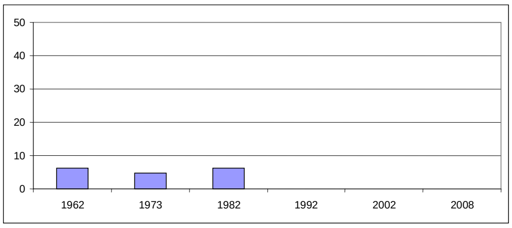


Figure 8.4 Content: Trigonometry

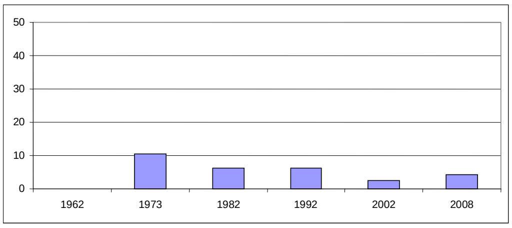


Figure 8.5 Content: Probability

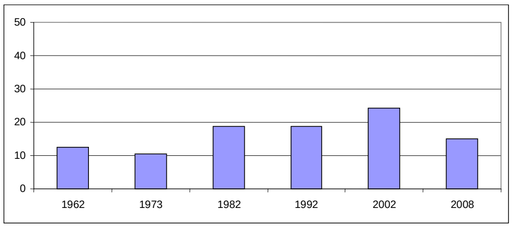


Figure 8.6 Content: Complex numbers

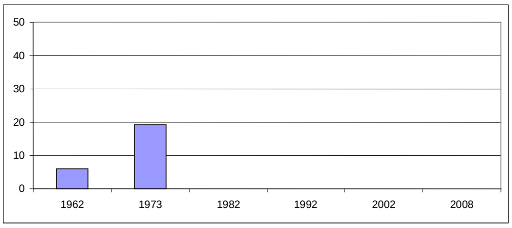


Figure 8.7 Content: Matrices

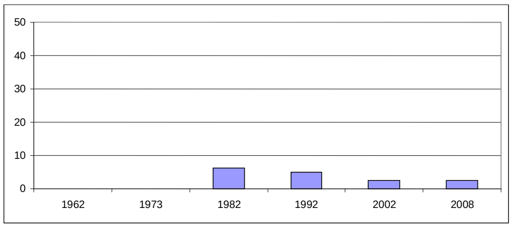


Figure 8.8 Content: Induction

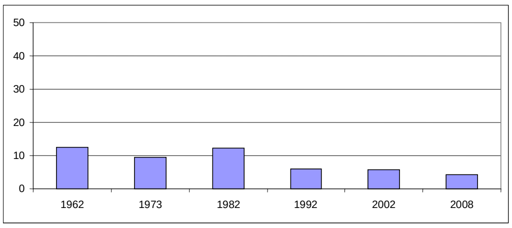


Figure 8.9 Content: Conics

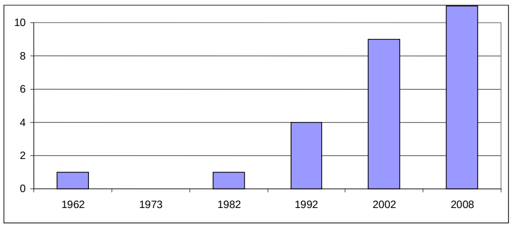


Figure 8.10 Diagrams, graphs and tables

Content at ten year intervals, Figures 8.11 – 8.16

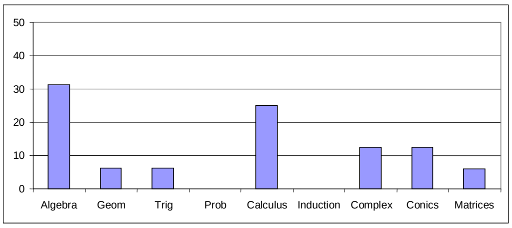


Figure 8.11 Content in 1962

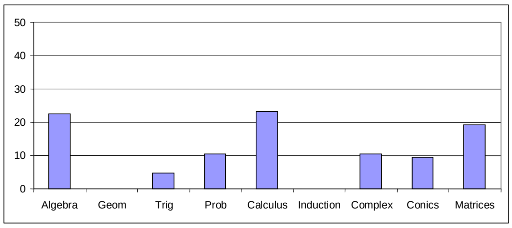


Figure 8.12 Content in 1973

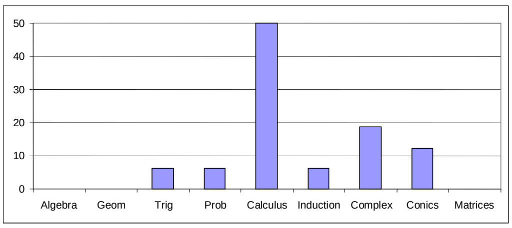


Figure 8.13 Content in 1982

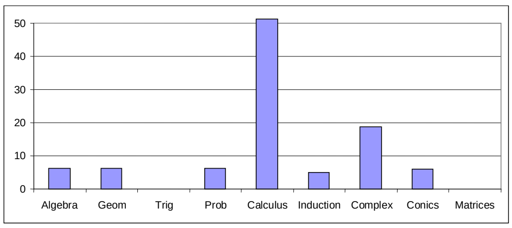


Figure 8.14 Content in 1992

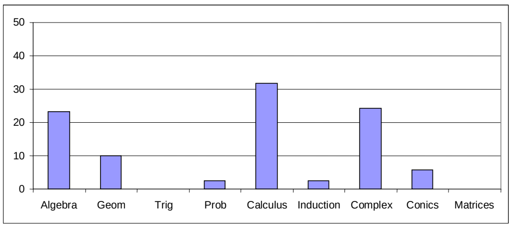


Figure 8.15 Content in 2002

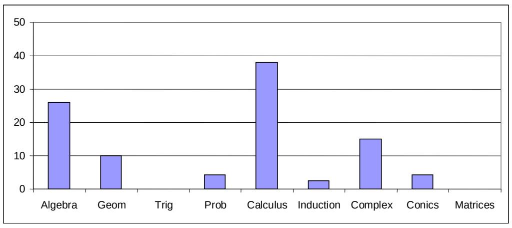


Figure 8.16 Content in 2008

8.5.2.1.2 Instructions

Between 50% and 60% of the examinations used a combination of *find*, *prove* and *show* (Figures 8.17 – 8.19) however as shown by Figure 8.18 the instruction *prove* had almost disappeared. Instructions *state*, *deduce*, *what is*, *write down* and *sketch* were used for about 35 – 40% of the examinations, representing a mixture of rote learning and deductive reasoning. The remaining 5 – 10% used instructions *solve*, *calculate*, *evaluate*, *simplify how*, *discuss*, *describe* and *explain*, some of these terms such as *evaluate*, *discuss*, *describe* and *explain* indicating that on a few occasions students were asked to apply deductive thinking to solve problems. As indicated by Figure 8.24A all the examinations used between 10 – 14 different instructions.

Instructions, Figures 8.17 – 8.24

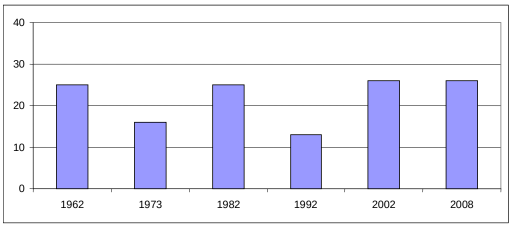


Figure 8.17 Instructions using Find

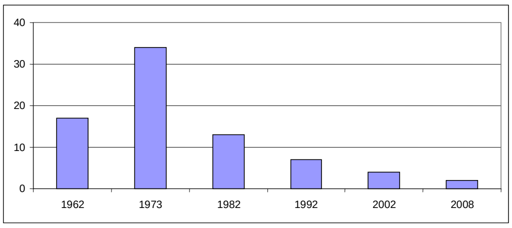


Figure 8.18 Instructions using Prove

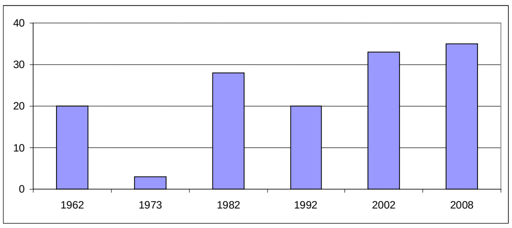


Figure 8.19 Instructions using Show

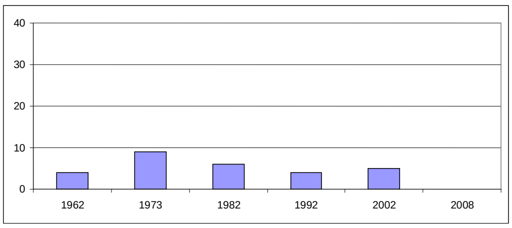


Figure 8.20 Instructions using State

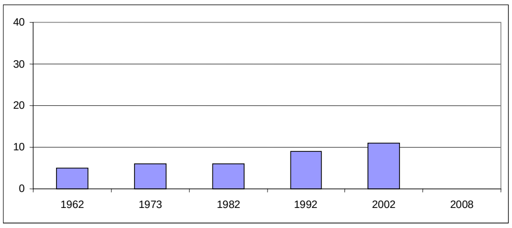


Figure 8.21 Instructions using Deduce

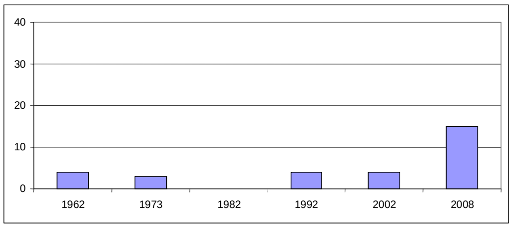


Figure 8.22 Instructions using What is

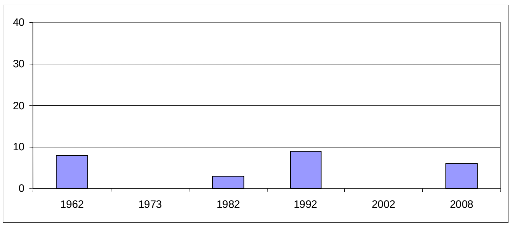


Figure 8.23 Instructions using Write down

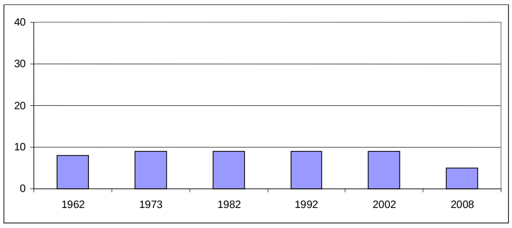


Figure 8.24 Instructions using Sketch

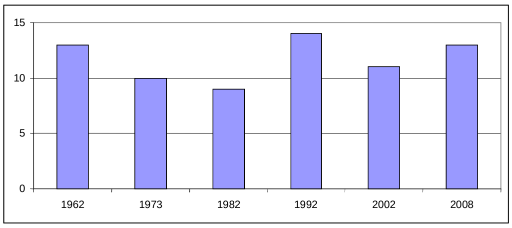


Figure 8.24A Variety of Instructions

Instructions at ten year intervals, Figures 8.11 – 8.16

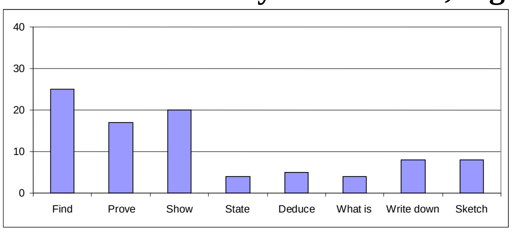


Figure 8.25 Instructions used in 1962

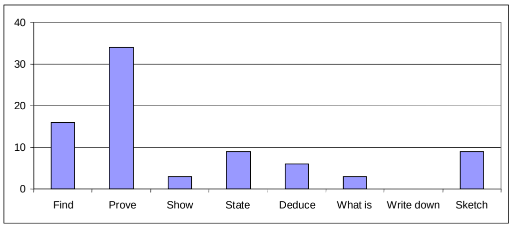


Figure 8.26 Instructions used in 1973

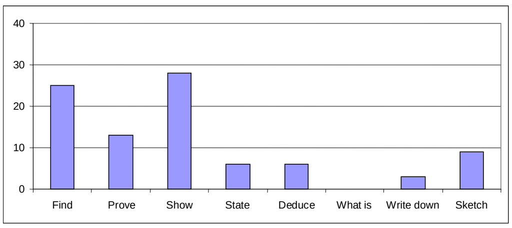


Figure 8.27 Instructions used in 1982

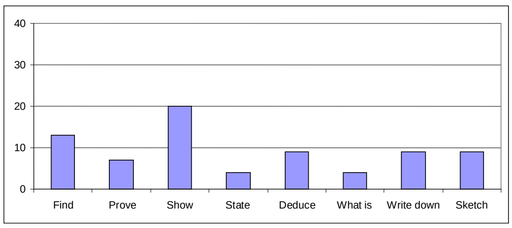


Figure 8.28 Instructions used in 1992

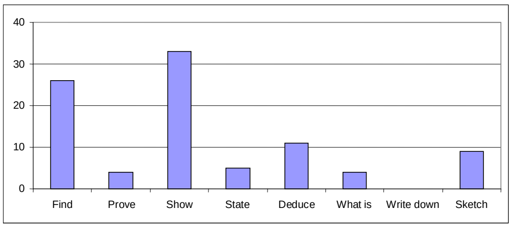


Figure 8.29 Instructions used in 2002

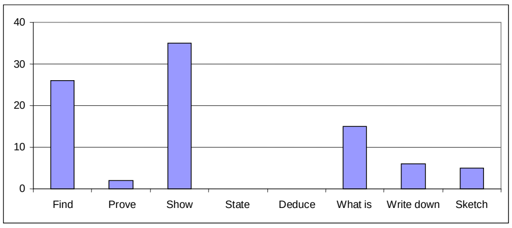


Figure 8.30 Instructions used in 2008

8.5.2.2 Second level

During this period there were only two sets of corresponding Matriculation examinations in 1962 and 1972. In 1978 the University of Sydney decided to indefinitely suspend any further Matriculation examinations.

8.5.2.2.1 Content

Since the 1950s six hours of examinations had been reduced to just two hours in length however as Figures 8.31 – 8.41 indicates the proportions of each paper of the topics remained fairly constant. This would indicate that there were fewer questions for each topic and generally less knowledge or rigor required to solve the problems because less time was allocated to teach each topic. Questions on projectile motion (Figure 8.39) were introduced by the 1970s and simple harmonic motion (Figure 8.40) in the 1980s. Induction replaced questions on series (Figures 8.37 and 8.38) and apart from a short period during the 1980s questions on the binomial theorem were always included (Figure 8.36). As Figures 8.31 - 8.48 indicate the same topics were tested without any changes since the 1990s. The binomial theorem was earlier tested at the first (highest) level until 1960s when it was shifted down to the second level. The Matriculation examinations from the 1960s followed the same pattern and format of LC and HSC examinations as seen in Figures 8.43 and 8.44.

Apart from the 1960s the total calculus content of the examinations was generally between 45 – 50% (see Figure 8.41). There were fewer diagrams in the second level than the first level (see Figure 8.42), nevertheless the graphical component increased after the 1960s.

Content by topics, Figures 8.31 – 8.41

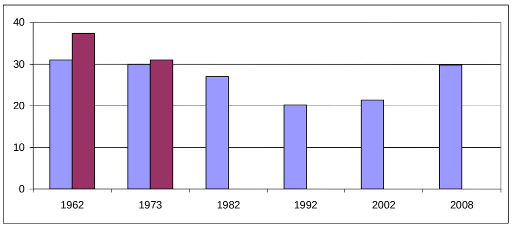


Figure 8.31 Content: Algebra

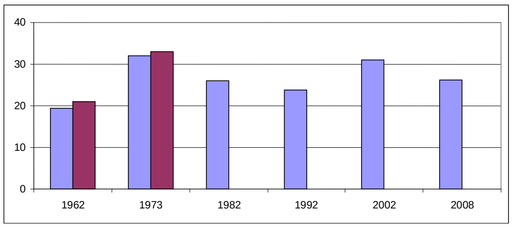


Figure 8.32 Content: Calculus

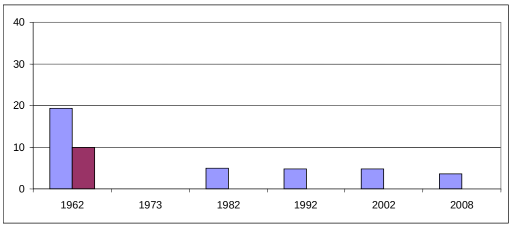


Figure 8.33 Content: Geometry

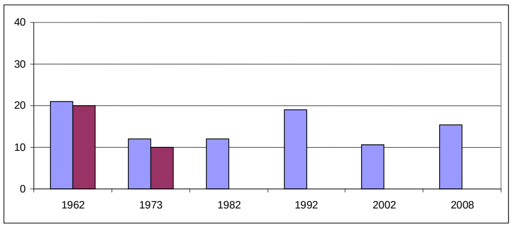


Figure 8.34 Content: Trigonometry

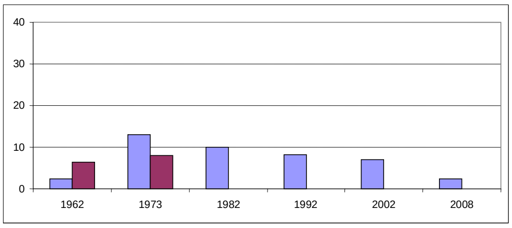


Figure 8.35 Content: Probability

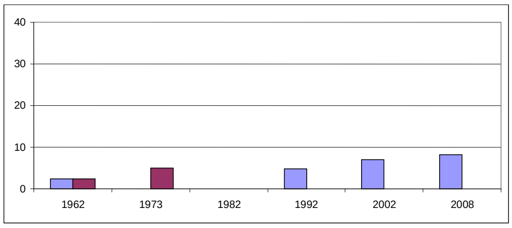


Figure 8.36 Content: Binomial theorem

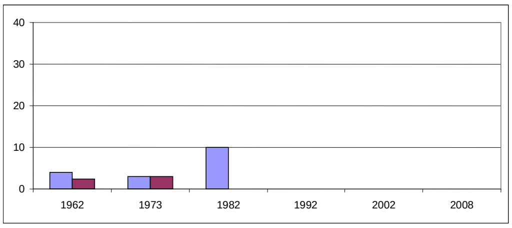


Figure 8.37 Content: Series

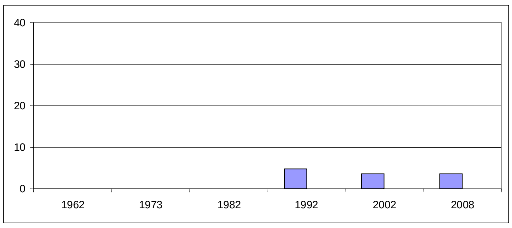


Figure 8.38 Content: Induction

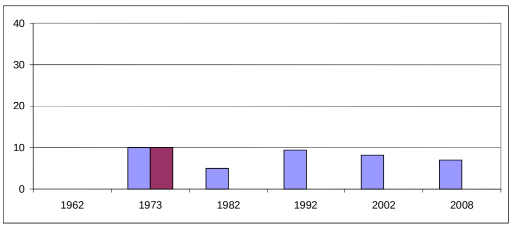


Figure 8.39 Content: Projectile motion

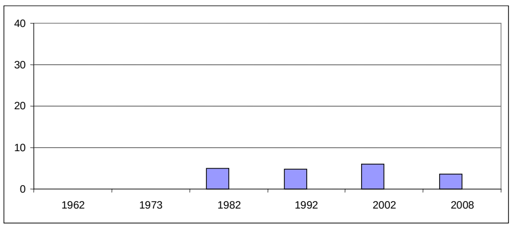


Figure 8.40 Content: S.H.M.

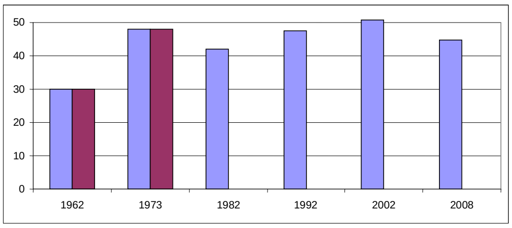


Figure 8.41 Total of all calculus

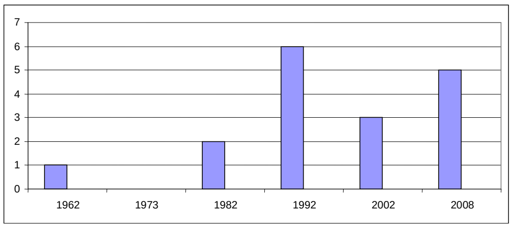


Figure 8.42 Diagrams, graphs and tables

Content at ten year intervals, Figures 8.43 – 8.48

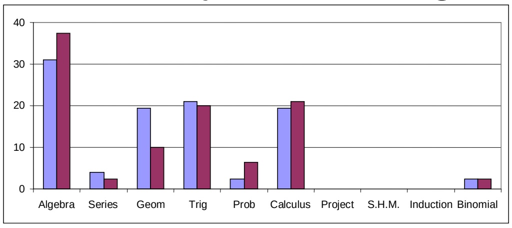


Figure 8.43 Content in 1962

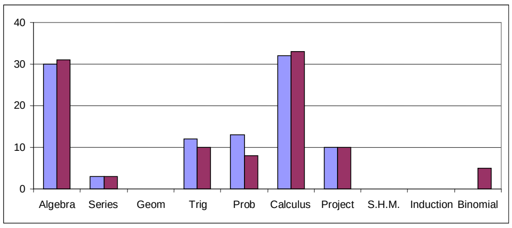


Figure 8.44 Content in 1973

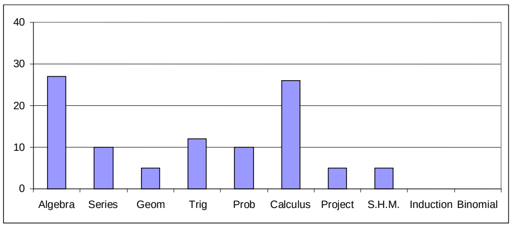


Figure 8.45 Content in 1982

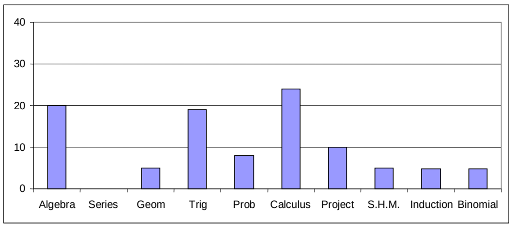


Figure 8.46 Content in 1992

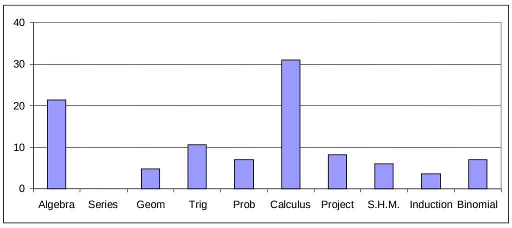


Figure 8.47 Content in 2002

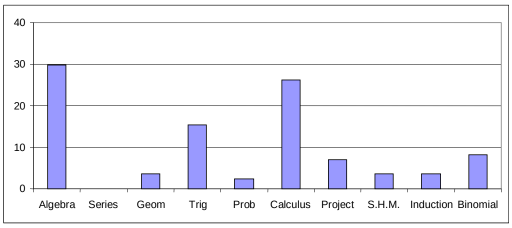


Figure 8.48 Content in 2008

8.5.2.2.2 Instructions

Between 50% – 60% of the examinations used *find* and *show*, indicating that the questions were specific in their requirements (Figures 8.49 and 8.50). The lack of *prove* further indicates a direction away from rote learning. *Calculate*, *evaluate*, *what is*, *write down* and *sketch* represent a further 30% (Figures 8.51 – 8.55) and the balance was made up of *prove*, *solve*, *state*, *deduce* and *explain* (not shown). Based on the instructions used for the second level examinations, one might conclude that this subject required fewer deductive skills than the first level examinations. Only 5% of the second level used deductive style instructions such as *deduce*, *evaluate*, *discuss*, *describe* and *explain*, compared with 12% of first level instructions (not shown). According to Figure 8.55A the variety of instructions remained constant throughout this period. This would indicate that the style and number of questions stayed the same between 1962 and 2008.

Instructions, Figures 8.49 – 8.55

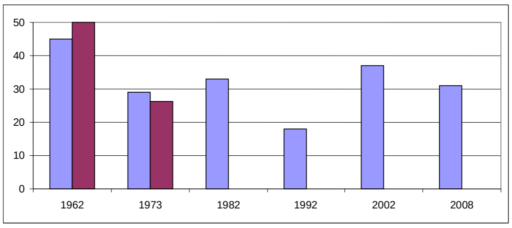


Figure 8.49 Instructions using Find

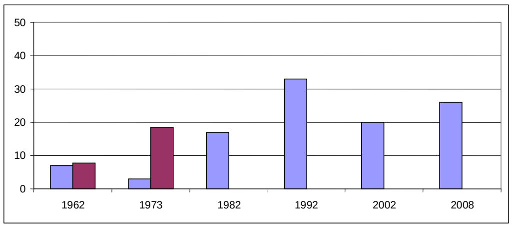


Figure 8.50 Instructions using Show

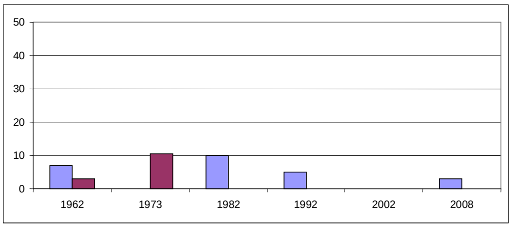


Figure 8.51 Instructions using Calculate

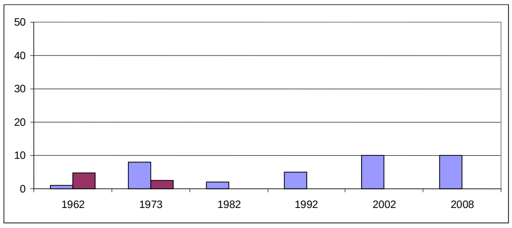


Figure 8.52 Instructions using Evaluate

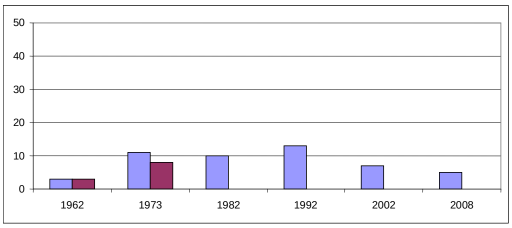


Figure 8.53 Instructions using What is

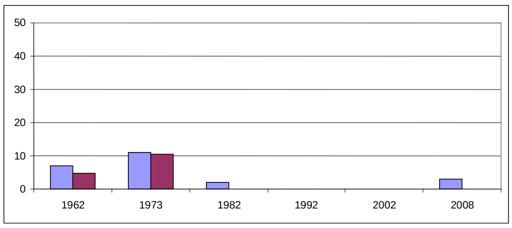


Figure 8.54 Instructions using Write down

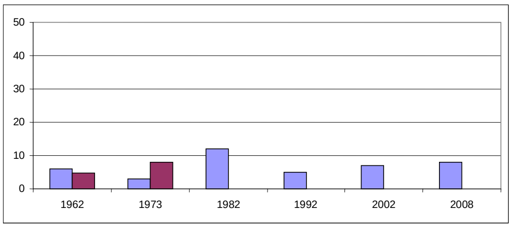


Figure 8.55 Instructions using Sketch

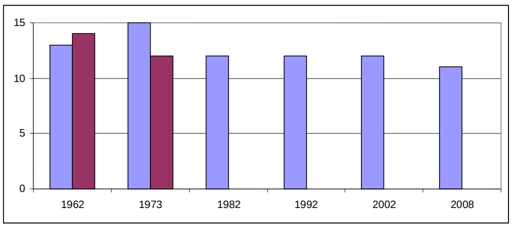


Figure 8.55A Variety of instructions

Figures 8.56 and 8.57 indicate that during the 1960s and 1970s the Matriculation examination closely followed the style of the corresponding LC and HSC. According to the Figures 8.58 -8.61 there were some small variations in using the instructions *find* and *show* between 1982 and 2008, however *calculate, evaluate, what is, write down* and *sketch* stayed the same.

Instructions at ten year intervals, Figures 8.56 – 8.61

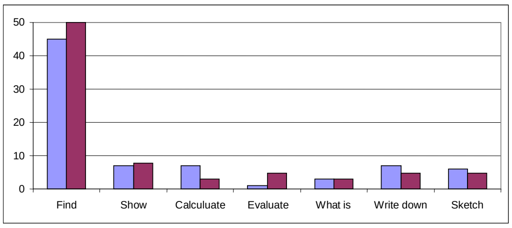


Figure 8.56 Instructions used in 1962

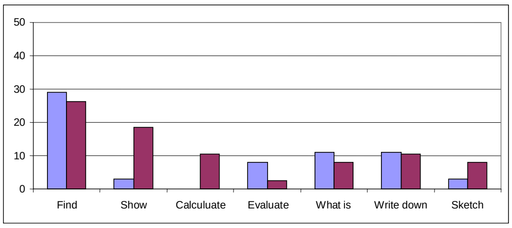


Figure 8.57 Instructions used in 1973

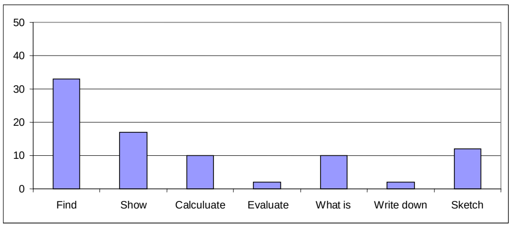


Figure 8.58 Instructions used in 1982

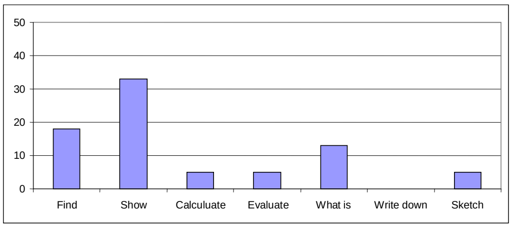


Figure 8.59 Instructions used in 1992

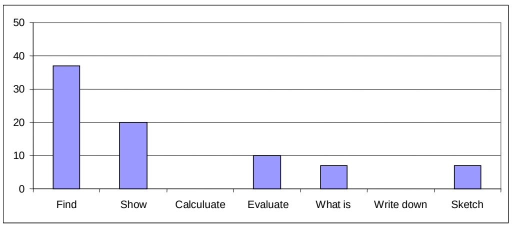


Figure 8.60 Instructions used in 2002

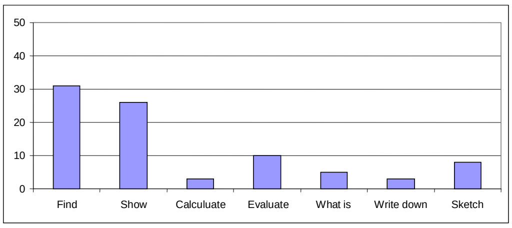


Figure 8.61 Instructions used in 2008

8.5.2.3 Third level

The 1962 examination was still part of the Leaving Certificate; all subsequent examinations were from the HSC. During this period there was only one corresponding Matriculation examination in 1974 (see Table 8.1). For the first time during this period all examinations were three hours long.

8.5.2.3.1 Content

The main topics tested continued to be algebra and calculus representing 75% – 80% of the examination (Figures 8.62 and 8.63). Calculus questions for all differentiation and integration of algebraic and exponential functions are shown in Figure 8.63 however differentiation and integration of trigonometric functions were shown as part of trigonometry. All calculus related questions including trigonometric functions are shown in Figure 8.68. The balance of 20% – 25 % was made up of a combination of questions on trigonometry, probability, series and finance. Geometry re-appeared in the 1980s and constituted about 5% of the examinations. Word processing became widespread by the 1980s, so more diagrams were included with the questions (see Figure 8.69) and remained constant until now. There has been no significant change in the syllabus since the 1980s and this constancy is also visible in Figures 8.72 – 8.75 however the style of questions have changed and this will be discussed in Section 8.5.2.3.2. It was also interesting to note that as the Matriculation examinations were winding down, there was only a small difference in the algebra and calculus content, otherwise the style and format of the 1974 Matriculation was very similar to the 1973 HSC (see Figure 8.71)

Content by topics, Figures 8.62 – 8.67

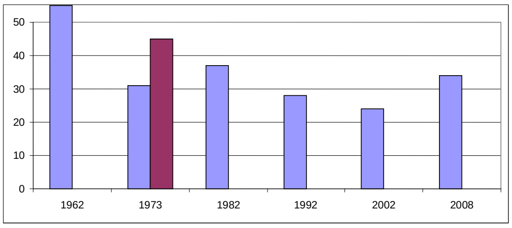


Figure 8.62 Content: Algebra

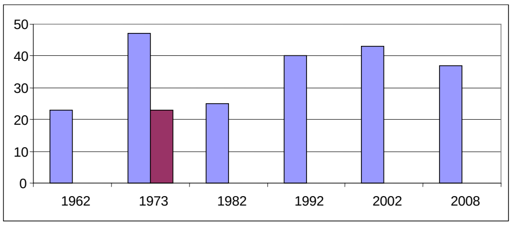


Figure 8.63 Content: Calculus

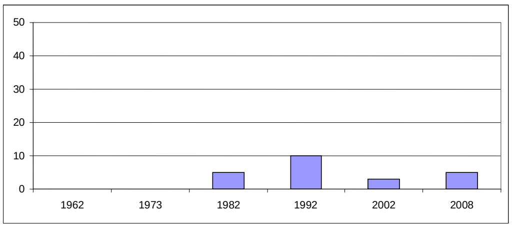


Figure 8.64 Content: Geometry

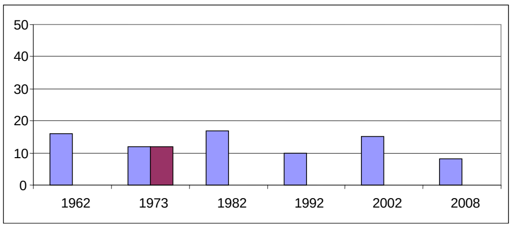


Figure 8.65 Content: Trigonometry

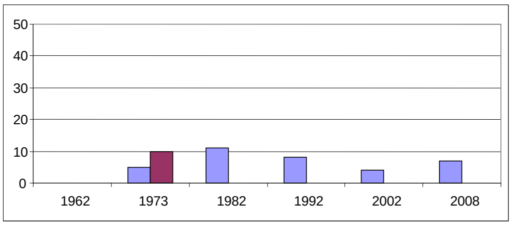


Figure 8.66 Content: Probability

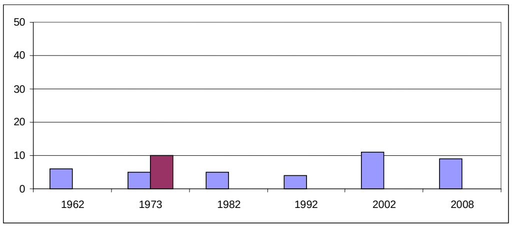


Figure 8.67 Content: Series and Finance

In general Figures 8.70 – 8.75 indicate that the content for algebra, series & finance, geometry, trigonometry, probability and calculus between 1962 and 2008 changed little. Specifically, calculus questions during the past twenty years have remained between 40% – 50% as shown in Figure 8.68.The number of graphics had jumped to10 in 1992 and also remained constant, as there was no change in the syllabus (Figure 8.69).

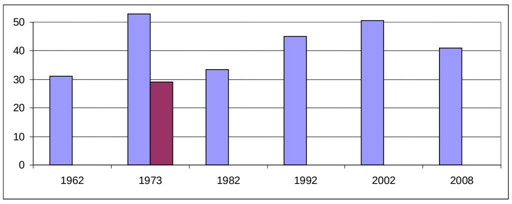


Figure 8.68 Content of all calculus

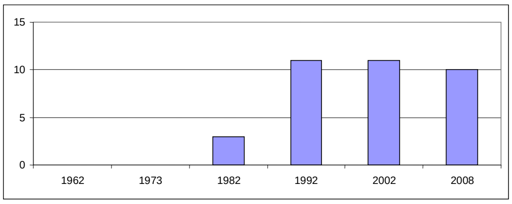


Figure 8.69 Diagrams, graphs and tables

Content at ten year intervals, Figures 8.70 – 8.75

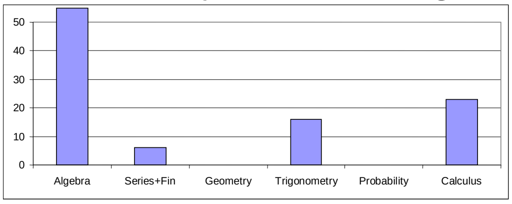


Figure 8.70 Content in 1962

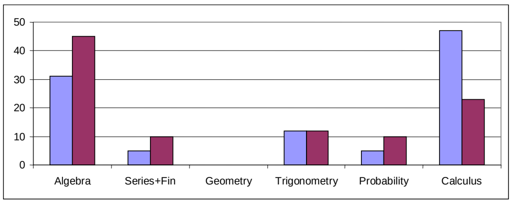


Figure 8.71 Content in 1973

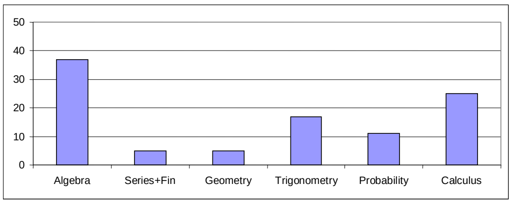


Figure 8.72 Content in 1982

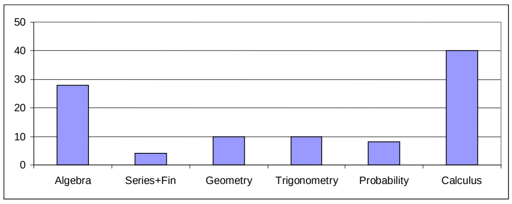


Figure 8.73 Content in 1992

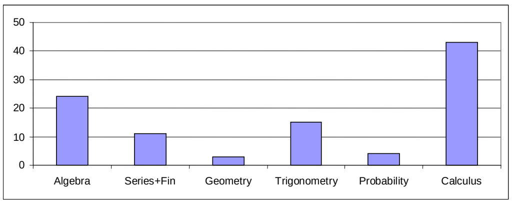


Figure 8.74 Content in 2002

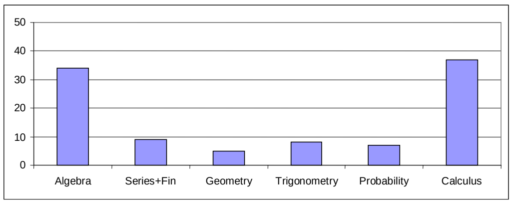


Figure 8.75 Content in 2008

8.5.2.3.2 Instructions

The commonly used instructions, namely *find, show, calculate, what is, write down* and *sketch* accounted for 75% – 80% of the examinations (see Figures 8.76 – 8.81 and 8.83 – 8.88). The remaining 20% – 25% used terms such as *prove, solve, state, deduce, evaluate, verify, simplify, differentiate, integrate, establish, discuss, describe* and *explain*, however these instructions individually were all less than 5% of any one paper. The point of interest being, that the terms *prove* and *state* used extensively in previous decades almost disappeared. This indicated a trend away from rote learning with a move towards giving explanation and logical reasoning (Afamasaga, 2007). The range of instructions used, as listed by the Board of Studies has gradually expanded (see Figure 8.82) by about 50%. Even though the syllabus had not altered, the increased number of instructions changed the way in which questions were asked, possibly reflecting social changes and a trend towards deductive thinking and reasoning.

Instructions, Figures 8.76 – 8.81

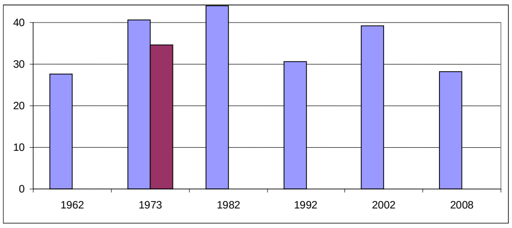


Figure 8.76 Instructions using Find

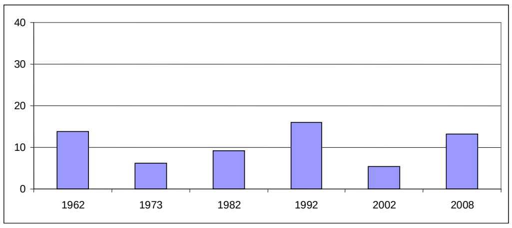


Figure 8.77 Instructions using Show

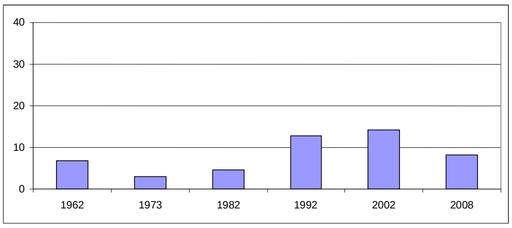


Figure 8.78 Instructions using Calculate

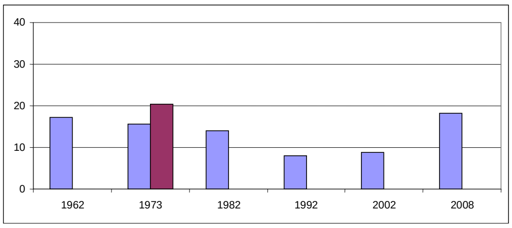


Figure 8.79 Instructions using What is

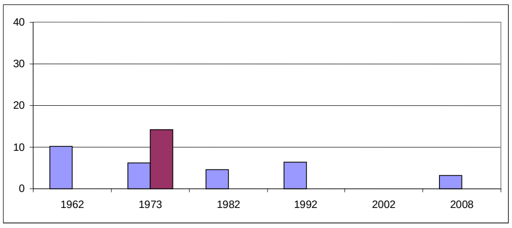


Figure 8.80 Instructions using Write down

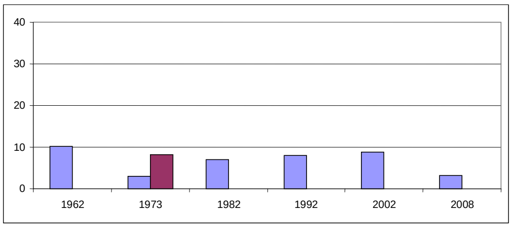


Figure 8.81 Instructions using Sketch

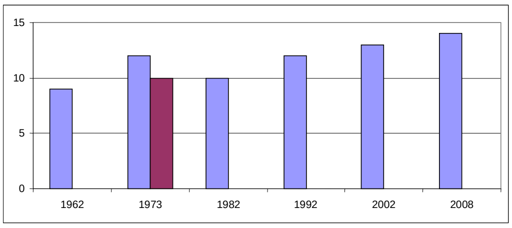


Figure 8.82 Variety of instructions

Figure 8.84 once again indicated the similarity between the use of instructions for both the HSC and Matriculation examinations. Figures 8.83 – 8.88 show that *Find* was consistently the most frequently used instruction generally followed by *show* and *what is.* The other instructions *calculate, write down* and *sketch,* each account for less than 10% usage.

Instructions at ten year intervals, Figures 8.83 – 8.88

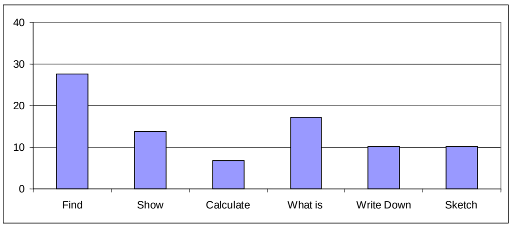


Figure 8.83 Instructions used in 1962

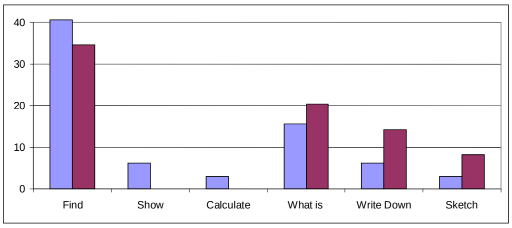


Figure 8.84 Instructions used in 1973

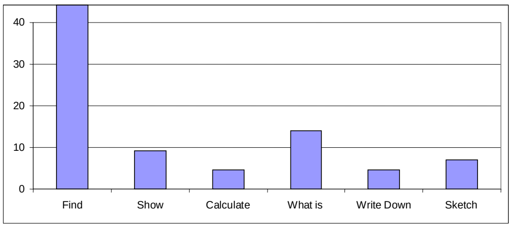


Figure 8.85 Instructions used in 1982

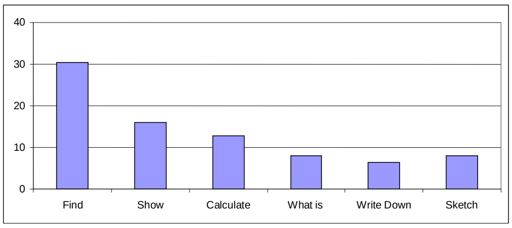


Figure 8.86 Instructions used in 1992

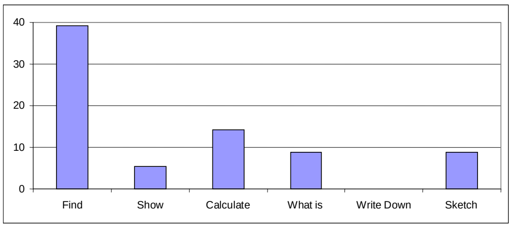


Figure 8.87 Instructions used in 2002

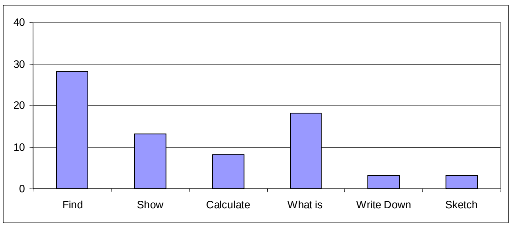


Figure 8.88 Instructions used in 2008

8.5.3 Examinations without calculus

Since 1962, this subject has changed its name from General Mathematics to 3rd. Level, then to Mathematics in Society and in 2002 back to General Mathematics (see Table 8.1). General Mathematics is the only course that took into account the changes and developments in technology by introducing computing as one of its components in the 1970s. In 2002 this topic was removed from the syllabus with the introduction of the new revamped General Mathematics and at this point graphics calculators were also allowed (to be used only in the General Mathematics examination) along with previously accepted scientific calculators.

8.5.3.1 Content

The duration of the examination paper was reduced from three hours to two and a half hours however the total number of questions remained constant. By 1990 the format of this paper also underwent change, with multiple-choice questions being introduced. This was an important change in the format of the examination (see Section 8.6). Some people in education believe that this change was to reduce the marking time and the cost of marking the examination papers.

The content of arithmetic & algebra and measurement remained constant (Figures 8.89 – 8.90). Geometry completely disappeared by the 1980s (see Figure 8.91) while trigonometry also continued to decline steadily after the 1990s (see Figure 8.92). The Computing option (not shown) was replaced with Financial Mathematics and Statistics (see Figures 8.93 and 8.94). Probability also remained constant since the 1980s (Figure 8.95). With the growing use of word processors and the ease with which text could be combined with graphics, there was a significant overall increase in the use of diagrams, graphs and tables (see Figure 8.97). Throughout this period arithmetic and algebra continued to dominate this subject by consistently taking up 20 – 35% of the course (Figure 8.98).

Content by topics, Figures 8.89 – 8.96

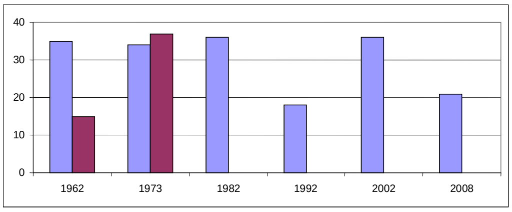


Figure 8.89 Content: Arithmetic and Algebra

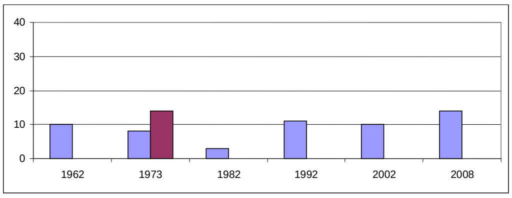


Figure 8.90 Content: Measurement

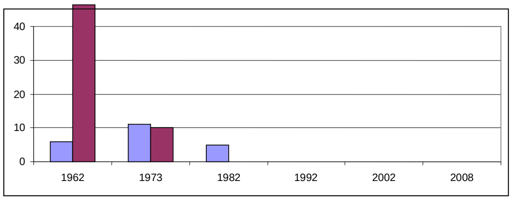


Figure 8.91 Content: Geometry

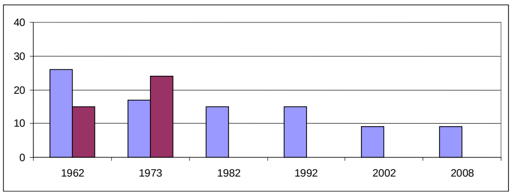


Figure 8.92 Content: Trigonometry

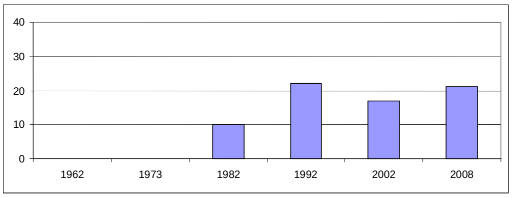


Figure 8.93 Content: Financial mathematics

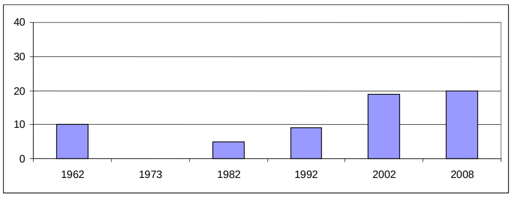


Figure 8.94 Content: Statistics

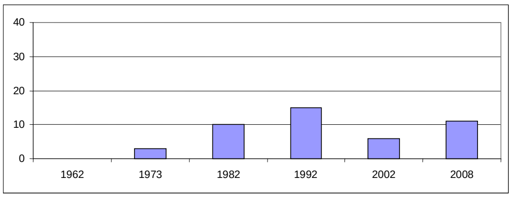


Figure 8.95 Content: Probability

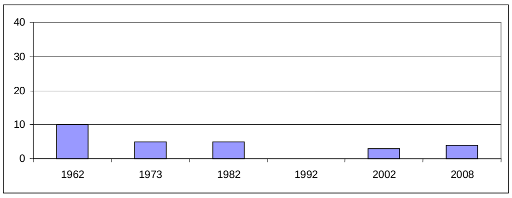


Figure 8.96 Content: Graphs

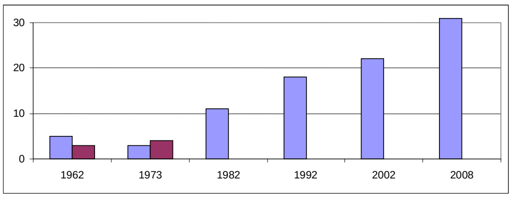


Figure 8.97 Diagrams, graphs and tables

Towards the end of the existence of the Matriculation examination there was similar content and format to the corresponding HSC examination. This result was also similar with the calculus-based subjects. Figure 8.98 shows the demise of geometry and one might be forgiven to think that the examiners of the Matriculation examination were left behind the HSC. In 1973 the Matriculation examiners decided to catch-up (Figure 8.99) and consequently the two examinations were almost identical to each other. Apart from arithmetic and algebra, the other subjects namely: financial mathematics, graphs, statistics, measurement, trigonometry and probability stayed similar between 1962 and 2008 (Figures 8.98 – 8.103). This would indicate that the topics examined stayed similar.

Content at ten year intervals, (Figures 8.98 – 8.103)

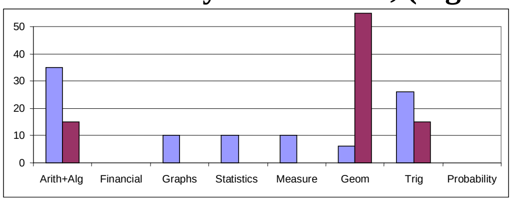


Figure 8.98 Content in 1962

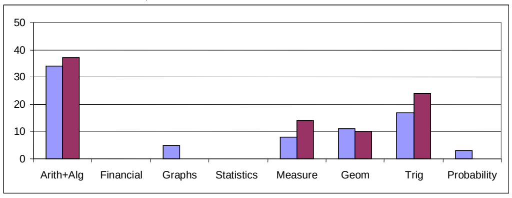


Figure 8.99 Content in 1973

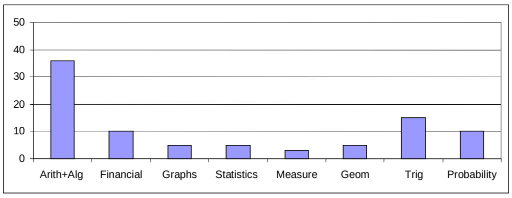


Figure 8.100 Content in 1982

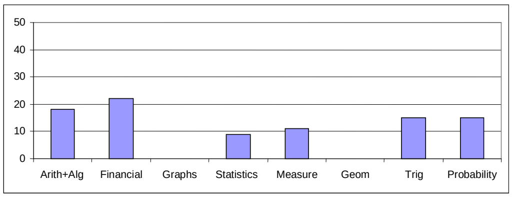


Figure 8.101 Content in 1992

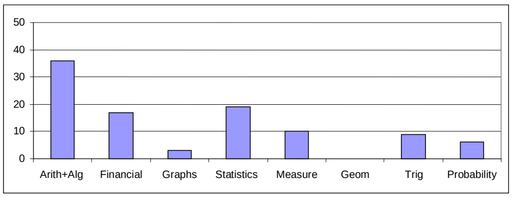


Figure 8.102 Content in 2002

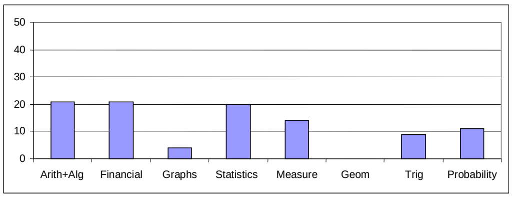


Figure 8.103 Content in 2008

8.5.3.2 Instructions

Traditionally the instructions *find* and *what is,* were used in 50% of the examinations, however change due to the requirements that "all questions must be questions" the term *find* (the most commonly used instruction in all mathematics examinations) virtually disappeared by 2008 (see Figure 8.104) and it was replaced by *what is* (see Figure 8.105). The next 40% of instructions were a combination of *how, which, calculate, sketch* and *write down*. Again these are the same terms used in all other mathematics examinations. Apart from a slight increase in the number of instructions when General Mathematics was introduced in 2002, the number of instructions stayed the same between 1962 and 2008 (Figure 8.110A).

Instructions, Figures 8.104 – 8.110

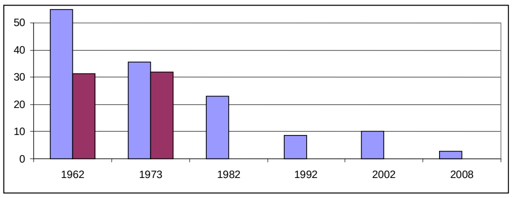


Figure 8.104 Instructions using Find

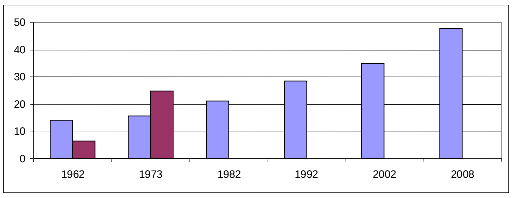


Figure 8.105 Instructions using What is

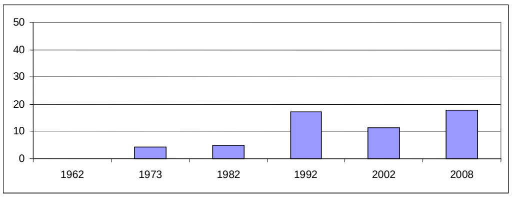


Figure 8.106 Instructions using How

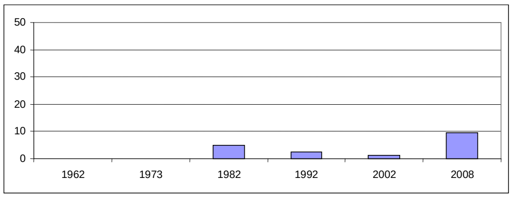


Figure 8.107 Instructions using Which

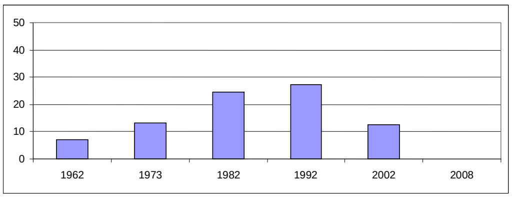


Figure 8.108 Instructions using Calculate

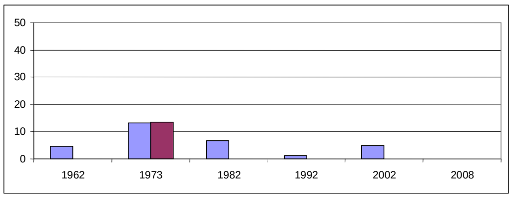


Figure 8.109 Instructions using Sketch

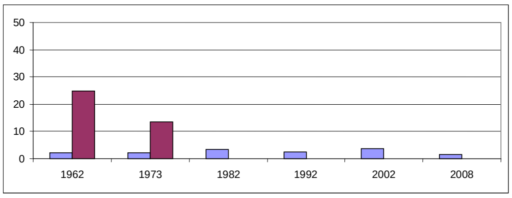


Figure 8.110 Instructions using Write down

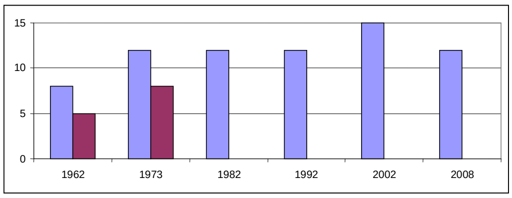


Figure 8.110A Variety of Instructions

In 1962 both sets of examinations used only three or four instructions indicating little variety in the style of questions (Figure 8.111). The 1974 Matriculation followed the instruction style of the 1973 HSC examination (Figure 8.112). Figures 8.113 and 8.114 are quite similar as there was no change to the syllabus. The pattern changed again with the introduction of the curriculum in 2002 (Figure 8.115) and in 2008 the paper once again had only a handful of instructions similar in number to the 1962 examination (Figure 8.116).

Instructions at ten year intervals, Figures 8.111 – 8.116

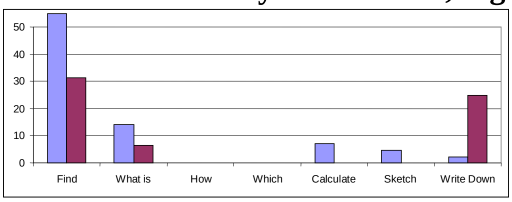


Figure 8.111 Instructions used in 1962

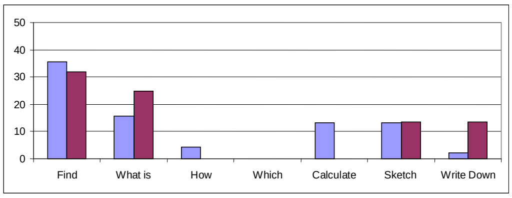


Figure 8.112 Instructions used in 1973

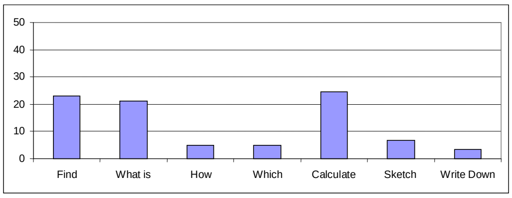


Figure 8.113 Instructions used in 1982

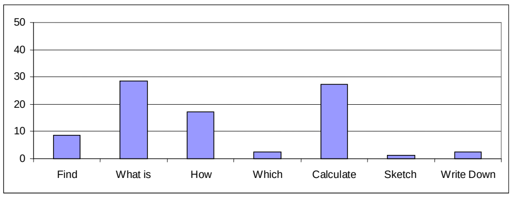


Figure 8.114 Instructions used in 1992

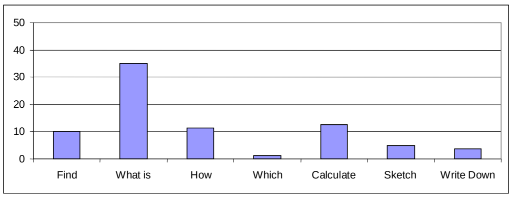


Figure 8.115 Instructions used in 2002

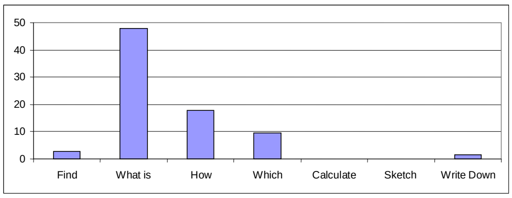


Figure 8.116 Instructions used in 2008

8.5.3.3 Comparing Mathematics in Society (MIS) and Mathematics in Practice (MIP)

As mentioned in Section 8.4.3 for a relatively short period between 1991 and 2002 there were five levels of mathematics examinations. Although MIP was an HSC subject it was not accepted for university entry. MIP might have been called “survival maths”, as many of these students wanted an HSC but had no plans towards tertiary studies. As Figure 8.117 indicates MIP focused on core topics to teach life skills such as arithmetic, algebra, financial mathematics, graphs and measurement. In addition to these topics MIS also contained statistics, trigonometry, probability and optional computing. MIP questions contained more than twice as many diagrams, graphs and tables compared with the MIS examination (see Figure 8.119). The MIP syllabus focused on students knowing how to read time tables and charts, hence the reason for the large number of diagrams. The difference in the use of instructions (Figure 8.118) demonstrated the different outcomes expected from the two subjects. As more topics were tested in the MIS course a greater number of instructions (Figure 8.120) were required for the questions. MIS in lighter color (blue), MIP in darker color (red).

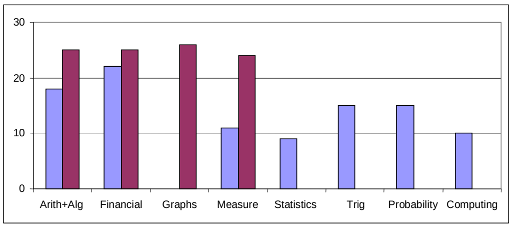


Figure 8.117 Topics for MIS and MIP

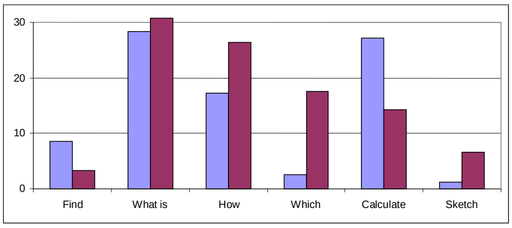


Figure 8.118 Instructions for MIS and MIP

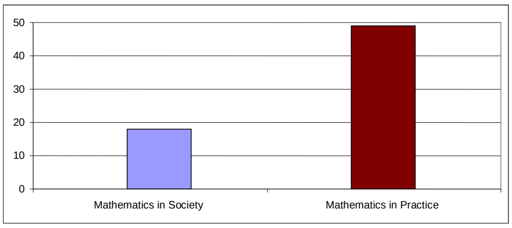


Figure 8.119 Diagrams for MIS and MIP

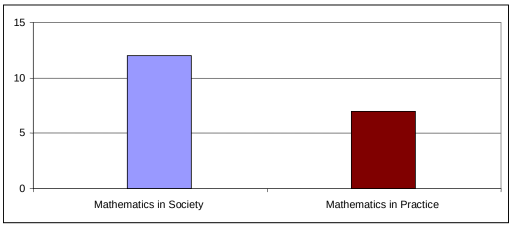


Figure 8.120 Variety of Instructions

8.6 Review

Let us consider the major educational and historical events at a glance since 1962. In education there was the Karmel Report (1973), first HSC (1967), last Leaving Certificate (1968), last Matriculation examination (1978), Metherell's *Excellence and Equity* (1989), Board of Studies established (1990), McGaw Report *Shaping their Future* (1997) and major syllabus and examination changes in 2002. In world affairs there was the Vietnam War (1959 – 1975), Gulf War (1990 – 1991), and the Iraq War (2003). In other words a lot has happened to affect our way of life, social values and attitudes.

In 1962 the population of New South Wales was 3.9 million people of which 17 900 (or 0.46%) of the population sat for their examinations at the end of secondary schooling. In 2008 the population of New South Wales had almost doubled to 6.7 million people of which 68 000 (or 1.01%) of the population sat for their HSC. In relative terms, twice as many students stayed at school to complete their final examinations. This was as a result of significant social changes in the community and its attitude towards the acceptance of education.

In 1962 Mathematics I & Mathematics II counted as two subjects with twice the class time allocated, clearly those students spent more time studying mathematics than the ones doing Mathematics 2 Unit in 2008. Although the topics and subject areas remained relatively constant with just half the class time available, one should accept that this subject had less overall content. On the other hand the variety of questions in calculus papers increased with the introduction of questions on projectile motion, S.H.M. induction and the binomial theorem, while in the non-calculus General Mathematics, financial mathematics and statistics were included.

Unfortunately (with the exception of General Mathematics) there has been little or no changes to the mathematics syllabus since the early 1990s and the results in Section 8.5 reflect this. This may also explain why there are schools and TAFE Colleges today that continue to use text books originally published thirty years ago by authors such as Jones and Couchman (1982), Fitzpatrick (1984) and Coroneos (1983) to teach the current syllabus. A further reason may be because many of today's mathematics teachers studied from these text books for their HSC. They clearly feel comfortable with these text books, which is possibly why many teachers still continue to refer to Extension 1 as 3 Unit and Extension 2 as 4 Unit.

Considering all the social and technological changes of the last fifty years little has changed in the variety of the content found in Mathematics examination papers. The impact of our changing society with the groups identified as Generation X, Y and Z appears to have been neglected. There were some changes such as the introduction of graphics calculators into the General Mathematics course in 2002 and today the use of these calculators is common amongst independent schools. However as an observation, many schools in the State system continue to use the conventional scientific calculator, even though class sets of graphics calculators are generally available.

If teachers are expected to implement technology such as Graphics Calculators and SmartBoards in the classroom then schools need to set aside more time and funding for the professional development of these teachers. General Mathematics also introduced multiple choice questions which is certainly a new development for HSC mathematics examinations. The plan is to introduce, multiple-choice questions in the other three examinations in the 2012 Higher School Certificate examinations (Board of Studies, 2010b).

As Genovese (2002) found, the style of the questions in general was leaning towards explaining the solution rather than demonstration of rote learned facts, hence there was a significant decrease in the instructions – *prove* and *state*. In General Mathematics there was a requirement that "*all questions be questions*", hence the instruction *find* has been replaced with *what is*. This instruction has also been implemented in the revised 1st Level examinations. Even though the syllabus had not changed for the 2nd and 3rd Level subjects, these instructions should have been taken into consideration. However as the results indicate (Section 8.5) *find* is still the most commonly used instruction in 2nd and 3rd Level examinations.

In 1962, 15 000 (or 84%) of students studied mathematics while in 2008 only 50 350 (or 74%) of students studied mathematics, possibly due to the introduction of the New HSC in 2002, after which mathematics was no longer mandatory. This represented a 10% drop in students taking mathematics, or to put it another way nearly 18 000 students completed their HSC in 2008 without studying any mathematics. In many countries around the world, students cannot matriculate without mathematics and it is also necessary for the mathematics to include calculus. One needs to ask why there is such a drop and lack of interest in mathematics in New South Wales. Is it because there are other subjects offered today which students find more interesting and perhaps easier than mathematics?

Having stood the test of time since the foundation of the University of Sydney in 1850 the Matriculation examination finally ceased to be offered in 1978. Yet in the University Calendar they continue to refer to the Matriculation examination as "*currently suspended*". Does this mean that one day in the future students may once again be sitting for the matriculation examination?

In each of the previous chapters consecutive time periods were studied and analyzed in detail, yet it is said that "*one cannot see the wood for the trees*". In other words, we are too close to see the Big Picture. Before presenting the conclusion, the next chapter will stand back, and analyze longitudinally a series of examinations from their beginning and provide some further statistical data relevant to these examinations.

Chapter 9

THE BIG PICTURE, 1881 – 2008

The previous chapters have critically analyzed mathematics examinations at the end of secondary schooling by separating them into four chronological groups. Within each group individual examinations were analyzed at ten-year intervals and all changes and notable distinctions and exceptions were identified and explained.

At the end of this research it is also important to stand back and consider the examinations as a dynamic and evolving process. Having already analyzed the examinations at a micro level, this chapter will look at three separate aspects of the examinations at a macro level in order to provide a holistic view of the events.

9.1 Cognitive competencies

In Section 2.5.1 Genovese (2002) described high stakes examinations as one way a society expresses the cognitive competencies it values. His study suggested that examinations from the early 1900s demanded deep declarative (factual) knowledge of culturally-valued information and simple interrelation between facts. One hundred years later students were expected to understand complex interrelations between concepts but required only superficial knowledge of culturally valued information.

As an extension to analyzing mathematics examinations it was thought relevant to replicate the concept of Genovese's research with data from this study. One must keep in mind that this research looked at mathematics examinations compared with essay-structured examinations used by Genovese. This study has fewer terms to analyze, however these words all have very specific meaning and direction to students.

Chapter 2 includes Table 2.3 from the Board of Studies which groups syllabus knowledge, skills and understanding to key words (instructions). This table was aimed at all examinations and subjects in general and certainly is not specific for mathematics since three of the most frequently used instructions *find, prove* and *show* were not included in this table. The sections in Table 2.3 were separated into six areas, namely: skills in analysis and critical thinking; skills in application and performance; knowledge, recall and understanding; skills in evaluation; skills in problem solving and skills in synthesis and creative thinking. Unfortunately none of these sections were directly applicable to mathematics examinations.

This study has chosen to compare the use of two sets of instructions. The first set used *find* and *what is,* as these were skills related to problem solving. The second set used *prove, show* and *define,* as these were related to recall and knowledge, generally considered as rote learned material. There was also a consideration to include instructions generally applied to skills for evaluation and critical thinking such as *explain, discuss* and *justify*. However these instructions were not used in all the examinations and when they were used, they would only constitute at the most 3%- 5% of the instructions used in any one paper.

The next two sections will focus on two sets of examinations, the entry level (third level) calculus examinations and the non-calculus (higher standard) examinations. These were specifically selected because with each of these levels there was a continuous set of examinations from 1916 for the third level and from 1881 for the higher standard.

Since the two sets of examinations were at least ninety years apart, in order to rationalize the results four of the instructions were combined, namely: *find = determine; what = which; prove = verify* and *discuss = explain*. Data from 1881 or 1916 were displayed in lighter color (blue) and data from 2008 were displayed in darker color (red).

9.1.1 Entry level calculus, 1916 and 2008

In the 1916 Leaving Certificate there was only one set of calculus papers, Mathematics I & II Honours. In addition the instructions from the non-calculus Mathematics I & II Pass papers were also included and combined with the honours papers since students attempting the Honours also had to sit for the Pass papers. The instructions from all four 1916 examinations were added together, the relative percentages for the instructions were calculated and compared to the instructions from the 2008 Mathematics 2 Unit paper.

The commonly used instructions were: *what is, find, solve, prove, show, how, evaluate, write down* and *sketch.* The two time periods were displayed in Figure 9.1. There were also other instructions, but as Figure 9.1 indicated apart from *what is, find, prove* and *show* their usage was all below 10% (most under 5%). Figure 9.1 further indicates that the use of *what is* has increased, while *prove* has significantly decreased. Since *find* & *what is,* are considered similar problem solving instructions and *prove* & *show* are considered similar knowledge & recall instructions, they were grouped together and displayed in Figure 9.2. Indicating that the problem solving instructions *what is* & *find* remained the same, while there was a small decrease in the knowledge based instructions *prove* & *show,* even though the two periods were over 90 years apart.

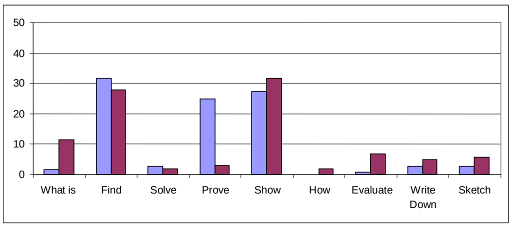


Figure 9.1 Instructions for 1916 (blue) and 2008 (red)

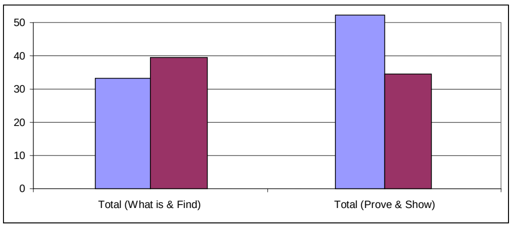


Figure 9.2 Totals for What is/Find and Prove/Show

9.1.2 Non-calculus, 1881 and 2008

The two sets of examinations selected were the 1881 Senior Public examinations consisting of four separate examinations in arithmetic, algebra, geometry and trigonometry and compared to the 2008 General Mathematics examination. All the instructions from each of the four 1881 Senior Public examinations were added together, the relative percentages for each of the instructions was calculated and compared to the instructions from the 2008 General Mathematics paper.

The commonly used instructions *what is, find, solve, prove, show, how, define, describe* and *explain* for the two time periods were displayed in Figure 9.3 instead of *evaluate, write down* and *sketch* from Figure 9.1 were replaced with *define, describe* and *explain*. Again there were also other instructions, but as Figure 9.3 indicates, apart from *what is, find, prove* and *show* their usage was generally below 10% (most under 5%). Figure 9.3 shows that *what is* has increased, while the use of *find* and *prove* have significantly decreased. Since *find* & *what is,* were considered similar problem solving instructions, and *prove* & *show* were considered similar knowledge and recall instructions, they were grouped together and displayed in Figure 9.4. Indicating that the problem solving instructions *what is* & *find* stayed constant, while the knowledge based instructions *prove* & *show* had significantly decreased between the two periods almost 130 years apart.

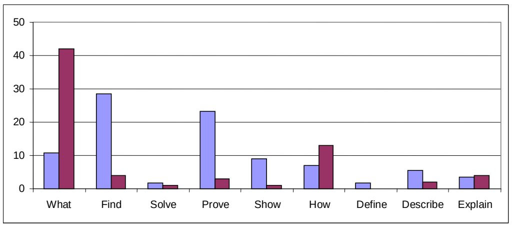


Figure 9.3 Instructions for 1916 (blue) and 2008 (red)

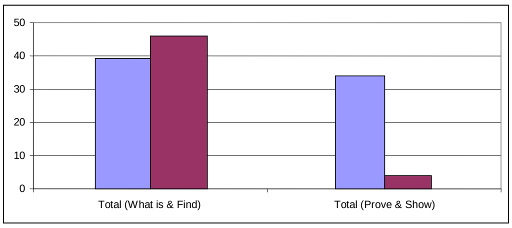


Figure 9.4 Totals for What is/Find and Prove/Show

9.1.3 Cognitive results

According to the Board of Studies NSW instructions such as *explain, evaluate* and *discuss* may be considered as skills in analysis and critical thinking. Since less then 3% of the examinations used these instructions and because there was no particular trend or pattern to these terms, this researcher concluded that this was not a parameter considered in mathematics examinations.

The majority of mathematics examinations, regardless of the level of difficulty used the same set of instructions, namely: *find, what is, prove* and *show* accounting for about 80% of all instructions. On one hand Figures 9.2 and 9.4 indicate that the problem solving instructions *find* and *what* had remained fairly constant, regardless of the academic difficulty of the examination. On the other hand these same Figures 9.2 and 9.4 indicate that the knowledge and recall instructions *prove* and *show* had changed over a long period of time, and this change was significantly greater at the lower academic level.

Figure 9.2 indicates that the knowledge and recall instructions for the more academic subject had decreased from 52% (1914) to 35% (2008) representing a change of 17%. For the less academic subject as indicated by Figure 9.4 the instructions decreased from 34% (1881) to just 4% (2008), a change of 30%. Admittedly this was over a longer period of time, 127 years compared with 92 years, however this does not diminish the importance of the result.

Genovese (2002) suggested that high stakes examinations from the early 1900s demanded deep declarative knowledge of culturally valued information, whereas one hundred years later students were expected to understand complex interrelations between concepts. This study indicated that while problem solving instructions remained constant, the need for knowledge and recall (which may also be described as declarative knowledge) had significantly diminished. This part of the study was in agreement with the results found by Genovese.

9.2 Longitudinal overview

The previous chapters analyzed individual sets of examinations within a specified time periods. This chapter will provide a “bird’s-eye view” of the evolution of mathematics examinations at ten year intervals over a period of 92 years for the entry level calculus examinations and 127 years for the non-calculus examinations.

9.2.1 Entry level calculus, 1916 and 2008

In this section entry level calculus examinations from the 1916 Leaving Certificate through to the 2008 Higher School Certificate were critically analyzed. This set was chosen because these examinations were produced continuously over a 92 year period, which was almost twice the time span of other calculus-based examinations. In the previous chapters individual examinations were analyzed and compared with other similar standard examinations for the same time period. This chapter will examine the “complete” examination which was at times made up of four separate papers.

From 1916 (first available examination) to 1942 the entry level calculus examinations were Mathematics I & II Honours. As stated earlier, students attempting these papers also had to sit for Mathematics I & II Pass papers during the one examination session. In this chapter these four examinations are combined and treated as a single three hour examination. In 1952 the entry level calculus examination were the Mathematics I & II Pass papers, this was also combined and treated as a single three hour examination. After 1962 all the entry level calculus examinations were reduced to a single three hour examination.

9.2.1.1 Content

Figures 9.5 – 9.13 display the topics examined. As Figure 9.5 indicates algebra was always examined and took up between 10% – 20% of the content. After a slow but constant start (Figure 9.6), calculus questions had increased from 5% to over 40% of the content by 1962. As the content of calculus increased, geometry and trigonometry decreased (Figures 9.7 and 9.8) from a constant 30% to 15% in case of geometry and to below 10% for trigonometry. As Figures 9.9 – 9.13 indicate, other topics such as series, financial mathematics, logarithms, binomial theorem and probability each took up about 5%. The only significant change that took place was the growth of calculus against the decline of geometry and trigonometry. As Figure 9.14 indicates graphics started to appear by 1970s and over the last 15 years each examination had 10 – 11 tables, graphs or diagrams.

Content by topics, Figures 9.5 – 9.13

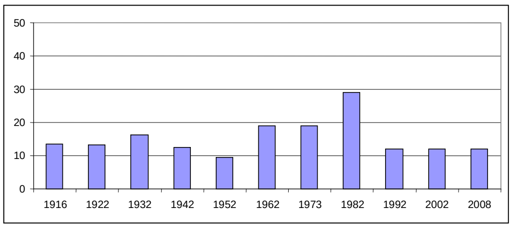


Figure 9.5 Content: Algebra

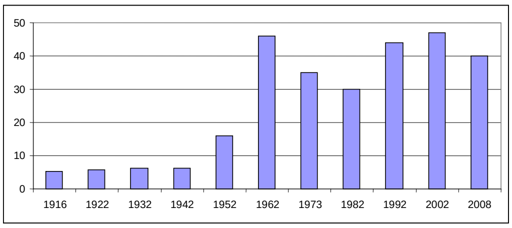


Figure 9.6 Content: Calculus

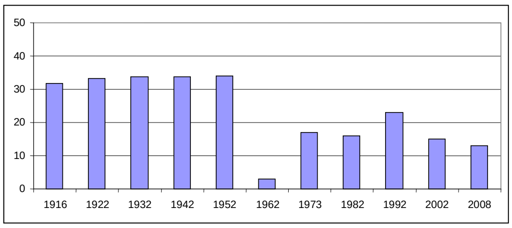


Figure 9.7 Content: Geometry

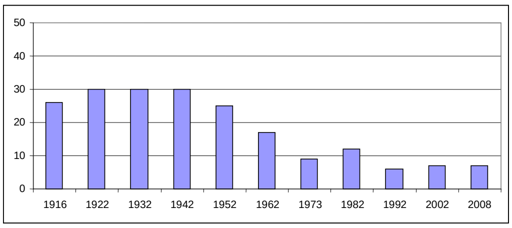


Figure 9.8 Content: Trigonometry

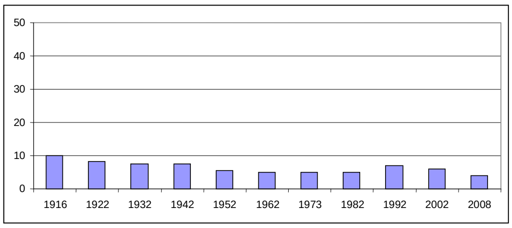


Figure 9.9 Content: Series

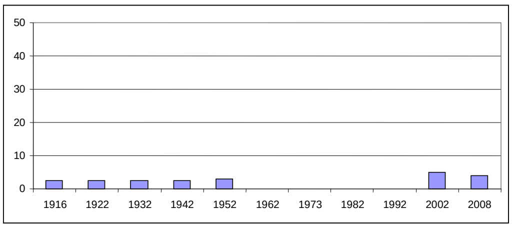


Figure 9.10 Content: Finance

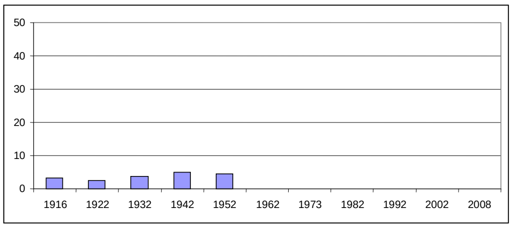


Figure 9.11 Content: Logarithms

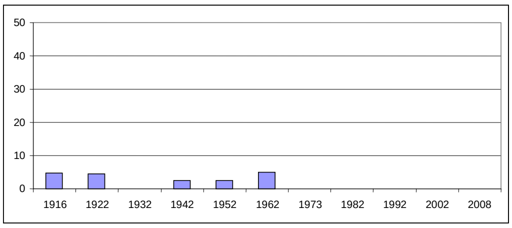


Figure 9.12 Content: Binomial theorem

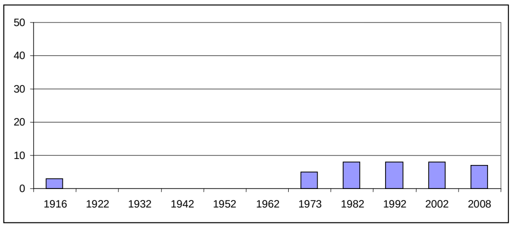


Figure 9.13 Content: Probability

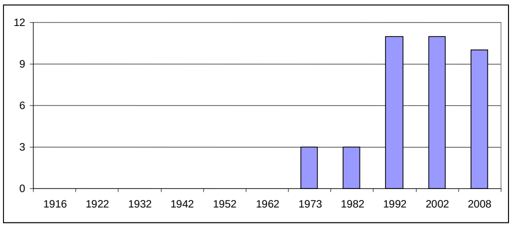


Figure 9.14 Diagrams, graphs and tables

As Figures 9.15 – 9.18 indicate there was little change in the content and format of the examinations from 1916 – 1942. In the 1952 examination papers (Figure 9.19) the total number of individual papers were halved to two sets of three hour examinations. However the format and content remained the same (apart from a small increase in calculus) as it had for the past 30 years. The introduction of a new syllabus in 1962 is clearly indicated by the changes in Figure 9.20 with a 30% increase in calculus and a corresponding 30% decrease in geometry. Figures

9.20 – 9.25 indicates that changes were minimal from the 1960s. The total for each of the topics was added together for the eleven time periods from 1916 to 2008 and expressed as a percentage. During the period 1916 – 2008, four topics namely: algebra, geometry, trigonometry and calculus represented 80% of all the examinations (Figure 9.26).

Content at ten year intervals, Figures 9.15 – 9.25

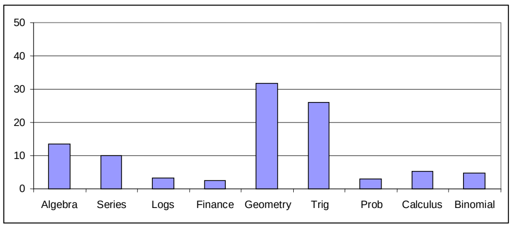


Figure 9.15 Content in 1916

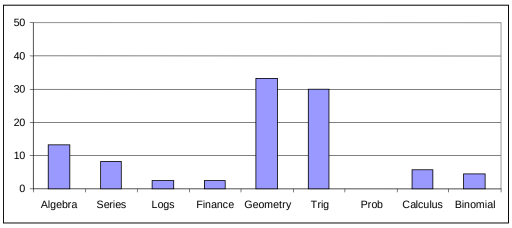


Figure 9.16 Content in 1922

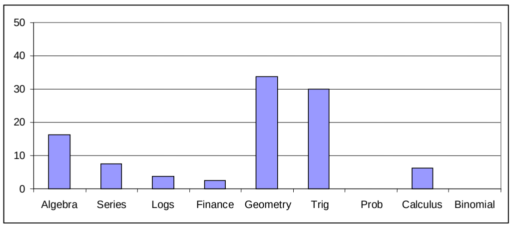


Figure 9.17 Content in 1932

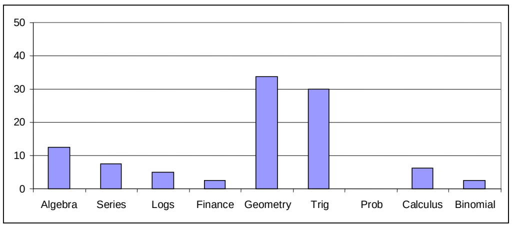


Figure 9.18 Content in 1942

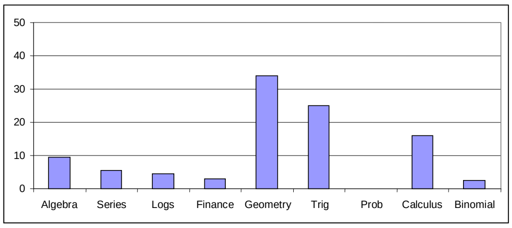


Figure 9.19 Content in 1952

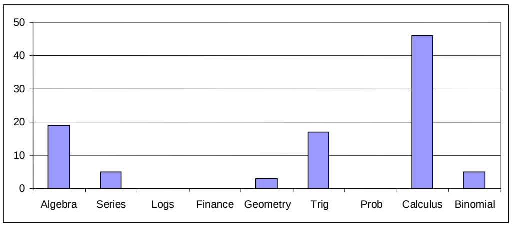


Figure 9.20 Content in 1962

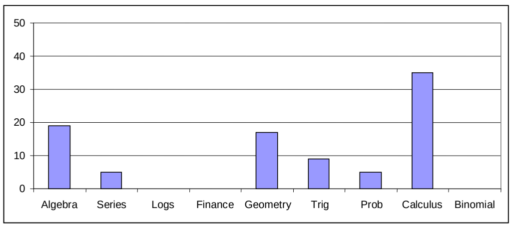


Figure 9.21 Content in 1973

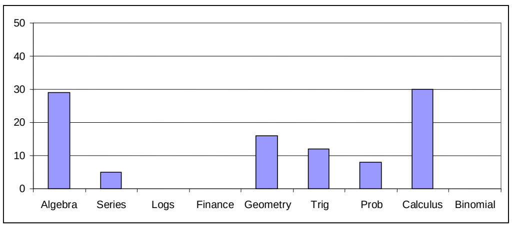


Figure 9.22 Content in 1982

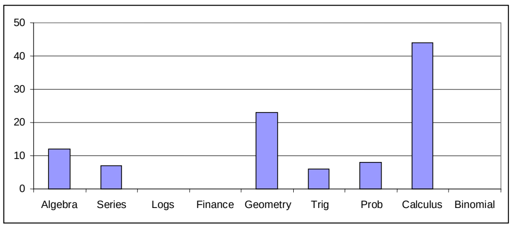


Figure 9.23 Content in 1992

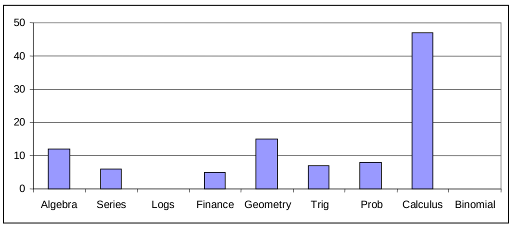


Figure 9.24 Content in 2002

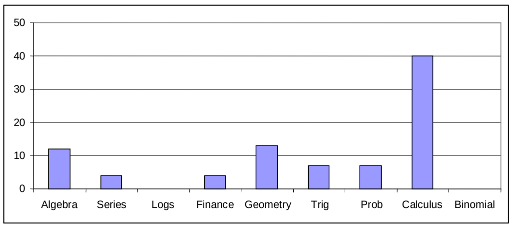


Figure 9.25 Content in 2008

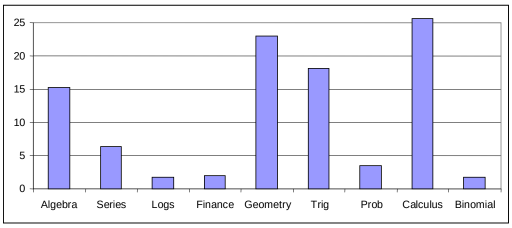


Figure 9.26 Overview of Content 1916-2008

9.2.1.2 Instructions

Throughout this period the most significant changes occurred with the introduction of a new syllabus in 1962. The term *find* stayed relatively the same (Figure 9.27), while the use of the term *what is* increased by about 15% (Figure 9.28). The instruction *prove* almost disappeared (Figure 9.29) and *show* (Figure 9.30) was reduced to about 10%. The balance of the instructions (Figures 9.31 – 9.34) remained unchanged, generally under 10% compared with the rest of the instructions.

Instructions, Figures 9.27 – 9.34

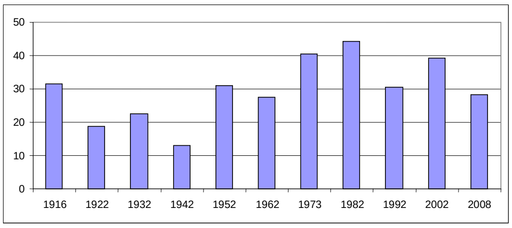


Figure 9.27 Instructions using Find

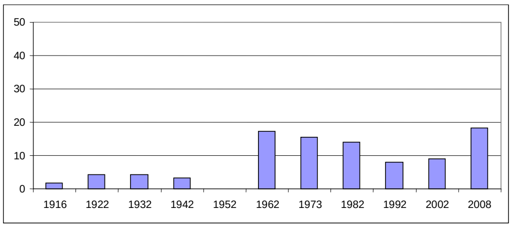


Figure 9.28 Instructions using What is

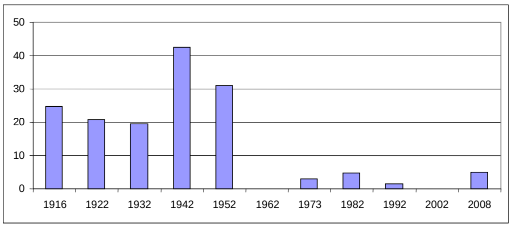


Figure 9.29 Instructions using Prove

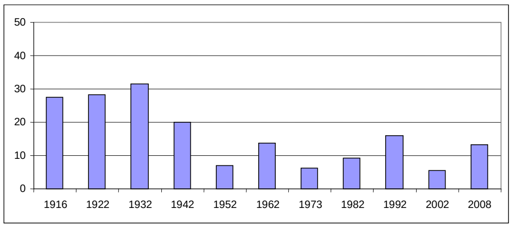


Figure 9.30 Instructions using Show

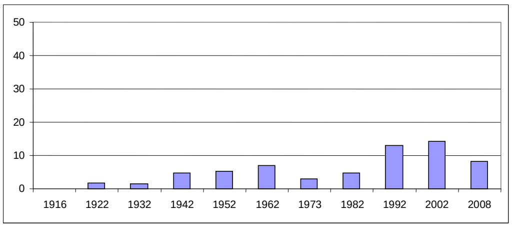


Figure 9.31 Instructions using Calculate

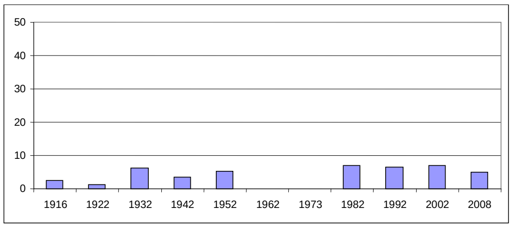


Figure 9.32 Instructions using Solve

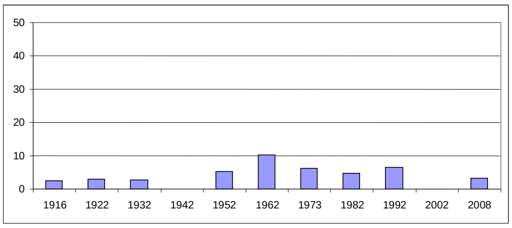


Figure 9.33 Instructions using Write down

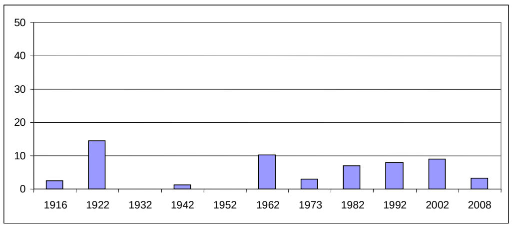


Figure 9.34 Instructions using Sketch

While the format of the examinations remained the same during 1916 – 1942 the instructions also remained constant (Figures 9.35 – 9.38). With the change in the 1952 format of the examination (Figure 9.39) the use of *prove* and *show* dropped by about 15% each. From 1962 onwards the term *prove* had almost completely disappeared from further examinations. The total for each of the instructions was added together for the eleven time periods from 1916 to 2008 and expressed as a percentage. Between 1916 and 2008 the three most commonly used instructions, representing 60% of all the instructions, were *find*, *prove* and *show* (Figure 9.46).

Instructions at ten year intervals, Figures 9.35 – 9.45

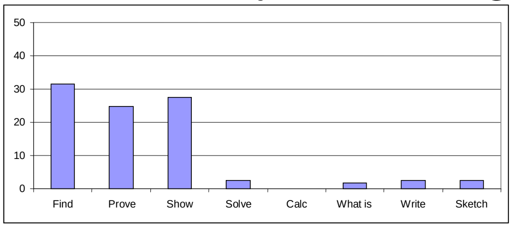


Figure 9.35 Instructions used in 1916

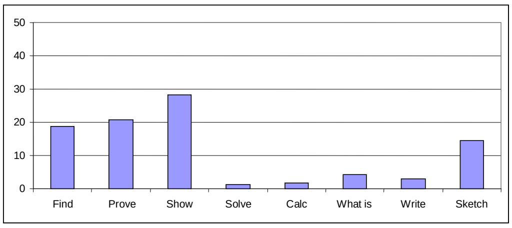


Figure 9.36 Instructions used in 1922

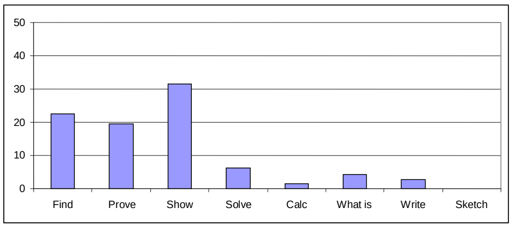


Figure 9.37 Instructions used in 1932

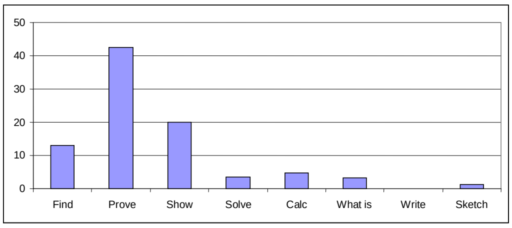


Figure 9.38 Instructions used in 1942

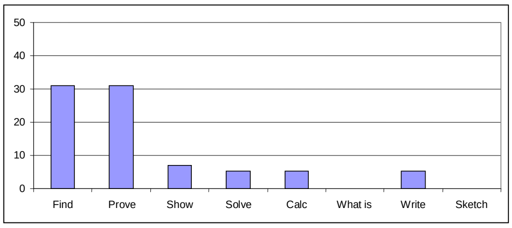


Figure 9.39 Instructions used in 1952

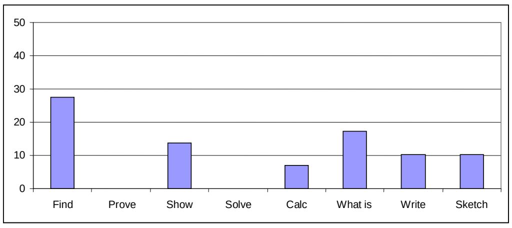


Figure 9.40 Instructions used in 1962

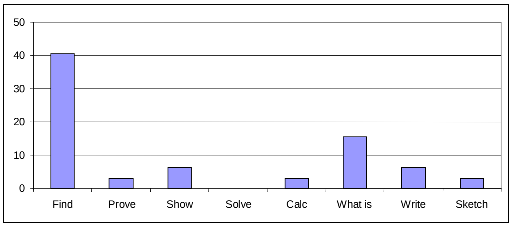


Figure 9.41 Instructions used in 1973

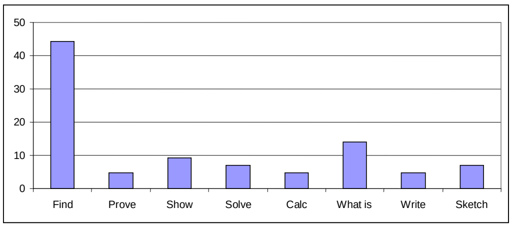


Figure 9.42 Instructions used in 1982

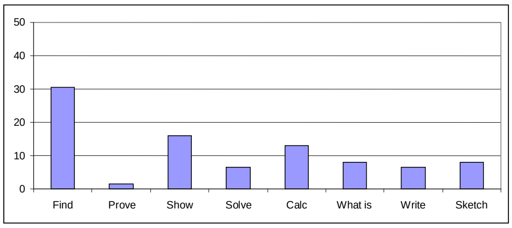


Figure 9.43 Instructions used in 1992

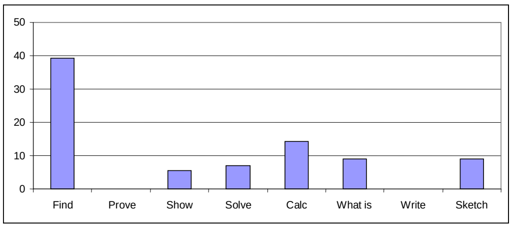


Figure 9.44 Instructions used in 2002

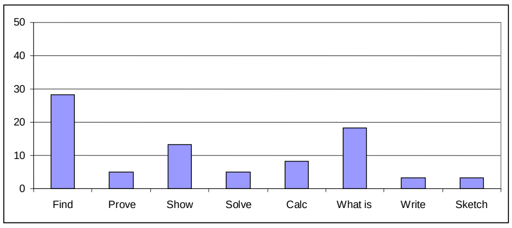


Figure 9.45 Instructions used in 2008

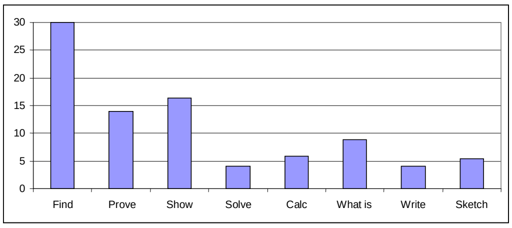


Figure 9.46 Overview of Instructions 1916 - 2008

9.2.2 Non-calculus, 1881 and 2008

Non-calculus examinations from 1881 Senior Public examination to 2008 Higher School Certificate were progressively analyzed at ten year intervals. Until 1942 there were two sets of non-calculus examinations a higher and a lower standard, afterwards only one set (except when Mathematics in Practice) was produced. This study started with the Senior Public examination followed by the Leaving Certificate Mathematics I & II Pass papers (until 1942). As with the entry level calculus examinations, the multiple sets of individual examinations for the Senior Pubic and the early Leaving Certificate examinations were combined and treated as a single three hour examination so that direct comparisons were possible with the subsequent Leaving Certificate and HSC examinations.

9.2.2.1 Content

In this subject, most of the significant changes occurred after the introduction of a new curriculum in 1962. Later, there were further distinctive changes made to the new General Mathematics in 2002 with other topics and Multiple Choice questions added and previous option topics were deleted. Overall this had little impact on the content as shown by Figures 9.47 – 9.55.

As indicated by Figure 9.47 arithmetic and algebra had always played an important part in this subject, generally accounting for about 30% – 40% of the overall content. Following the 1962 changes to the curriculum, questions on financial mathematics, statistics and probability reappeared as shown by Figures 9.48, 9.53 and 9.54, replacing questions on series and logarithms (Figures 9.51

and 9.52). At the same time geometry (Figure 9.49) was removed from the syllabus and the content of trigonometry (Figure 9.50) was reduced from 35% (in the 1940s) to just 10% following the latest changes in 2002. The length of the examination was reduced from 12 hours in 1881 to 2.5 hours by 2002, from 1962 the number of diagrams, graphs and charts increased to over 30 (Figure 9.55).

Content by topics, Figures 9.47 – 9.55

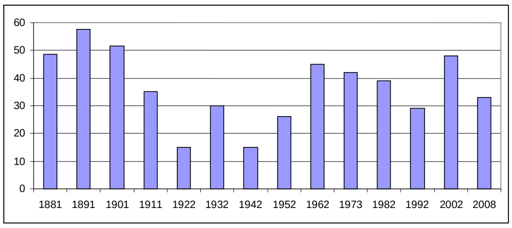


Figure 9.47 Content: Arithmetic & Algebra

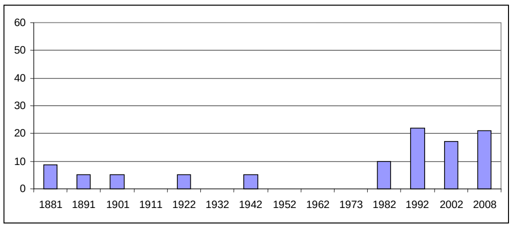


Figure 9.48 Content: Finance

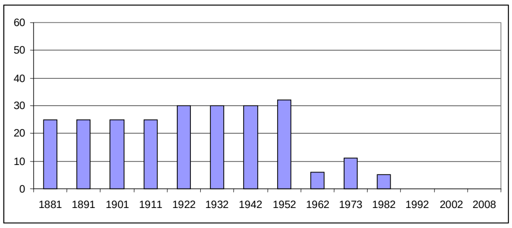


Figure 9.49 Content: Geometry

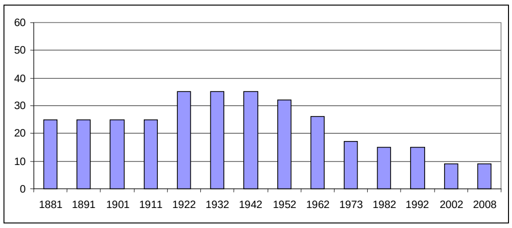


Figure 9.50 Content: Trigonometry

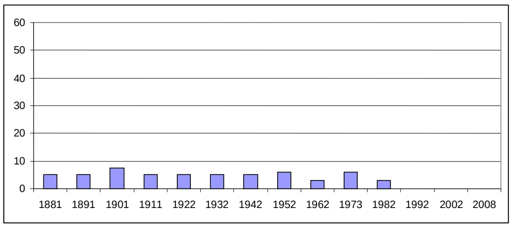


Figure 9.51 Content: Series

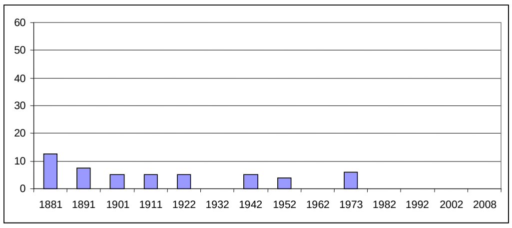


Figure 9.52 Content: Logarithms

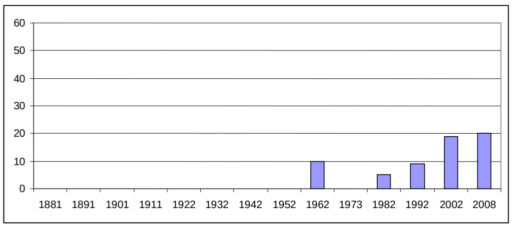


Figure 9.53 Content: Statistics

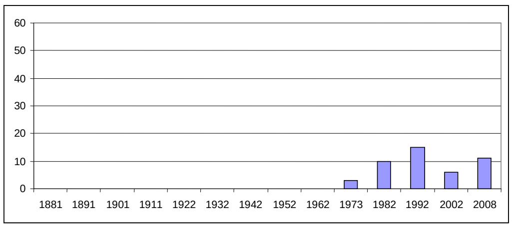


Figure 9.54 Content: Probability

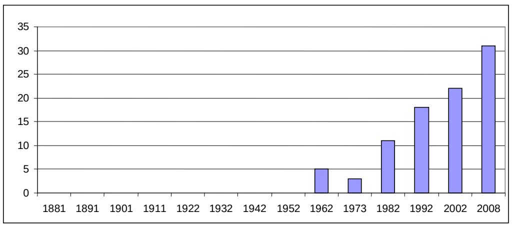


Figure 9.55 Diagrams, graphs and tables

Figures 9.56 – 9.63 indicate that during the 70 year period from 1881 to 1952, arithmetic, algebra, geometry and trigonometry dominated the examinations. During the next 50 years, arithmetic and algebra continued to be included, while financial mathematics, statistics and to a lesser extent probability, replaced the earlier content of geometry and trigonometry. Between 1881 – 2008 arithmetic, algebra, geometry and trigonometry represented 75% of all the topics examined (Figure 9.70).

Content at ten year intervals, Figures 9.56 – 9.68

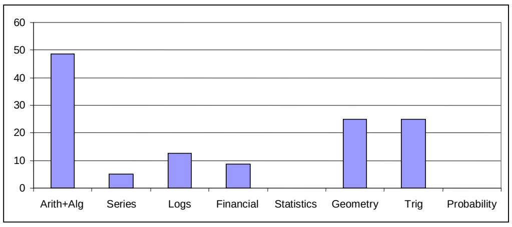


Figure 9.56 Content in 1881

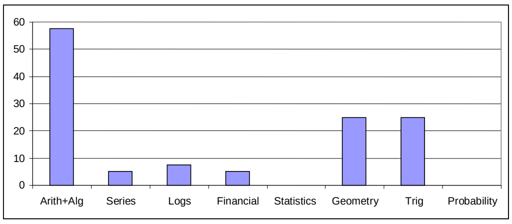


Figure 9.57 Content in 1891

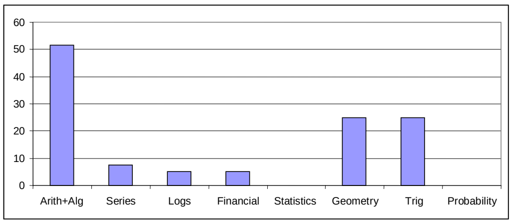


Figure 9.58 Content in 1901

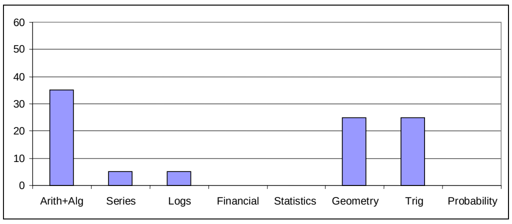


Figure 9.59 Content in 1911

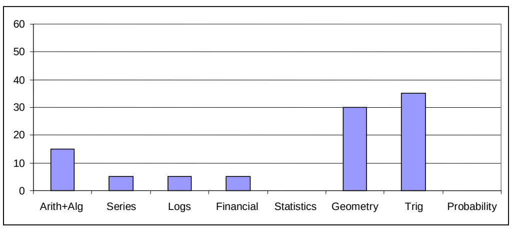


Figure 9.60 Content in 1922

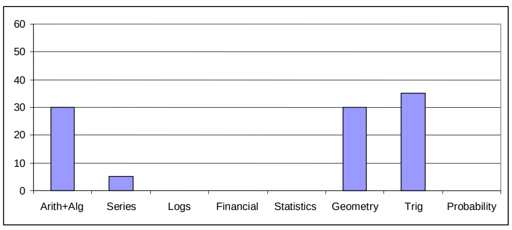


Figure 9.61 Content in 1932

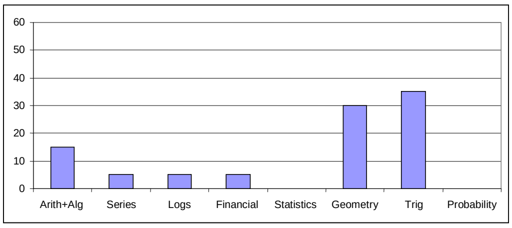


Figure 9.62 Content in 1942

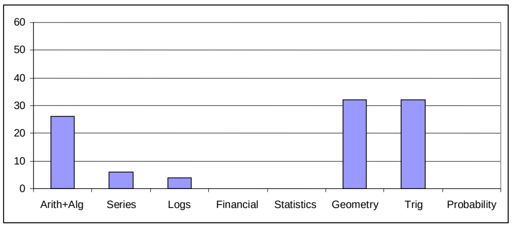


Figure 9.63 Content in 1952

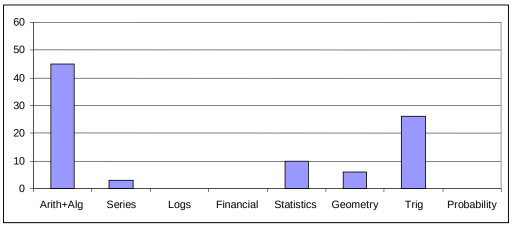


Figure 9.64 Content in 1962

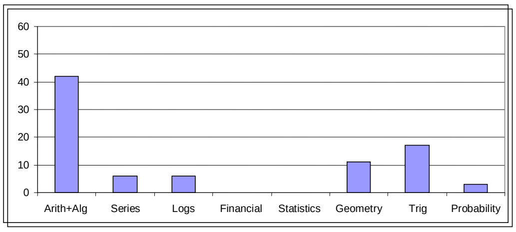


Figure 9.65 Content in 1973

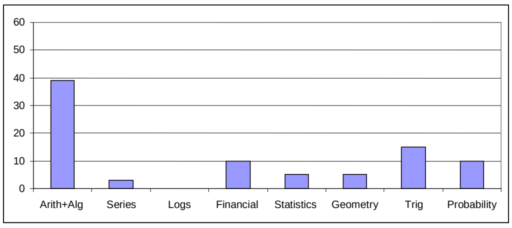


Figure 9.66 Content in 1982

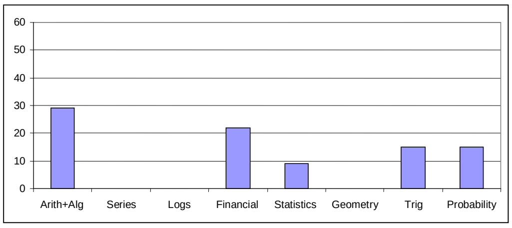


Figure 9.67 Content in 1992

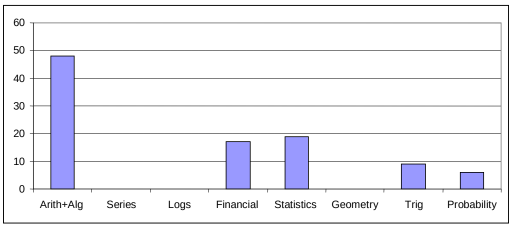


Figure 9.68 Content in 2002

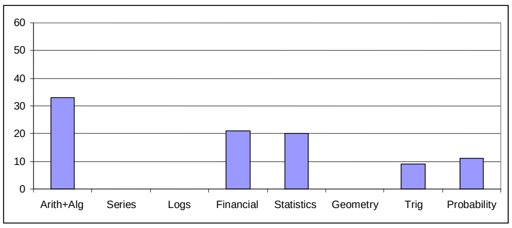


Figure 9.69 Content in 2008

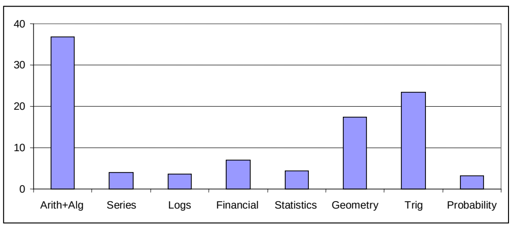


Figure 9.70 Overview of content 1881 - 2008

9.2.2.2 Instructions

Significant changes occurred in the use of instructions following the introduction of the 1962 syllabus. After 1962 *find* was gradually replaced by *what is* (Figures 9.71 and 9.72). Prior to 1962 a combination of instructions *prove* and *show* (Figures 9.73 and 9.74) dominated the examinations, after 1962 *find* and *what is* totally replaced *prove* and *show* as these terms disappeared. Furthermore the use of *calculate* and *how* each increased by about 10% (Figures 9.75 and 9.76).

Instructions, Figures 9.71 – 9.76

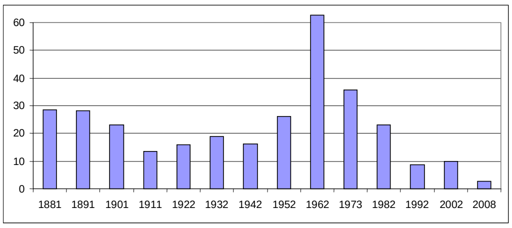


Figure 9.71 Instructions using Find

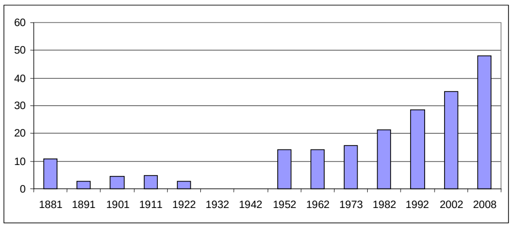


Figure 9.72 Instructions using What is

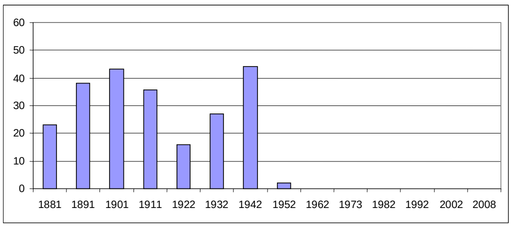


Figure 9.73 Instructions using Prove

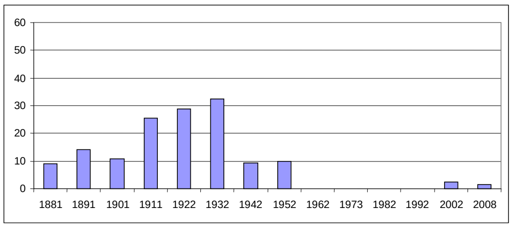


Figure 9.74 Instructions using Show

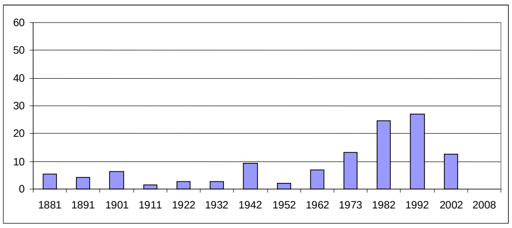


Figure 9.75 Instructions using Calculate

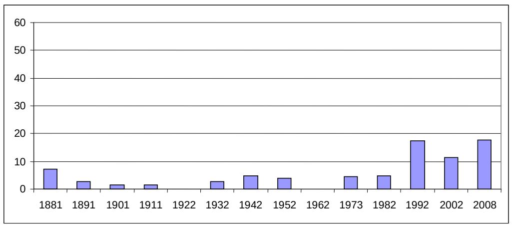


Figure 9.76 Instructions using How

As indicated by Figures 9.77 – 9.90 all the examinations analyzed used only 2 – 4 instructions for the majority of questions. All the other terms accounted for just 2% – 3% of the individual instructions. An overview of all the instructions between 1881 and 2008 (Figure 9.91) shows that *find*, *what is*, *show*, *calculate* and *prove* was used in 75% of all questions.

Instructions at ten year intervals, Figures 9.77 – 9.90

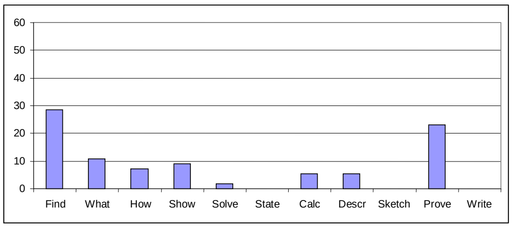


Figure 9.77 Instructions used in 1881

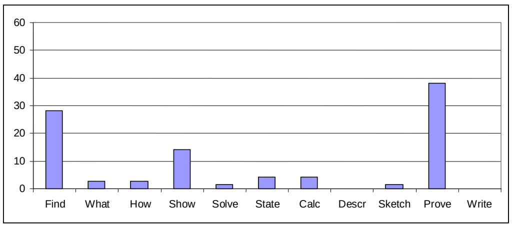


Figure 9.78 Instructions used in 1891

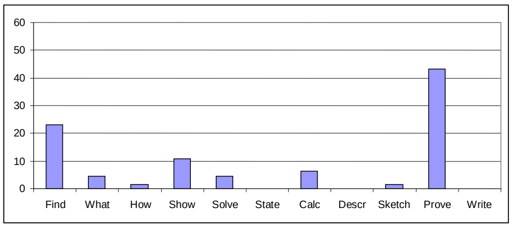


Figure 9.79 Instructions used in 1901

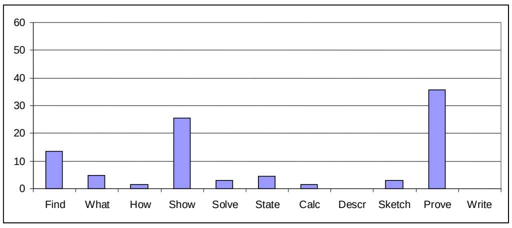


Figure 9.80 Instructions used in 1911

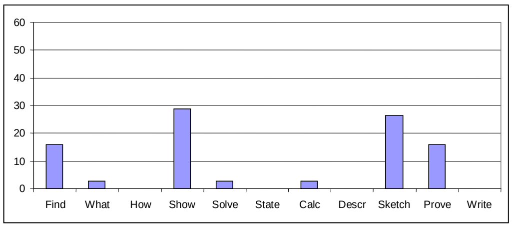


Figure 9.81 Instructions used in 1922

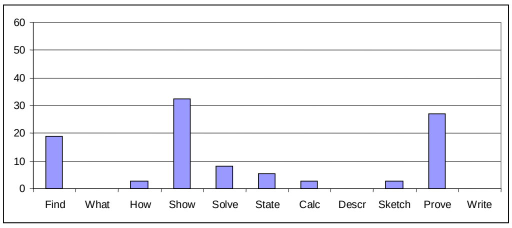


Figure 9.82 Instructions used in 1932

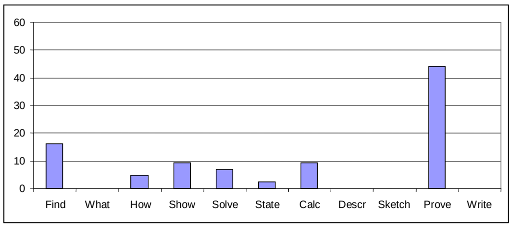


Figure 9.83 Instructions used in 1942

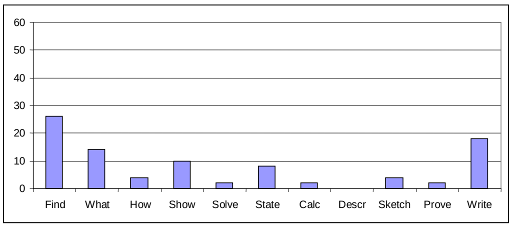


Figure 9.84 Instructions used in 1952

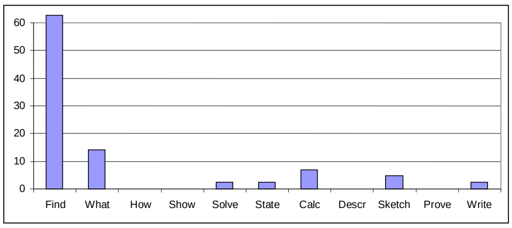


Figure 9.85 Instructions used in 1962

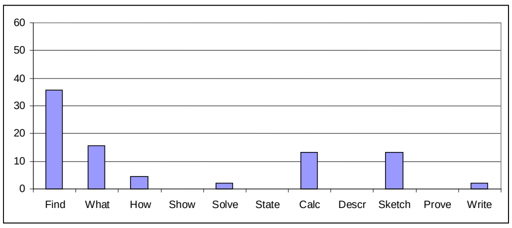


Figure 9.86 Instructions used in 1973

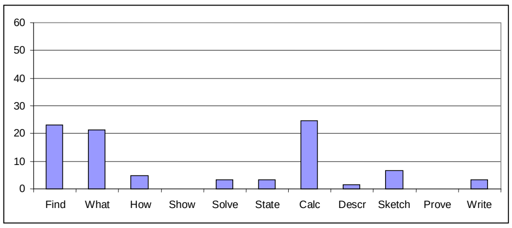


Figure 9.87 Instructions used in 1982

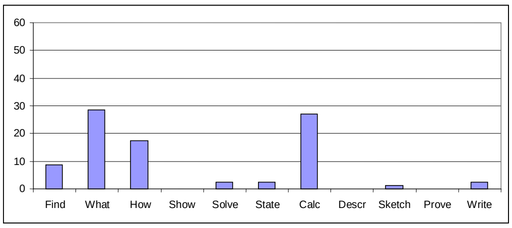


Figure 9.88 Instructions used in 1992

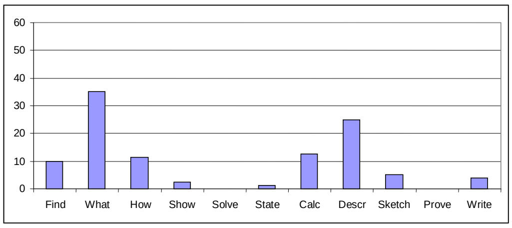


Figure 9.89 Instructions used in 2002

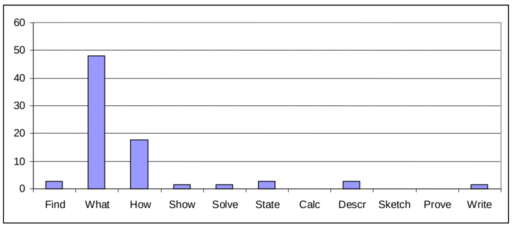


Figure 9.90 Instructions used in 2008

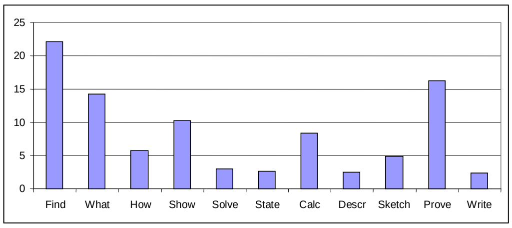


Figure 9.91 Overview of Instructions 1881-2008

9.2.3 Longitudinal results

The "big picture" produced unexpected results. Although there were some changes between 1881 and 2008, the most significant changes occurred before the introduction of the Higher School Certificate. Comments by the Chief Examiner: Mr. J. Williams (1962, p.163) about the Mathematics III paper, following the introduction of a new syllabus in 1960 indicated that "*many teachers and students* *had little idea of the difficulty of the questions or a clear interpretation of the syllabus*". He then stated that "*the instructions from the Board to intending candidates is quite clear about the difficulty of the questions; they shall be of the same order as for Mathematics I and II*". Furthermore he felt that most questions were nevertheless easier because the Mathematics III syllabus did not require the detailed study of topics required by Mathematics I and II. In fairness to the Mathematics III students he neglected to mention that these students had only half the time allocated to study for this subject.

The Chief Examiner for General Mathematics: Professor W. Smith-White (1962) stated that *"This paper was the first to be set on the New Syllabus issued in October 1960. The form of the paper was that of recent years".* One might possibly wonder about the accuracy of his statement, given that the content of algebra increased by over 15% (Figure 9.47), while the contents of geometry and trigonometry was reduced (Figures 9.49 and 9.50). At the same time statistics was introduced (Figure 9.53) and diagrams started to appear (Figure 9.55).

The following set of figures will illustrate the similarity between the content and instructions for:

(i) entry level calculus examinations 1916 & 1952 and 1962 & 2008.

(ii) non-calculus examinations 1881 & 1952 and 1962 & 2008

The earlier dates (1916 and 1962) are shown in lighter (blue) and the later dates (1952 and 2008) in darker (red). The charts are either 36, 46 or 71 years apart, so they cannot be expected to be exactly the same. However considering the time span between them the similarity is unmistakable. According to Figures 9.92 – 9.95 and 9.96 – 9.99 the entry level calculus papers have changed less than the non-calculus examinations

Entry level calculus examinations

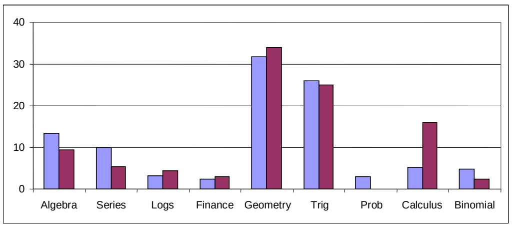


Figure 9.92 Content: 1916 and 1952

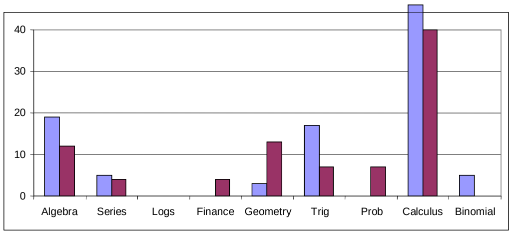


Figure 9.93 Content: 1962 and 2008

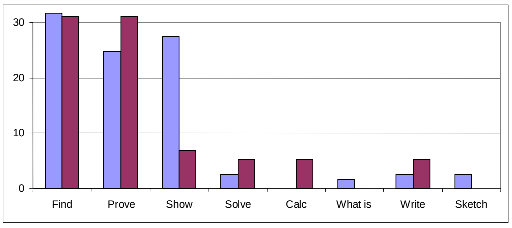


Figure 9.94 Instructions: 1916 and 1952

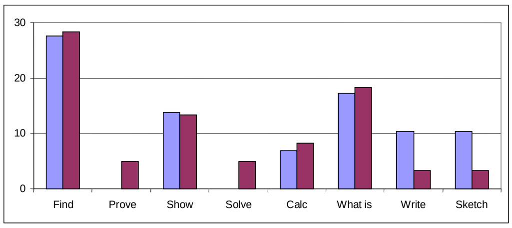


Figure 9.95 Instructions: 1962 and 2008

The similarity for both content and instructions between the 1916 and 1952 examinations is unmistakable (Figures 9.96 and 9.98). The least similar, thus indicating the greatest content change was Figure 9.97 this was due to the 2002 revised General Mathematics syllabus. Apart from the fact that in the instruction *find* was more recently replaced with *what is*, Figure 9.99 still shows similarity between the styles of the 1962 and 2008 examinations.

Non-calculus examinations

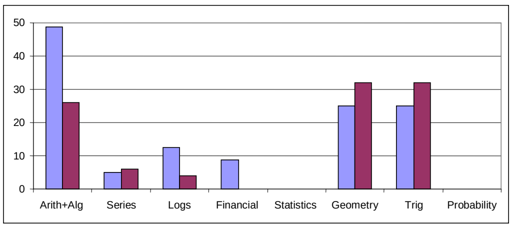


Figure 9.96 Content: 1916 and 1952

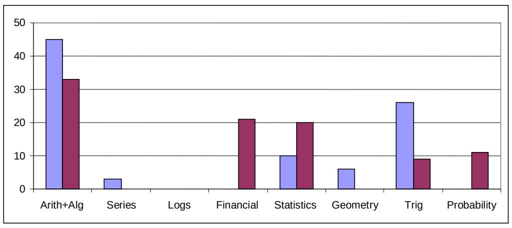


Figure 9.97 Content: 1962 and 2008

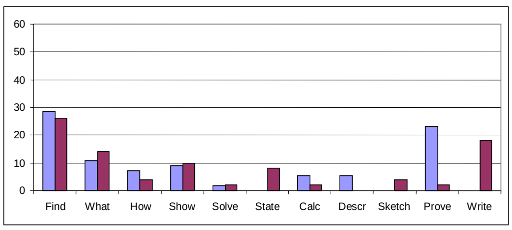


Figure 9.98 Instructions: 1916 and 1952

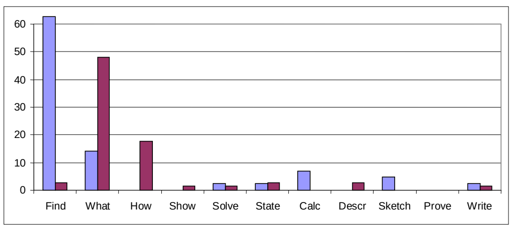


Figure 9.99 Instructions: 1962 and 2008

9.3 Statistical overview

In order to consider the "big picture" in context, this researcher felt that it would also be important to look at some statistical information about the examinations at the end of secondary schooling. This statistical data was obtained from the Australian Bureau of Statistics (ABS) and the Board of Studies NSW (BOS).

Figure 9.100 shows population growth of New South Wales since 1850 at ten year increments, currently standing at about 7 million people. In comparison Figure 9.101 shows the percentage of students attempting examinations at the end of secondary schooling since 1913 at ten year increments. This number has been gradually increasing to about 1% of the population, indicating that people in New South Wales are becoming better educated. Figure 9.102 shows the comparison between the number of students attempting examinations at the end of secondary schooling in the lighter color (blue) and those students who chose to take mathematics in the darker color (red), as part of their final school examinations. This figure clearly indicates a significant drop in the number of mathematics students since the year 2000. Looking at the percentage of mathematics students since 1946 at ten year intervals, Figure 9.103 (starting at 70%) indicates that at the end of this 60 year period in 2008, fewer students attempted mathematics than ever before. To further highlight this fact, Figure 9.104 (starting at 50 000 students) shows that there were fewer students studying mathematics for end of secondary school examinations than back in 1990. At that time the population of New South Wales was a little over 5 million, that figure is almost 2 million less people than the current population.

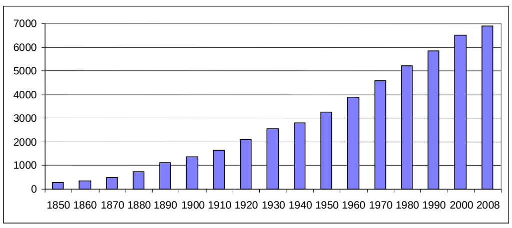


Figure 9.100 Population growth of NSW

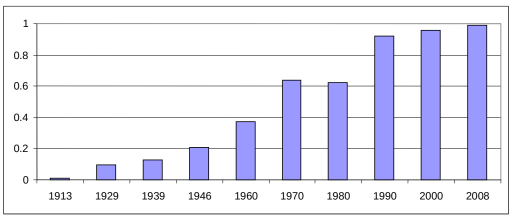


Figure 9.101 Percentage of students doing examinations at the end of secondary schooling

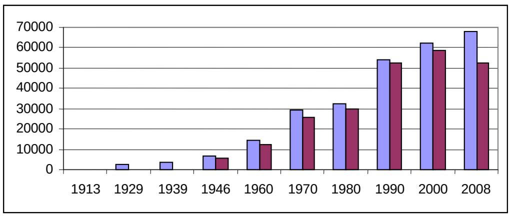


Figure 9.102 Total number and mathematics students at the end of secondary schooling

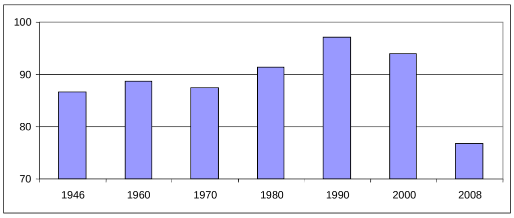


Figure 9.103 Percentage of mathematics students at the end of secondary schooling

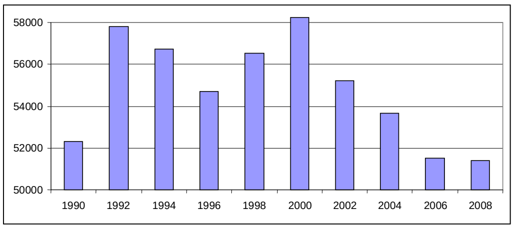


Figure 9.104 Total number of mathematics students at the end of secondary schooling

9.3.1 Statistical results

The current education trends in New South Wales means that while the state is becoming "smarter" with more people completing their secondary education (Figure 9.101) a large percentage of people have minimal mathematical skills. This, in the longer term, will mean that many people will have difficulty handling household budgeting and purchasing major items such as cars and housing. This cannot be good for a state that prides itself on being an egalitarian society.

9.4 Review

This chapter took a longitudinal overview of the examination process by analyzing the:

- Cognitive competences;
- Changes to entry level calculus examinations;
- Changes to non-calculus examinations; and
- Demographic changes.

This chapter delivered some of the more surprising and unexpected results which were not obvious when shorter time spans were analyzed.

The results showed that longitudinal changes were selective and relatively few. Similar results were found by Watson and Semel (2010) from analyzing the curriculum reform in the public schools of New York since the Civil War. They metaphorically compared changes in assessment practices in the Regents examination system to "*pouring old wine into new glasses*" (Watson & Semel, 2010, p.10). Section 7.13 showed that while rote learning has been discouraged, the examinations continue to be dominated by skills and knowledge based questions.

Overall there was just one significant change to all the examinations. This change was very likely the result of the 1957 Wyndham Report and was well before the actual introduction of the Higher school Certificate. These changes included:

- additional entry level calculus based subject;
- move away from rote learning;
- growth of calculus;
- trend away from geometry and trigonometry; and
- increased use of diagrams, graphs and tables.

The percentage of mathematics students remained relatively constant (Figure 9.103), however since the end of World War II, there was a steady increase in the total number of students till the early 1990s. Between 1990 and 2008 the numbers peaked around 2000 then fell back to pre-1990 figures. This drop in the number of mathematics students is a serious concern and this issue will be addressed in the next chapter.

The following concluding chapter will summarize the findings of this thesis and makes a number of suggestions and recommendations in light of the fact that a new national curriculum is imminent.

Chapter 10

CONCLUSION

10.1 Introduction

Over one hundred mathematics examination papers at different academic levels used at the end of secondary schooling since 1886 in New South Wales, Australia were analyzed. One can conclude that changes have taken place in the style, format and content in all these examination papers. However considering the widespread social, political and technological changes that have also taken place during the past one 120 years, one may further conclude that the changes were in fact not as extensive or significant as might be expected.

In summary the mathematics examinations may be divided into two major groups. The first group consists of all the examinations before 1962 and the second group from 1962 to 2010. In 1962 Mathematics III Pass was added as the third (entry level) calculus subject. This subject was renamed in 1982 as Mathematics 2 Unit and now in 2010 almost thirty years later, the same subject with very little change to the syllabus continues to be taught (Section 8.5.2.3). The Board of Studies in 2010 is still using the curriculum first released in 1982, last revised on their website in 2008. Thus there was just one “real” significant change to the Leaving Certificate in 1962 during the time when Wyndham was Director General of Education. This event was well before the first Higher School Certificate examination.

The assumption in this study was that changes in society will be reflected in the examination process (Chapter 3). As there was just one notable change in the examination process, using this asumption would imply that there was just one corresponding change in society. However this study has indicated that there were many changes in society as suggested by social demographers.

Other results came from analyzing the instructions used in the questioning strategies. The general understanding of studying and teaching mathematics has been that it helped to develop logical thinking and reasoning (Chapter 2). This may well be the accepted classroom practice and it may have also been the intention of the curriculum. However analysis of the instructions used in the examination questions have indicated that mathematics examinations did not test logical reasoning, instead they predominantly tested knowledge skills. Given sufficient time, practice and diligence almost all the content could be learned and memorized.

10.2 Answers to research questions

This study began with two questions, however as the research progressed and additional details were uncovered, a further research question was added, three questions in total.

1. *What changes may have occurred in the mathematics examination process brought on by the changes in our ever evolving world?*
2. *Why have these changes taken place?*
3. *Is the teaching of mathematics to develop logical thinking and reasoning being tested in the examinations?*

Short answers have already been expressed in this introduction, with details to follow:

10.2.1 Research Question 1

What changes may have occurred in the examination process brought on by the changes in our ever evolving world?

10.2.1.1 What has changed?

Examination process - After the introduction of the Junior and Senior Public examinations in 1867, there were four significant changes to the style and format of the examinations at the end of secondary schooling.

1913 – Leaving Certificate replaced the Junior and Senior Public examinations with Mathematics I & II Honours and Pass. A new subject called Mathematics was added by 1920. Calculus was introduced in Mathematics I Honours.

1952 – General Mathematics (one subject) replaced three separate examinations, namely Mathematics I-Pass, Mathematics II-Pass and Mathematics. Calculus was introduced in both Mathematics I&II Honours and Pass examinations.
1962 – A third subject Mathematics III Pass was added to the calculus range, thus increasing the calculus based examinations to three sets, namely: Mathematics I & II Honours, Mathematics I & II Pass and Mathematics III Pass.
2002 – A "new" General Mathematics replaced Mathematics in Society and Mathematics in Practice. The introduction of this new subject and changes to the HSC requirements marked the downturn in the popularity of mathematics from 97% to 77% (Section 9.3).

There are now more subjects to cater for wider student abilities **–** As shown in Table 3.1 initially there were just two levels of courses, the Junior and Senior Public examinations as well as the corresponding Matriculation Honours and Pass examinations. With the start of the Leaving Certificate in 1913 an additional calculus based course was introduced. In 1952 a second calculus based course was added at the expense of the non-calculus courses which were reduced to a single subject called General Mathematics. After 1962 a third calculus based course was added, thus making it four separate levels of mathematics courses namely: Extension 2, Extension1, 2 Unit and General Mathematics. Students attempting Extension 2 also studied Extension 1, while students attempting Extension 1 also studied the 2 Unit course.

The numbers of examination papers in each subject are fewer **–** Initially each course had three or four separate 3 hour examinations in arithmetic, algebra, geometry and trigonometry for both Senior Public and Matriculation Honours. Today all of these topics can be examined in a single 2, 2.5 or 3 hour examination for students taking the 2 Unit or General Mathematics courses.

Instead of a single question, now each question has a number of smaller components, and multiple choice was introduced for General Mathematics **–** In the early examinations there was no indication as to the number of marks awarded to each part of a question, furthermore there was nothing to indicate that all questions were of equal value. More detailed information about the marking scheme was made available after the 1980s.

Questions are gender and race neutral – Early examinations had a number of separate questions specifically directed at *males only* and *females only*. Today there is no distinction made between gender and descriptions are carefully written not to offend or discriminate against anyone.

***Scientific and graphics calculators are allowed* –** Early examinations used logarithmic tables or slide rules. As electronic calculators became more commonplace and cheaper, scientific calculators replaced logarithmic tables in the 1980s, and after 2002 graphics calculators were also allowed to be used in the non-calculus General Mathematics course. Graphics calculators are still not allowed in the calculus based courses.

Rote learning is discouraged – As discussed in detail in Chapters 3, 5 and 6 instructions such as *prove* and *show* in earlier examinations meant that in most cases students were able to rote learn the answer without actually understanding the concept or ideas behind it. By 2008 *prove* and *show* had almost completely disappeared.

Diagrams are included with many of the questions – With the growth in the use of computers and word processors the number of graphics such as diagrams, tables and graphs started to appear in the 1960s and substantially increased by the 1990s.

10.2.1.2 What has stayed the same?

While discussing the changes that have taken place in the examination process it is also important to consider where no significant changes were recorded.

Most examinations are still 2.5 or 3 hours long – the only exception to this is Extension 1 which is only 2 hours long.

Algebra, geometry, trigonometry and calculus continue to be examined – although the content depth in each of these topics has changed over the years, geometry has almost disappeared and about half the trigonometry course now includes calculus.

Many of the terms such as 'find', 'what if' and 'show' continue to be the most commonly used instructions – according to Bloom et al. (1956) as shown in Table 2.4 terms such as the ones shown above, indicate that the style of questioning based on testing knowledge and skills has continued to be a dominant feature of mathematics examinations at the end of secondary schooling. Although they are all defined as instructions used for memorizing and recalling information, it could be argued that some of these terms such as *what if* require deeper thinking than the term *find*.

10.2.2 Research Question 2

Why have these changes taken place?

Changes to the examination process were largely caused by our changing society, influenced by political, cultural and economic factors. The actual changes to the mathematics examinations took place because a select group of key people with a vision towards change were given the task to implement changes.

10.2.2.1 Changing society

Social demographers such as McCrindle, et al., (2010) have clearly identified changes in our lifestyle, and attitudes to saving, shopping, food, sport, travel as well as education and learning. As shown in Table 2.1, since the turn of the last century we have had the oldest generation, lucky generation, baby boomers, followed by Generations X, Y and Z. The learning format and environment, including the training focus, has changed from formal, structured and classroom style (Table 2.2) towards a spontaneous, multi-modal and café style environment (AAMT, 2009). This study reviewed the Big Picture in Chapter 9 and the analysis showed that considering all aspects of social changes, the curriculum and the examination process have not kept pace with our life style changes. It would be fair to suggest that learning behavior has been almost completely ignored in curriculum development as reflected in the examination process. However it is beyond the scope of this study to carry out any analysis comparing examinations with learning behavior.

10.2.2.2 Key people and reports

Looking back over the past 120 years this researcher identified five individuals including two major reports that were mainly responsible for changes to the examination process. These people were Horatio Carslaw, Peter Board and Harold Wydham, while the two specific reports were produced by Terry Metherill and Barry McGaw. This should not take away from the contribution made by a great number of other people and organizations who contributed to building, developing and improving the education system and the teaching of mathematics in New South Wales.

Horatio Carslaw was the University of Sydney's third Professor of Mathematics in 1903 and retired later in 1935. In 1907 he originally argued for the case against establishing the Leaving Certificate examination, however before finishing his address he admitted that "*the university staff were not necessarily the best judges of the general educational requirements of the state*" (Crane and Walker, 1957). Carslaw was a member of the first board of examiners established under the Act, and acted as chief examiner in mathematics for both the Matriculation and the Leaving Certificate during his thirty year's reign and was responsible for implementing changes to the examination system.

Peter Board became Director of Education in 1905. He proposed a new balanced curriculum to include English, mathematics, natural knowledge, morals and civics and that each class should take one year to complete. Progression was dependent on adequate academic progress. Students were encouraged to stay at school longer following the Free Education Act of 1906 which abolished fees in primary and secondary State schools. Board also introduced the Intermediate Certificate examination after two years of secondary schooling and the Leaving Certificate after a further two years study replacing the Junior and Senior Public Examinations.

All courses after 1911 became the responsibility of the Department of Education which also established three types of vocational secondary schools, additional high schools, as well as a new syllabus. Various branches of mathematics were integrated within one or two sets of examination papers (Carslaw, 1914) and a higher level Mathematics Honours subject incorporating a new field of mathematics called calculus was also offered.

Harold Wyndham was appointed as Director-General of Education in 1952. He often cited the former Director of Education, Peter Board, as one role model he sought to emulate (Hughes, 1999). The Wyndham Committee was established in 1953 to solve the immediate crisis in education due to serious shortages in school buildings, teachers and funding (Barcan 1988). The Wyndham Report, introduced in 1957, led to the 1961 Education Act and the establishment of the Secondary Schools Board to conduct the new School Certificate after four years of secondary schooling and the Higher School Certificate after a further two years, thereby extending high school education from five to six years. After a hasty introduction the Wyndham Scheme began in 1962 and the first School Certificate was held at the end of 1965 followed by the first Higher School Certificate at the end of 1967. When Wyndham retired in 1968 he left a legacy of expanded school enrolments which had reached 750 000 and doubled the number of teachers employed in government schools to 32 500. In 1968 the retention rate for students at the end of secondary schooling was 20%. This improved to 70% by the mid-1990s.

Terry Metherell, the Minister for Education and Youth Affairs in 1989 released a White Paper on *Excellence and Equity: New South Wales curriculum reform.* This report was based on the Carrick Report (1989) which incorporated the recommendations of the Hobart Declaration on Schooling which included the State, Territory and Commonwealth Ministers of Education.

The White Paper identified the areas of curriculum as Key Learning Areas (KLA) in English, Mathematics, Science, Technology and Applied Studies (TAS), Human Society and its Environment (HSIE), Community and Family Studies (CAFS), Visual Arts, Vocational Education and Training (VET) and Languages other than English (LOTE). Each Key Learning Area was to have a number of mandated hours of study. Schools retained the freedom to adjust these hours upward and to provide structures whereby students were allowed to select further study in an area through elective subjects (Peacock, 1994).

Barry McGaw in 1997 produced a Green Paper *Their future: Options for reform of the Higher School Certificate* for the Department of Training and Education Co-ordination. This was to address the disenchantment of students, parents and industry with the curriculum and schools in general (ACER, 2002).

In March 1998, they released a revised report to review the NSW HSC '*Shaping their future: Recommendations for reform of the Higher School Certificate'* (McGaw Report). This report identified problems with curriculum, assessment and reporting, thus making a number of recommendations (see Section 8.2) to reform the HSC.

Following the McGaw Report, the new HSC started in 2001. Apart from abolishing the Key Learning Areas, many of the original twenty-six recommendations were implemented. This meant sweeping changes for most HSC courses including the demise of two non-calculus subjects namely: Mathematics in Society and Mathematics in Practice. These were replaced by a single more rigorous General Mathematics. Apart from name changes all the other calculus based mathematics subjects were virtually unaffected. Furthermore mathematics was no longer compulsory for the Higher School Certificate and as a consequence enrolment in mathematics has dropped from a high of 94% in 2000 to 77% in 2008.

10.2.3 Research Question 3

Is the teaching of mathematics to develop logical thinking and reasoning being tested in the examinations?

According to Benjamin Bloom et al. (1956) questioning strategies in educational settings can be used to examine a range of competencies starting with knowledge skills, followed by comprehension, application, analysis, synthesis and evaluation. Although mathematics was said to be a subject suited to build students' logical thinking and reasoning, the instructions used in the examinations have not reflected these ideas. Over 90 percent of instructions used in all the examinations fit into the knowledge and skill categories. By definition, to know something means to be able to remember or recall facts or bits of information, though one can "know" something without understanding it or expressing it in a higher context.

The analysis of the examination process has shown that less than 10% of the questions tested logical thinking and reasoning. Similar findings were also supported by TIMSS (2009) who developed specific tests for the cognitive domain criteria. Their results showed that Australian Grade 4 and 8 students performed below the standards of UK and USA as well as our Asian trading partners (Section 2.5.4). This concern regarding "problem solving" was also addressed by Anderson (2009) at a recent ACSA conference in Sydney. She stated that *"many curriculum documents present the school mathematics curriculum as lists of topics or content and a set of processes"* and also mentioned that Singapore and Hong Kong have undergone significant reform since 2000 with a focus on student learning through alignment of curriculum, pedagogy and assessment. In light of the current development and implementation of a National Curriculum, Anderson (2009, p.6) feels that there is an opportunity to address this issue and accordingly "*expectations for problem solving should be elaborated to* *support teaching and assessment, this is critical since teachers will need models of practice to support effective implementation".*

Clarkson (2003, p.15) also said that "*most recent learning theories for mathematics have at their centre logical thinking and rationalism. There has been an ongoing theme for a number of years now for the need to have teachers ask higher order questions in their teaching, perhaps using Bloom's cognitive taxonomy as a guide, but this approach has not been all that successful*". However Clarkson (2003) feels that this type of teaching will not be common until curriculum documents take this type of language seriously and make the need for its teaching quite explicit. In addition teachers will need the support of extensive and relevant curriculum and teaching resources. Testing the development of logical thinking and reasoning is a place for further research.

10.3 Difficulty of examinations

During the course of this study this researcher was often asked whether the current examinations are easier or harder than the "older" ones. Although this was not one of the research questions, the researcher believes that at the end of this study, it would be appropriate to comment on this issue.

This is not a simple question to answer because each examination needs to be addressed in context and in relation to its own curriculum at that time. Furthermore to have any relevance, each topic would need to be addressed separately. Clearly there were questions asked 100 years ago that students today would find impossible to work out, by the same token there are questions asked today that would have also challenged students in 1910. Some of these issues were addressed in Chapters 9. Possibly the best and fairest answer may have been provided in 1962 by the Chief Examiner at the time Mr. J. Williams when he commented on the Mathematics III examination by stating:

"The instructions from the Board to intended candidates is quite clear about the difficulty of the (Mathematics III) questions; they shall be of the same order as for

Mathematics I and II … However, even with this provision, most questions are easier … because of the interpretation to be placed on the Mathematics III syllabus. The latter does not require the detailed study of the topics as required by the Mathematics I or II syllabus." (Williams, 1962, p.151).
He indicated that although both subjects were of equal standard, since Mathematics III had only half the teaching time allocated, it had to be easier, because it did not have the same level of rigor as taught in Mathematics I & II.

In all fairness one cannot compare the standard of difficulty between old and more recent examinations because it would not be comparing similar sets of examinations. As an example, when the Leaving Certificate began in 1913, students attempting the entry level calculus course were required to take four separate subjects (compared with just one subject in 2010) see Table 6.2. Students in 1913 would have studied more content for 12 hours of examinations as more time was allocated in a given week to study each subject, compared with a single 3 hour examination in 2010. This would suggest that in the early examinations a number of topics such as algebra were more rigorous. This study did not compare questions in terms of their difficulty, however applying the comments made by Williams (1962) it would be reasonable to state that with increased emphasis on calculus, the rigor of calculus has also increased compared with the early Leaving Certificate examinations.

10.4 Suggestions for future research

At the conclusion of every research project, additional questions are always asked as we uncover more knowledge and understanding. There is certainly scope to extend this research. Further studies may include the examination process in all other subject areas, such as English, other languages, science areas and social sciences. This study has also identified some of the changes and attitudes in our society. Useful research could be carried out to analyze examinations and the curriculum in all subjects by comparing them to the learning behavior of the intended student population. Having identified a number of areas where improvements might be considered, further questions arise such as '*What are the* *key factors that have prevented other needed changes from being adopted*?' Answers to these questions are likely to provide guidelines towards a more relevant curriculum and a better examination process.

Many classrooms are today equipped with overhead projectors and interactive white-boards or SmartBoards. This researcher has observed that many high school mathematics teachers continue to use the techniques of "chalk and talk" for teaching high stakes mathematics classes. Although a number of new mathematics text books have been written for all the subjects since the implementation of General Mathematics in 2002, some students today continue to learn from text books, first produced 30 – 40 years ago. Most of these "older" books have been updated and many are printed in color with improved typeface, while the content has remained largely unchanged. These "older" books continue to appear along side the "newer" books on the shelves of all the book sellers. Research should be carried out towards improving student delivery methods. Possibly replacing text books with integrated wireless technologies, using telephone networks and new hand held devices such as iPhones and computer tablets would improve what happens in the classroom.

Earlier answers to the second research question suggested that changes to the examination process were largely due to our changing society. It was further proposed that changes are needed to our current high stakes mathematics curriculum. Working towards this change in 2004 the Federal Government took steps towards establishing a national Year 12 Certificate, expected to be called the Australian Certificate of Education. Professor Geoff Masters of ACER was commissioned to investigate this and in his report *Australian Certificate of Education: Exploring a Way Forward* he found significant inconsistencies between the examination standards across Australia at the end of secondary schooling. The Report made many recommendations including the establishment of common standards for key subjects such as mathematics (Patty, 2006).

Shortly after, the Board of Studies planned to introduce a new mathematics syllabus by 2010 for Years 11 and 12, however this was later deferred to coincide with the National Curriculum announced by the then Prime-Minister Kevin Rudd on January 2008. Mr Rudd appointed Professor Barry McGaw as head of the Federal Government's new National Curriculum Board, in order for the national curriculum to take effect in 2011. However according to the Australian Curriculum Assessment and Reporting Authority (ACARA) now charged with the implementation of the national curriculum, "*Feedback from the consultation on the draft Australian Curriculum will be analyzed and will shape revisions and refinements ahead of the final online publication of the K–12 Australian Curriculum for English, mathematics, science and history later in 2010*".

Included in the same announcement ACARA also stated that "*There will be flexibility in commencement of implementation of the Australian Curriculum for K–10 English, mathematics, science and history depending on specific issues to be addressed in each jurisdiction, provided the K–10 Australian Curriculum is implemented by 2013*" (ACARA, 2010). This suggested that the revised Years 11 and 12 mathematics program was not likely to be implemented until some time after 2013.

In April 2009 the Premier of New South Wales announced a $150 million government contract to supply 267 000 laptops to senior secondary public school students and their teachers (NSW Government, 2009). This is a positive step taken towards updating and improving the resources for both students and teachers. The effectiveness of this initiative has yet to be assessed.

While there have been changes to the mathematics examinations, they have not been as profound or extreme as the changes evident in society. Although the current curriculum emphasizes strategies towards the development of logical thinking and reasoning, there are few questions in the examinations testing higher order thinking.

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