Participation in Physics and rigorous Mathematics and a consideration of educational, economic and political influences.

Thesis submitted by
John Cyril Ridd BSc, AKC, PGCE, BA, BEd.
in March 2003

for the degree of Doctor of Philosophy in
the School of Mathematical and Physical Sciences
James Cook University.

I, the undersigned, the author of this thesis, understand that James Cook University of North Queensland will make it available for use within the University Library and, by photographic or electronic means, allow access to users in other approved libraries. All users consulting this thesis will have to sign the following statement:

> "In consulting this thesis I agree not to copy or closely paraphrase it in whole or in part without the written consent of the author; and to make proper written acknowledgement for any assistance which I have obtained from it"

Beyond this, I do not wish to place any restriction on access to this thesis.

J. C. Ridd.

Acknowledgements

I would like to take this opportunity to express my gratitude to my supervisor Professor M. Heron for the advice, enthusiasm, encouragement and constructive criticism that he has provided during the period of my candidature.

It is also important to acknowledge the remarkable assistance that has been provided by the staff of the Queensland Board of Senior Secondary Studies who made a plethora of detailed information freely available. My thanks also to the school principals who not only gave me a mass of information and skilled opinion but who, by their extraordinary response rate, provided me with an important psychological boost. In particular the principals, staff and especially the students of the five survey schools provided an unrivalled insight into the realities of subject selection.

My thanks to all of my family, John and Julia Bell, Michael and Sue Ridd and Peter and Cheryl Ridd for their constant encouragement and, when required, valuable criticism. Most of all to my wife Elaine who, in addition to providing some candid but constructive comments endured six years with a husband who was even more irascible than usual.

Declaration

I declare that this thesis is my own work and has not been submitted in any form for any other degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Preface.

The work reported in this thesis was based on a number of separate but interconnected pieces of research that were performed during a six year Ph.D. candidature:

An initial and then on going examination of Mathematics and physical Science enrolments at Tertiary level in a number of countries including Australia. Evidence of both demand and supply side influences were noted.

An initial and then on going examination of Secondary enrolments in Physics, Chemistry and rigorous Mathematics, primarily in Australia and with a strong focus on Queensland.

Queensland state legislation pertaining to Statutory bodies involved in Secondary education and some consequences arising from that legislation were examined.

A major survey of opinions of Queensland Secondary Principals in respect of Mathematics and physical Science with emphasis on the condition of the lower Secondary level. That survey had a 70% response rate.

An examination of student outcomes at the end of Year 10 in both physical Science and Mathematics. That examination involved a consideration of the scant hard data in existence together with an inspection of popular text-books.

A survey of the opinions of all the Year 12 students in five schools who had just completed their study of Maths C.

A survey of approximately 300 Year 10 students in the five schools at the time they were making their subject selections for Years 11 and 12. The survey examined student motivation, attitudes and knowledge of the Year 11/12 subjects.

A detailed examination and analysis of the Overall Position (OP) implications of the concurrent study of Maths B, Maths C and Physics for the students in the five schools.

An examination of the OP effect of that concurrent study by gender-viewed in terms of comparative advantage.

The performance of females and males in a number of Year 12 subjects was examined. That examination was over the whole state and considered subject performance in comparison to a measure of general ability.

Publications.

Ridd, J. and Heron, M. (1998) Science in crisis?-Participation in Physics. *A.N.Z. Physicist.*35 pp. 255-260

Ridd, J. (2000). Year 9 and 10 structures in Queensland and possible implications for subsequent studies in Mathematics and Physics. *The Physicist.* 37(3). Pp94-98

Ridd, J. (2002) Attainment in Maths and Science to Year 10 in Queensland: a tragedy in one Act. Conference paper, ASERA July 2002.

Ridd, J. (2002) A Ricardian approach to subject selection. *Journal of Institutional Research,* Vol.11(2). Melbourne.

ABSTRACT

In this thesis the level of participation in Physics and the allied discipline of rigorous Mathematics at Tertiary and upper Secondary level is examined. Various possible supply side constraints are considered, in particular the condition of Maths and Physics in lower Secondary schools in Queensland. Some of the effects of weak Maths and Physics in that part of the education chain are examined indicating that there is a commonality of interest between many school students, especially males, and the disciplines per se.

Participation in Physics at Tertiary level is in decline in USA, Canada and Germany as well as in Australia. There are indications from both Germany and USA that those declines are not entirely explicable by a consideration of demand side influences, supply side factors must have some influence. Because it may be possible to manipulate supply side influences, the work reported here concentrates on those issues, in particular in Queensland.

Participation in Physics and especially rigorous Mathematics in the last two years of Secondary schooling has been in medium to long term decline across Australia. In Queensland that decline is mainly a decline in male participation. The student decisions not to study those subjects are made at the end of Year 10. Hence their educational experiences prior to that time are important. Clear evidence is presented from a large sample of school Principals in Queensland that there is a high degree of concern in the schools about the condition of both Mathematics and Science in Years 8,9 and 10.

An inappropriate structure of relevant Statutory Authorities in Queensland has led to there having been no collection for 15 years of data vis-à-vis student outcomes up to the end of year 10. The only exception being a single but excellent study for Mathematics that showed that outcomes are highly variable and frequently weak, particularly for algebra.

For physical Science there is no data but indications from textbooks are that very little numerical Science is studied. Hence there is a discontinuity at the Year10/11 interface.

It is known that participation in the physical Sciences is highly dependent on previous educational experiences. The discontinuity referred to will affect participation in Physics and Maths C, the most rigorous Mathematics in Queensland at the Year11/12 levels. An analysis of effects on student Overall Position (the equivalent of ENTER) consequent to the concurrent study of Maths B, Maths C and Physics shows that students are advantaged in OP terms by that concurrent study. Hence the decision by an increasing number of capable students not to take those subjects may have a deleterious effect on their final outcomes. A survey of students from five North Queensland schools confirms that students who are taking Maths B/Maths C/Physics are comfortable with it and recognise that it has been to their advantage. Another part of that survey demonstrates a degree of ignorance about both Physics and Maths C amongst the Year 10 students at the time that they are making their subject selections. It is noteworthy that the advantage gained by taking the combination Maths B, Maths C and Physics is at least as noticeable for males as for females. Consequently it is an area of comparative advantage for males. An examination of male/female performance in rigorous Mathematics and numerical Science across the whole state demonstrates that, contrary to received wisdom, females are not performing better than males of similar general ability or have relatively improved their performance over the last decade at least.

It is suggested that a major overhaul of both Mathematics and physical Sciences in lower Secondary schools in Queensland is required. Such an improvement would tend to raise participation levels in both Physics and rigorous Mathematics to the advantage of many students, particularly males and provide a larger pool of qualified students from which Tertiary physical Science and Engineering Departments could draw.

The condition of both Mathematics and physical Sciences in Years 8/9/10 is at best highly variable, at worst poor, to the detriment of many thousands of

students and the related disciplines Mathematics and Physics. It is suggested that Parliament, the Statutory bodies, schools and Tertiary Education Faculties need to accept that a problem exists, accept a part of the responsibility for that problem and act decisively to rectify the situation.

CONTENTS

List of Tables

List of figures

Acronyms and abbreviations

AIP	American Institute of Physics.
ASAT	Australian Scholastic Aptitude Test. Replaced by QCS. (qv).
CSP	Canada Scholarship Program.
DEETYA	Commonwealth Department of Employment, Education, Training and Youth.
DEST	Commonwealth Department of Education, Science and Training.
Edexcel	A major London based secondary school examinations authority
EFTSU	Equivalent Full Time Student Unit.
ENTER	Equivalent National Tertiary Entrance Rank.
E.U.	European Union.
FASTS	Federation of Australian Scientific and Technological Societies.
LSAYR	Longitudinal Survey of Australian Youth. There are over twenty of these, LSAYR 22 is the most frequently referred to in this thesis.
OP	Overall Position. The Queensland equivalent of ENTER. (qv). See Appendix 4.
QBSSSS	Queensland Board of Senior Secondary Studies. Now superseded by QSA (qv). QBSSSS was frequently referred to as BOSSSS. Responsible for all studies and assessment in Years 11 and 12 only.
QCS	Queensland Core Skills Test. A test used in the Scaling process leading to the OP. See Appendix 4.
QSA	Queensland Studies Authority. The present single studies authority. The successor to QBSSSS, TEPA and QSCC. (qv)
QSCC	Queensland Schools Curriculum Council. Responsible for curriculum in Years 1 to 10. No assessment responsibilities.
SAI	Subject Achievement Indicator. See Appendix 4.
SCAT	Secondary Catholic.
SGOV	Secondary Government.
SIND	Secondary Independent.
TEPA	Tertiary Entrance Procedures Authority.
TIMSS	Third International Maths and Science Study.
WT	Writing Task. A part of QCS. (qv).