

Fresh Minds for Science: Using marketing science to help school science

Tracey-Ann Palmer

BTeach, BSc(Hons), MBA

University of Technology Sydney

A thesis submitted in the fulfilment of the requirements for the degree of

Doctor of Philosophy

Supervisor: Professor Peter Aubusson

Co-supervisor: Dr Paul F. Burke

© Tracey-Ann Palmer 2015

All rights reserved. This thesis may not be reproduced in whole or in part, by photocopy or other means, without the permission of the author.

Certificate of original authorship

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.

Signature of Student:

Date:

Acknowledgement

Thank you to my supervisor Professor Peter Aubusson and my co-supervisor Dr Paul Burke. I have been most fortunate to have enjoyed the help and support of two people of outstanding intelligence who have been enthusiastic supporters of my research. They have shared my excitement for discovery and helped me focus my gaze on the wood without losing sight of the forest. Through this wonderful journey they have been kind and given me support when I needed it and been silent when I did not. I could not have wished for better guidance.

I give my thanks also to the University of Technology Sydney who supported my work at all stages. I took full advantage of the excellent human and technical resources and feel I benefited greatly from the high quality information I received and skills I learned. I note the great assistance of Ms Racheal Laugery who guided me through the internal ethics process and also the Human Research Ethics Committee who were thorough yet pragmatic. My gratitude also to my editor, Dr Terry Fitzgerald, who helped me communicate my findings in a way that I hope you will find clear and enjoyable.

I am grateful for the support of the Australian Government for the Australian Postgraduate Award which afforded me the luxury of studying my doctorate on a full-time basis. It would have been difficult for me to complete this work without this financial support.

Finally my most sincere thanks must also go to the teaching professionals, administrators, and students at the participating schools. The staff at each school were a delight to work with – obliging and helpful. The students were generous with their time and opinions. I gained an understanding of just how hard educators and administrators work to provide quality education to our children. I am in awe of them.

Dedication

I dedicate this body of work to my daughters, Elizabeth and Victoria. They are my love and inspiration and have been the best in-house test subjects a mother could wish for.

Glossary

ACARA	Australian Curriculum, Assessment and Reporting Authority, an independent statutory authority responsible for the development of school curriculum, assessment and reporting
Achievement goal theory	A psychological model based on the idea that goals are a key motivation to learn
ATAR	Australian Tertiary Admission Rank, a score used by tertiary institutions either alone or with other criteria to rank applicants for selection into courses
Attribution theory	A psychological model based on how people attribute meaning to other people's behaviour or their own
BOSTES	The Board of Studies, Teaching and Educational Standards NSW, the NSW Government authority for standards in curriculum, student assessment and teacher quality
BWS	Best Worst Scaling, a survey method in which respondents determine the best and worst option from sets of factors to determine the relative importance of factors affecting a decision
Career indecision	A measure of how sure a student is of their career path
CCA	Constant Comparative Approach, an analysis technique that used to develop a theory from the data collected (grounded theory)
Content analysis	A research technique for making replicable and valid inferences from data to their context
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia's national science research agency
DCE	Discreet Choice Experiment, a survey method in which respondents trade-off between scenarios to determine the importance of factors affecting a decision

Environment Phase	The second phase of the Fresh Minds for Science study
Expectancy-value theory	A psychological model based on the theory that behaviour is a function of the expectancies a person has and the value of the goal toward which that person is working
Focus group	A group discussion based on a chosen topic or topics and designed to provide generalised group data
Focus Group Phase	The first phase of the Fresh Minds for Science study
Framing	The ways in which options are described when questions are asked
Fresh Minds for Science	Short title for this study
Fresh Minds	Short title for this study
Generation Z	Those people born 1982-2000 (approximately)
Grounded theory	A social science methodology involving the construction of theory through the analysis of data
Good marks	Student phrase used to indicate academic proficiency in a subject
Government School	School which are operated by the relevant Australian State or Territory government
HSC	Higher School Certificate, the highest educational award school students can gain in New South Wales, Australia
ICSEA	Index of Community Socio-Educational Advantage, a scale created by ACARA for the purpose of identifying schools serving similar student populations
Marketing	An activity that is aimed at exchanging offerings that have value for customers, clients, partners and society at large
NESB	Non-English Speaking Background, a person who has migrated to Australia and whose first language is not English, or someone who is the child of such a person
Non-government school	School that operates under the authority of an Australian State or Territory government but is not operated by a government education department
NSW	New South Wales, a state on the eastern coast of mainland Australia

OECD	Organisation for Economic Co-operation and Development
PISA	Program for International Student Assessment, a triennial survey by the OECD which aims to evaluate education systems worldwide by testing 15-year-old students
Science	Science (capitalised) refers to the school subject or subjects teaching science
Scientific literacy	“The ability to engage with science-related issues, and with the ideas of science, as a reflective citizen” (OECD, 2015)
Semi-structured interview	An interview using a questioning framework but which is open and so allows new ideas to be brought up during the interview
Self-efficacy	The belief that person has in their ability to influence events that affect their lives
Self-efficacy theory	A psychological model based on individual differences in the motive to achieve and on the effects of subjective expectancy on both this motive and the incentive value of success
Social cognitive career theory	A theory that suggests career behaviour is a result of interaction between self-efficacy, goals, and outcome expectation
Temporal discounting	The tendency of people to discount rewards as they approach a point in time in the future or the past
TRA	Theory of Reasoned Action, a behavioural model that predicts behaviour based on a person’s behavioural intention
STEM	Science, Technology, Engineering and Mathematics
Survey Phase	The third phase of the Fresh Minds for Science study

Table of Contents

CHAPTER 1: Introduction.....	1
1.1 Background	1
1.2 A fresh approach	1
1.3 Fresh Minds for Science.....	3
1.3.1 Research questions	3
1.3.2 Research approach	4
1.3.3 Scope	6
1.4 Contribution to knowledge.....	7
1.5 Limitations	8
1.6 Theoretical approach.....	8
1.7 Structure of this thesis.....	9
1.8 Summary	9
CHAPTER 2: Literature Review.....	11
2.1 Introduction	11
2.2 Need for science and scientists	12
2.2.1 Choosing Science at school.....	13
2.2.2 The supply of science based skills	14
2.3 Research into choice of Science at school	15
2.3.1 Overview of research	15
2.3.2 Logistics of choice	16
2.3.3 Student characteristics.....	17
2.3.4 Subject characteristics.....	21
2.4 Subject choice behaviour	24
2.4.1 Adolescent decision making	24

2.5	Theoretical foundation	26
2.5.1	Marketing perspective.....	26
2.5.2	Predicting and changing behaviour.....	27
2.6	Summary	31
CHAPTER 3: Methodology		32
3.1	Introduction.....	32
3.2	Research design.....	32
3.2.1	Theoretical positioning.....	32
3.2.2	Qualitative research phases	39
3.2.3	Quantitative research phase.....	42
3.2.4	Validity and reliability	43
3.2.5	Overview of the study	48
3.3	Focus Group Phase.....	53
3.3.1	Sample selection in the Focus Group Phase	53
3.3.2	Data collection in the Focus Group Phase	54
3.3.3	Analysis in the Focus Group Phase.....	56
3.4	Environment Phase.....	57
3.4.1	Sample selection in the Environment Phase	58
3.4.2	Data collection in the Environment Phase	59
3.4.3	Analysis in the Environment Phase.....	60
3.5	Survey Phase	61
3.5.1	Sample collection in the Survey Phase	61
3.5.2	Data selection in the Survey Phase	61
3.5.3	Analysis in the Survey Phase	69
3.6	Risks and limitations of the study	71

3.6.1	Procedural risks and ethical considerations	71
3.6.2	Data protection	73
3.6.3	Limitations of the methodology	73
3.7	Summary	74
CHAPTER 4:	Focus Group Phase.....	75
4.1	Introduction	75
4.2	Analysis of the focus groups	76
4.2.1	Overview	76
4.2.2	Nodes	77
4.3	Focus group findings.....	83
4.3.1	Student characteristics.....	83
4.3.2	Subject characteristics.....	89
4.3.3	Choice process	98
4.4	Summary	102
4.4.1	Process of choice.....	102
4.4.2	Factors for choice.....	104
4.4.3	Choice of Science.....	107
CHAPTER 5:	Environment Phase.....	113
5.1	Introduction	113
5.2	Subject choice information	113
5.2.1	Number of units	114
5.2.2	Subject selection events	115
5.2.3	Written information.....	120
5.2.4	Careers information.....	125
5.3	Adult interviews.....	126

5.3.1	Student characteristics.....	128
5.3.2	Subject characteristics.....	131
5.3.3	Choice process	139
5.4	Summary	146
CHAPTER 6: Survey Phase		148
6.1	Introduction	148
6.2	Sample statistics	149
6.2.1	Participants.....	149
6.2.2	BWS sample statistics.....	151
6.3	Interval-scale and free-response questions.....	152
6.3.1	Future study or career decision status	152
6.3.2	Subject choice decision making difficulty	154
6.3.3	Choice of Science.....	161
6.3.4	Advice from respondents	168
6.3.5	Summary of key findings	173
6.4	Best Worst Scaling.....	174
6.4.1	Factors for BWS.....	175
6.4.2	BWS-Accept	177
6.4.3	BWS-Reject.....	185
6.4.4	BWS-Accept and BWS-Reject	193
6.5	Summary	199
CHAPTER 7: Conclusion		201
7.1	Introduction	201
7.2	Choosing subjects	201
7.2.1	Student characteristics.....	202

7.2.2	Subject characteristics	203
7.2.3	Choice process	204
7.3	Choosing Science	205
7.4	Marketing of Science	206
7.4.1	Target market	206
7.4.2	The value of Science	207
7.4.3	The marketing mix	210
7.5	Strategies for influencing choice of Science	213
7.5.1	Science is valuable	214
7.5.2	Science is achievable.....	215
7.5.3	Science is empowering.....	216
7.6	Study limitations	217
7.7	Future research	218
7.8	Summary	220
	References	222
	Appendices	237
	Appendix A: Summary of rules relating to Higher School Certificate and Australian Tertiary Admissions Rank.....	237
	Appendix B: Information to participants	239
	Document B.1: Information for schools	240
	Document B.2: School process cheat sheet.....	252
	Document B.3: Adult consent.....	253
	Document B.4: Student consent.....	254
	Document B.5: Adult interview fact sheet.....	255
	Document B.6: Focus group fact sheet	256

Appendix C: Fresh Minds for Science Survey.....	257
Appendix D: Best Worst Scaling gender and Science choice data.....	278

Table of Figures

Figure 1.1: The three phases of the Fresh Minds for Science study.	5
Figure 1.2: The scope of the study.	7
Figure 2.1: The Theory of Reasoned Action.	29
Figure 3.1: Overview of the Fresh Minds methodological approach.	36
Figure 3.2: Relationship between Fresh Minds methodology and the Theory of Reasoned Action.	38
Figure 3.3: Timeline for the Fresh Minds study.	49
Figure 3.4: Data collection sequence for schools.	51
Figure 3.5: Example of BWS-Accept statement set.	66
Figure 3.6: Example of BWS-Reject statement set.	67
Figure 4.1: Coding relationships of focus group parent and child nodes.	79
Figure 4.2: The number of coding references for child nodes grouped into parent nodes. .	80
Figure 4.3: Dendrogram showing nodes clustered by coding similarity.	82
Figure 4.4: Student characteristics nodes.	83
Figure 4.5: Subject characteristics nodes.	89
Figure 4.6: Choice process nodes.	98
Figure 4.7: Model of the subject choice process that Year 10 students use to select subjects for Years 11 and 12.	103
Figure 4.8: Model of how advice is perceived in subject choice.	107
Figure 4.9: Relationship between engagement and performance in Science choice.	109
Figure 4.10: Model of how past teaching experiences affect the choice of Science.	110
Figure 4.11: Model of the role of career in choosing Science.	111
Figure 5.1: Format of Chemistry pages in school subject selection handbooks.	121
Figure 5.2: Format of Chemistry subject selection information leaflets.	124
Figure 6.1: Percentage and number of male and female responses to 'How sure are you about what you will study or choose as a career after you leave school?'	153
Figure 6.2: Percentage and number of male and female responses to, "How difficult was it to find out information about the subjects?"	155

Figure 6.3: Percentage and number of male and female responses to, “How difficult was it to make your final subject selection?”	156
Figure 6.4: Percentage and number of male and female responses to, “How difficult was it to choose the subject you wanted to do?”	157
Figure 6.5: Percentage and number of male and female responses to, “How difficult was it to choose the subjects you did not want to do?”	157
Figure 6.6: BWS-Accept: Reasons for choosing a subject.	178
Figure 6.7: BWS-Accept comparison of mean male and female BWS scores.	182
Figure 6.8: BWS-Accept comparison of mean BWS scores for students who indicated they did or did not choose Science.....	184
Figure 6.9: BWS-Reject: Reasons for rejecting a subject.....	186
Figure 6.10: BWS-Reject comparison of mean male and female BWS scores.	190
Figure 6.11: BWS-Reject comparison of mean BWS scores for students who indicated they did or did not choose Science.....	192
Figure 6.12: Comparison of responses to BWS-Accept and BWS-Reject surveys.	194
Figure 7.1: Value assessment model for students who are undecided about Science.....	209
Figure 7.2: Fresh Minds and the Theory of Reasoned Action.	214

Table of Tables

Table 1: Participation of Australian 17-year-olds in Science subjects	15
Table 2: Overview of the three phases of the Fresh Minds study.....	33
Table 3: Validity measures for qualitative and quantitative research.....	44
Table 4: Rationale for sample selection.....	52
Table 5: Student participants in the focus groups.....	54
Table 6: Subject selection events observed and adult stakeholders interviewed.....	58
Table 7: Survey demographic questions.....	62
Table 8: Survey choice of Science questions.....	63
Table 9: The risks identified and managed within the Fresh Minds study.....	72
Table 10: Subject selection school events.....	115
Table 11: Subject selection handbook comments on usefulness of Chemistry.....	122
Table 12: Interviews with adult stakeholders within schools.....	127
Table 13: Number of students completing each part of the Fresh Minds survey.....	150
Table 14: Educational sector of survey respondents.....	151
Table 15: Number and percentage of respondents to the BWS survey component by gender and school sector.....	151
Table 16: Descriptive statistics for difficulty of subject selection choice survey questions	158
Table 17: Correlations between responses to difficulty of subject selection choice survey questions.....	159
Table 18: Percentage of students choosing Science subjects.....	161
Table 19: Science subjects chosen by male and female students who chose a Science subject.....	162
Table 20: Percentage of male and female students taking 1, 2 or 3 Science subjects.....	162
Table 21: Percentage of students choosing Science subjects as reported by participating schools.....	163
Table 22: Student reasons for choosing to study Science.....	164
Table 23: Student reasons for not choosing to study Science.....	166
Table 24: Student comments on factors missing from survey.....	168

Table 25: Survey responses - advice from students on ways to encourage Science study	169
Table 26: BWS-Accept and BWS-Reject subject selection attribute statement pairs	176
Table 27: BWS-Accept reasons for choosing a subject - ranking and descriptive statistics	179
Table 28: BWS-Accept inferential statistics comparing rankings	180
Table 29: BWS-Accept male and female statistically significantly different scores	183
Table 30: BWS-Reject reasons for not choosing a subject - ranking and descriptive statistics	187
Table 31: BWS-Reject inferential statistics comparing rankings	188
Table 32: BWS-Reject male and female statistically significantly different scores	191
Table 33: Comparison of BWS-Accept and BWS-Reject scores	195
Table 34: Top seven reasons to choose or reject a subject for Years 11 and 12 at school	205

Abstract

The supply of scientists and scientifically literate citizens is vital for Australia's prosperity. However, traditional approaches to inspire Australian children to choose Science in senior school and through to university have been insufficient to meet Australia's needs for scientifically educated individuals. This study, Fresh Minds for Science, attempts to understand how students choose their subjects for study in Years 11 and 12 and how the choice of Science is influenced by this decision-making process. The study was conducted within a marketing and science framework informed by the Theory of Reasoned Action. It employed a mixed methods approach in an exploratory sequential design to examine student career aspirations and perceptions of subject choice. Research was conducted in five schools in the Sydney region. Data were collected and analysed from 10 focus groups with 50 students, interviews with 15 adult stakeholders within schools, and seven subject selection event observations. Findings from this qualitative investigation were used to construct and administer a survey to 379 students. The survey examined student career aspirations, perceptions of subject choice and contained a Best Worst Scaling component to investigate the relative importance of the 21 factors that were found to be considered by students when choosing subjects. The findings indicate that participating students accepted and rejected subjects based on enjoyment, interest and the perceived need for those subjects in their future study or career plans. They saw the principal benefit of studying Science in particular was as preparation for a stereotypical career in science. This study suggests redressing students' narrow perceptions of Science by marketing Science as an empowering and achievable 'purchase' that is valuable for a range of occupations and for life generally. It also recommends that students' perceptions of their own abilities in Science be supported during the critical time in Year 10 at which subject choice is made.