



# **Reconciling Image with Innovative Need**

**How Employers Determine the 'Fit' of Engineering Higher Degree  
by Research Graduates for Industry**

**Karen Adams**

B.Mus. (Hons), Dip. Ed., M.Ed.

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

School of Mechanical Engineering

The University of Adelaide

July 2011

# Table of Contents

<b>List of Tables .....</b>	<b>viii</b>
<b>List of Figures .....</b>	<b>x</b>
<b>List of Acronyms .....</b>	<b>xii</b>
<b>Abstract.....</b>	<b>xiii</b>
<b>Thesis Declaration.....</b>	<b>xv</b>
<b>Publications.....</b>	<b>xvi</b>
<b>Acknowledgments .....</b>	<b>xvii</b>
<b>Chapter 1: Introduction .....</b>	<b>1</b>
1.1 Aims and purpose of the study .....	1
1.1.1 Approach to study.....	2
1.2 Significance of the study .....	3
1.3 Thesis structure.....	5
<b>Chapter 2: The Substantive Context.....</b>	<b>8</b>
2.1 Political, economic and industrial contexts.....	9
2.1.1 International perspective.....	11
2.2 The university-government-industry nexus.....	12
2.2.1 Criticisms of nexus models.....	14
2.3 Evolving HDR curriculum in response to nexus models .....	17
2.3.1 Generic skills development.....	18
2.3.2 University and industry collaborative doctoral programs .....	19
2.3.3 Outcomes of collaborative doctoral programs.....	21
2.4 Employers' beliefs about higher degree by research graduates .....	25
2.5 Demographic context of the present research .....	30
2.6 Summary of chapter .....	32
<b>Chapter 3: Theoretical and Methodological Approach .....</b>	<b>34</b>

3.1 Research paradigms .....	34
3.1.1 Beginning with the questions.....	35
3.1.2 Epistemologies and paradigms in social research.....	36
3.1.3 Objectivist and constructionist interpretivism .....	40
3.1.3.1 Influence of symbolic interactionism on interpretivism .....	40
3.1.3.2 Constructionist interpretivism .....	41
3.2 Grounded theory methodology .....	42
3.2.1 The process of developing a grounded theory .....	42
3.2.2 Data collection and coding.....	44
3.2.2.1 Working with grounded theory methodology .....	47
3.2.3 Constructionist grounded theory methodology.....	48
3.2.3.1 Reflexivity .....	49
3.3 Grounded theory methodology in the present study.....	50
<b>Chapter 4: Student Perspectives .....</b>	<b>52</b>
4.1 Use of focus groups .....	53
4.1.1 Elements of focus groups.....	53
4.2 Method.....	55
4.3 Method 1: Content analysis .....	56
4.3.1 Coding.....	57
4.3.2 Results.....	58
4.3.3 Summary of content analysis .....	70
4.3.3.1 Group differences .....	70
4.4 Method 2: Concept analysis .....	72
4.4.1 Emergent categories from focus group discussion data.....	74
4.4.1.1 Wanting more .....	75
4.4.1.1.1 Wanting more opportunity to excel .....	75
4.4.1.1.2 Wanting more autonomy .....	75
4.4.1.1.3 Wanting more intellectual challenge .....	76
4.4.1.1.4 Wanting more freedom and variety .....	76
4.4.1.1.5 Wanting more opportunity to indulge curiosity .....	77
4.4.1.2 Knowing their worth .....	77
4.4.1.2.1 Gaining problem-solving awareness .....	78

4.4.1.2.2 Knowing financial worth.....	79
4.4.1.2.3 Claiming independent ownership of achievement .....	79
4.4.1.2.4 Prioritising personal goals .....	80
4.4.1.3 Feeling stuck .....	81
4.4.1.3.1 Feeling devalued.....	81
4.4.1.3.2 Stuck in the ‘mid-ground’ .....	82
4.4.1.4 Moving away.....	83
4.4.1.4.1 Feeling duped .....	84
4.4.1.4.2 Boycotting as a completion strategy .....	85
4.4.2 Summary of concept analysis findings .....	85
4.5 Summary and discussion .....	87
<b>Chapter 5: Methods for Employer Study .....</b>	<b>89</b>
5.1 Epistemological basis of the interviewing strategies.....	89
5.1.1 Issues arising in the study .....	91
5.2 Selection of participants .....	93
5.2.1 Convenience sampling technique .....	93
5.2.2 Snowball sampling technique .....	94
5.3 Participant contact and recruitment.....	95
5.4 Participant characteristics and identifiers.....	97
5.5 Interview content.....	100
5.6 Analysis .....	104
5.7 Summary of chapter .....	105
<b>Chapter 6: Overview of the theory’s emergence.....</b>	<b>107</b>
6.1 Phases of the theory’s emergence .....	108
6.1.1 Phase 1: Emergence of originality of outcome sought .....	109
6.1.2 Phase 2: Emergence of personal bias and selectivity .....	111
6.1.3 Phase 3: Moving to saturation .....	112
6.2 Final theory construction.....	114
6.3 Peripheral matters .....	117
6.3.1 The interview experience.....	117
6.3.2 Merged views about undergraduates and HDR graduates.....	119

6.3.3 Distinction between research and development and other roles .....	120
6.3.3.1 The research-engineer dichotomy .....	122
6.4 Summary and conclusion of chapter .....	124
<b>Chapter 7: Establishing Context.....</b>	<b>126</b>
7.1 HDR engineers in innovator roles .....	127
7.2 Initial concepts.....	128
7.2.1 Innovative adapter role .....	129
7.2.2 Niche innovator role .....	130
7.2.3 Visionary role.....	131
7.3 Shift from innovative roles to innovative outcomes.....	132
7.3.1 Adapted innovation outcomes.....	136
7.3.2 Niche innovation outcomes.....	136
7.3.3 Visionary innovation outcomes .....	137
7.3.4 Outcome preference and individual employer.....	138
7.4 Linking knowledge and skills to outcomes .....	139
7.4.1 Linking knowledge and skills to innovative adaptation .....	141
7.4.2 Linking knowledge and skills to niche innovation .....	142
7.4.3 Linking knowledge to visionary innovation .....	143
7.4.4 Summary of knowledge, skills and outcomes link .....	144
7.5 Linking problem-solving approach to outcome.....	146
7.5.1 Received problem-solving approach.....	146
7.5.2 Intrepid problem-solving approach.....	147
7.6 Linking personal-social characteristics to outcomes .....	148
7.7 Summary and discussion of chapter .....	149
<b>Chapter 8: Invoking Personal Theories .....</b>	<b>151</b>
8.1 Self-referencing .....	156
8.1.1 Historicising.....	156
8.1.2 Empathising .....	158
8.1.3 Minimising.....	159
8.2 ‘Just from the image of them’ .....	161
8.2.1 Imaging the engineer person.....	163
8.2.2 Imaging the HDR graduate .....	164

8.2.2.1 Imaging knowledge focus .....	164
8.2.2.2 Imaging social engagement.....	166
8.2.2.2.1 Imaging the EHDR problem solver.....	167
8.2.2.2.2 Imaging the HDR engineer.....	169
8.2.3 Imaging academia.....	171
8.2.3.1 Imaging social relevance.....	171
8.2.3.2 Imaging the university environment .....	173
8.3 Hypothesising impact: Imaging an EHDRG in the workplace .....	175
8.3.1 Predicting impact on business .....	177
8.3.2 Predicting impact on clients.....	178
8.3.3 Predicting impact on workers .....	180
8.4 Imaged desirable and troublesome attributes .....	181
8.5 Conclusion.....	182
<b>Chapter 9: Determining Workplace Fit.....</b>	<b>185</b>
9.1 Weeding.....	185
9.1.1 Sensing.....	188
9.1.2 Norming .....	188
9.1.3 Testing .....	189
9.2 Linking weeded EHDRG to outcomes .....	191
9.2.1 Tolerance of troublesome attributes .....	192
9.3 Hypothesised decision-making pathway to determine fit .....	194
9.3.1 Selecting an EHDRG for problem-solving approach .....	198
9.3.2 Selecting an EHDRG for skills and knowledge type.....	199
9.3.2.1 EHDRG as knowledge specialist .....	200
9.4 Accommodating troublesome attributes.....	202
9.4.1 Imaged knowledge and approach to outcomes: Exceptions .....	202
9.4.1.1 Case 1 .....	203
9.4.1.2 Case 2 .....	204
9.4.1.3 Case 3 .....	204
9.4.2 Refining factors for accommodation .....	205
9.5 Summary of chapter .....	205
9.6 Conclusion.....	207

<b>Chapter 10: Relevance to Extant Literature .....</b>	<b>209</b>
10.1 Relevance to creativity literature .....	210
10.1.1 Working definitions of creativity .....	211
10.1.2 The componential framework of creative performance .....	215
10.1.2.1 Influences on development of domain and creativity skills .....	217
10.1.2.2 Influences on the strength of task motivation .....	218
10.1.3 Outcomes of failure to integrate components .....	218
10.1.4 Creativity and professional identity of engineering HDR students .....	220
10.2 Focus on personal characteristics of creative people .....	222
10.2.1 Implicit personal theories are implicit person theories .....	223
10.2.2 Common perceptions of intelligent creative people .....	225
10.2.2.1 The myth of the mad genius .....	225
10.2.3 Conclusion of section .....	228
10.3 Focus reversal: Personal characteristics of the employers .....	229
10.3.1 Relevance to Kirton's theory of adaptors and innovators .....	229
10.3.2 Relevance to literature on recruitment .....	232
10.3.3 Conclusion of section .....	233
10.4 Higher education employability research .....	234
10.4.1 Studies investigating university-industry collaboration .....	235
10.4.2 Relevance to literature on employers' perspective .....	237
10.4.2.1 Relevance of creativity to understanding employers' views .....	238
10.4.2.2 Relevance of 'imaging academia' .....	239
10.4.2.3 Relevance of 'contextualising EHDRG innovative outcome' .....	240
10.4.2.4 Relevance of implicit personal theories of HDR graduates .....	241
10.5 Conclusion of chapter .....	242
<b>Chapter 11: Discussion and Implications of the Study .....</b>	<b>243</b>
11.1 Achievement of study purpose .....	243
11.2 Contribution of the study .....	244
11.3 Implications of study .....	246
11.3.1 Implications for higher education .....	246
11.3.1.1 Concern about academia .....	247
11.3.1.2 Concern about creative problem-solving approach .....	248
11.3.1.3 Concern about image .....	248

11.3.1.4 Implication of preliminary study.....	249
11.3.2 Implications for engineering industry.....	251
11.3.3 Implications for government policy.....	253
11.4 Future work .....	254
11.5 Concluding remarks .....	255
<b>Appendix 1: Qualitative Research in a Quantitative World.....</b>	<b>257</b>
A1.1 Additional background to Chapter 3 .....	257
A1.1.1 Simple paradigmatic dichotomy .....	258
<b>Appendix 2: The Evolution of Grounded Theory Methodology.....</b>	<b>261</b>
A2.1 Additional background to Chapter 3 .....	261
A2.1.1 Is a grounded ‘theory’ a theory? .....	264
A2.1.2 The impossible ‘blank slate’ .....	266
A2.1.3 Hypothetic inference, deduction and induction .....	269
A2.1.4 Summary .....	272
<b>Appendix 3: Ethics Approval for Preliminary Study .....</b>	<b>274</b>
<b>Appendix 4: Preliminary Study Request for Participants .....</b>	<b>275</b>
<b>Appendix 5: Preliminary Study Consent Form .....</b>	<b>277</b>
<b>Appendix 6: Ethics Approval for Employer Study.....</b>	<b>278</b>
<b>Appendix 7: Email Sent to Potential Employer Participants .....</b>	<b>279</b>
<b>Appendix 8: Information to Employer Study Participants.....</b>	<b>280</b>
<b>Appendix 9: Employer Study Consent Form .....</b>	<b>281</b>
<b>Appendix 10: Detailed Description of Emergence of Theory .....</b>	<b>282</b>
A10.1 Phase 1 categories.....	283
A10.1.1 Emergence of the notion of the ‘creative thinker’ .....	284
<b>Appendix 11: Definitions of Knowledge and Skill .....</b>	<b>289</b>
<b>References .....</b>	<b>291</b>



## List of Tables

Table 3.1: Framework of research paradigms: Summary of Annells' (1996, p. 384) outline of Guba and Lincoln (Guba and Lincoln, 1994) .....	39
Table 4.1: Reasons given for undertaking higher degree by research study, in descending order of frequency .....	59
Table 4.2: Plans for post-completion work .....	60
Table 4.3: Previous professional experience .....	62
Table 4.4: Contributions of higher degree by research experience to professional role .....	63
Table 4.5: Beliefs about impediments to professional preparation .....	68
Table 4.6: Four emergent categories and associated concepts from conceptual analysis of the focus group discussions.....	75
Table 5.1: Employer descriptive details, organisation type and size, interview location and sampling phase. Employer identifiers that include letters indicate that more than one employer from an organisation was interviewed; employers identified with the same letter were in the same organisation.....	102
Table 6.1: Phases of theoretical sampling reflecting conceptual emergence.....	108
Table 7.1: Employer expectations categorised as 'Specifying EHDRG workplace roles' with personal-social or knowledge-skills emphasis .....	128
Table 7.2: Key innovative advanced engineering role types and associated activities as identified from employers' comments.....	135
Table 10.1: The components of creative performance (Amabile, 1983, p. 68).....	217
Table 10.2: Characteristics and tendencies of creative people (Runco, 2007). .....	227
Table A.1: Quantitative style versus qualitative style (Burns, 1997, p. 14).....	259

Table A.2: Theory building in quantitative and qualitative research (Sarantakos, 1998, p. 15) ..... 259

## List of Figures

Figure 3.1: Four elements of a research design (based on Crotty, 1998), with the approaches taken in the present study highlighted in bold italics .....	36
Figure 4.1: Structure of content analysis.....	58
Figure 6.1: The three stages and six categories with component concepts that form the process of 'reconciling image with innovative need' .....	116
Figure 7.1: 'Contextualising EHDRG innovative outcomes' and sub-categories.....	135
Figure 7.2: The relationship between employers' expectations of original outcomes (x) and the value they place on each knowledge type (y) when considering the suitability of an EHDRG for the workplace.....	145
Figure 7.3: Favouring approach: received and intrepid .....	146
Figure 8.1: Invoking implicit personal theories. Factors in the employers' process of invoking personal theories of EHDRGs.....	154
Figure 8.2: The three sub-categories of 'imaging the HDR engineer' .....	162
Figure 8.3: The three sub-categories of 'imaging the engineering HDR graduate' ..	177
Figure 9.1: The three sub-processes of 'weeding'.....	187
Figure 9.2: Hypothesised employers' decision pathway when considering the suitability of an EHDRG for the workplace.....	196
Figure A: Phase 1 Categories. concepts and categories from interviews with employers 1–7, identified with a predominantly knowledge-skill or personal-social focus, or both.....	283
Figure B: Phase 1 to Phase 2 categories. Phase 1 categories re-formed after interviews 8–15 to create Phase 2 categories, shown here with their concepts. ....	285
Figure C: Imaging EHDRGs. Hypothesised central position of the employers' imaging of EHDRGs as a reciprocal influence on perception of achievable EHDRG	

innovative outcomes, and through the weeding process, on the ultimate decision  
about the suitability of an individual EHDRG.....288

## List of Acronyms

ACED	Australian Council of Engineering Deans
ADTP	Australasian Digital Theses Program
ARC	Australian Research Council
BAA	Backing Australia's Ability
BHERT	Business/Higher Education Round Table
CRC	Collaborative Research Centre
DEST	Department of Education, Science and Training
DETYA	Department of Education, Training and Youth Affairs
DITR	Department of Industry, Tourism and Resources
EHDR	Engineering Higher Degree by Research
EHDRG	Engineering Higher Degree by Research Graduate
GTM	Grounded Theory Methodology
HDR	Higher Degree by Research
HR	Human Resources
IPR	Intellectual Property Rights
KBE	Knowledge-Based Economy

## **Abstract**

A substantial proportion of engineering higher degree by research (HDR) graduates indicate an interest in a career in business and industry. However, little of substance is known about the ways these graduates and the engineering work they perform are perceived and valued by their industry employers. The purpose of this study was to research the beliefs and perceptions of employers of engineering HDR graduates, in order to gain a more complete understanding of how they perceive the abilities developed through higher degree by research study to contribute to the Australian industrial workplace.

Constructionist grounded theory methodology was used to explore the perceptions of 22 employers of research masters and PhD engineers in the fields of mechanical and chemical engineering in two major urban settings, both strong manufacturing and science and technology centres in Australia. The participants were located in a range of workplace contexts: consulting engineering firms, manufacturing firms, public utilities and government funded research organisations.

The study revealed that the employers viewed their engineering HDR employees with positive regard, but maintained a number of 'theoretical' concerns about engineering HDR graduates in general. Their concerns mainly emanated from (a) beliefs about the nature of engineering problem solving and how it contributes to the innovative needs of their workplaces, and (b) beliefs about, or the image of, personal characteristics of engineering HDR graduates. With respect to these latter beliefs, it is argued in this thesis that the employers maintained idiosyncratic, implicit personal theories of engineering HDR graduates. When considering accommodating engineering HDR graduates in the workplace, the employers resolved their concerns by engaging in a process of reconciliation between these two sets of beliefs.

The reconciliation process occurred in three stages: establishing innovative context, invoking personal theories and determining workplace fit. The employers were found to accommodate engineering HDR graduates to different extents, depending on the following factors: the value the employers placed on creativity to achieve workplace outcomes; the employers' tolerance of the perceived personal attributes they

associated with engineering HDR graduates; and the perceived costs they perceived to the workplace of engineering HDR graduates who display personal creativity attributes. A decision pathway, or algorithm, is hypothesised in this thesis that illustrates the way these factors are taken into account by the employers.

In keeping with grounded theory research practice, each of the stages detailed in the thesis is then shown to elaborate, extend or challenge notions found in extant literature on creative achievement, implicit theories of creative people, and recruitment biases. The findings are also argued to contribute to the literature on HDR graduates' employability and, in particular, to what is already known from studies of industry collaborative PhD programs.

## **Thesis Declaration**

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Karen Adams and, to the best of my knowledge and beliefs, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the Provisions of the Copyright Act 1968.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue, the Australasian Digital Theses Program (ADTP) and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Karen Adams



## Publications

The following publications arose from this study:

Adams, K., Ripper, M., Zander, A.C.& Mullins, G. (2010). 'The value of creativity in the workplace roles of engineering research graduates', *Educating Engineers for a Changing World*. In Refereed Proceedings of the 3rd International Symposium for Engineering Education 2010, University College Cork, Ireland, June 2010

Adams, K., Mullins, G. & Zander, A. (2008). 'Postgraduate research education and the engineering workplace: employers' perspectives', M. Kiley and G. Mullins (Eds.), *Research Education in the New Global Environment*. In Refereed Proceedings of the 8<sup>th</sup> Quality in Postgraduate Research 2008 Conference, Adelaide, April 2008.

Adams, K., Zander, A. & Mullins, G. (2007). 'What do engineering postgraduate research students know about industry work?', H. Sondergaard and R. Hadgraft (Eds.), *Connecting Teaching, Research and Industry through Engineering Education*. In Refereed Proceedings of the 18<sup>th</sup> Conference of the Australasian Association of Engineering Education. Melbourne, December 2007.

Adams, K., Zander, A. & Mullins, G. (2006). 'The professional expectations and experiences of Australian postgraduate research students in engineering fields', In Refereed Proceedings of EDU-COM 2006 International Conference, Nong Khai, Thailand, November 2006.

## Acknowledgments

It is a pleasure to acknowledge the people who have helped me to arrive at this point.

I have been very fortunate to have the sure and steady guidance of remarkable supervisors. Associate Professor Anthony Zander provided me with his perceptive insights into engineering culture and the nature of engineering research study. Associate Professor Gerry Mullins generously shared his extensive knowledge of the research education field in Australia and elsewhere. Associate Professor Margie Ripper guided me expertly through the travails inherent in a first-time undertaking of grounded theory research. I am extremely grateful for my supervisors' willingness to undertake the supervision of this transdisciplinary study, and for their encouragement and enthusiasm. Their combined expertise as researchers and supervisors meant that our meetings were rigorous, challenging and enormous fun. I was also fortunate to benefit from the guidance of Professor Richard Russell in the early stages of my project. I extend my gratitude to the participants who gave so generously of their time and ideas and who were, without exception, delightful people to interview. Special thanks also goes to Peter Murdoch, who assisted with word processing and final layout of this document.

I thank my family, friends and colleagues who offered practical support and stimulating discussion. In so many ways, they all helped me to see it through. I pay very special tribute to my children Maribel, Samuel, Maxwell and Daniel. My PhD has wound its way around birthdays, graduations, holidays, weddings and now the birth of a grandchild. This has certainly helped me to keep my study in perspective.

Above all, my heartfelt thanks go to my husband, Michael. He offered unstinting practical, emotional and intellectual support throughout this undertaking. There are no words, really, that can express my gratitude to him.