Information Technology Architect
Capabilities: Which are important and can they be improved?

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR
FOR DOCTOR OF PHILOSOPHY

Keith MacKenzie Frampton
(Bachelor of Science)

SCHOOL OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
SCIENCE, ENGINEERING AND TECHNOLOGY PORTFOLIO
RMIT UNIVERSITY, MELBOURNE, VICTORIA, AUSTRALIA

December 2007
Declaration

I declare and certify that:

a) except where due acknowledgement has been made, the work is that of the candidate alone;

b) the work has not been submitted previously, in whole or in part, to qualify for any other academic award;

c) the content of the thesis is the result of work that has been carried out since the official commencement date of the approved research program;

d) any editorial work, paid or unpaid, carried out by a third party is acknowledged;

e) ethics procedures and guidelines have been followed.

Keith MacKenzie Frampton (Candidate) ________________________________
Acknowledgements

As is always the case with endeavours such as completing a PhD, you very rarely ever do it alone and in my case that was very true. My partner Lesley Forsyth has been amazing in her encouragement, listening, reviewing, and total support – thank you! My two supervisors, Associate Professor James Thom and Doctor Jennie Carroll have both been great, constructive, and knowledgeable and I have been privileged to work with them.

I am clear that I could not have managed to undertake and complete this endeavour without the support and contributions of many other people. They include Doctor John Reece from RMIT, who consulted throughout my journey, Bruce Crossman from IBM who not only asked good questions and provided unstinting support but also organised the invaluable IBM participation and support. Cecily Walker and other RMIT staff and students gave valuable advice, suggestions, support, and encouragement. Within RMIT in addition to the very much appreciated ongoing support from the schools of Computer Science and Information Technology and Business Information Technology, I could not have undertaken the research in the manner I was able to without the committed people within RMIT’s Disability Liaison Unit or the library and its staff and facilities, in particular LIDDAS (my friend!).

For key aspects of the research itself I am grateful for the passionate and enthusiastic participation of the interviewees, support, encouragement, and invaluable information from P. Paul Heppner, Phil Zimbardo, Christopher Allinson, IBM overall, the generous participation of survey respondents and testers, and the students, tutors, and lecturer of Systems Architecture.

Finally to my friends, family and The Marlo Group, thank you for being understanding and supporting me through this journey.

All stages were reviewed and approved by the RMIT University Science Engineering and Technology ethics committee and all trademarks are the owners of the respective companies and organisation.
The research for this thesis has resulted in portions of it already being published in the following papers at refereed conferences:

- Frampton, K, Carroll, JM & Thom, JA 2005, 'What Capabilities Do IT Architects Say They Need?' *paper presented to 10th United Kingdom Academy for Information Systems (UKAIS)* Newcastle, United Kingdom, 22-24th March.


In the cases where I was first author, I was primarily responsible for both the research itself and the writing up of the findings. For the paper where I was second author, I was responsible for all the research and reporting relating to IT Architects and how they compared to systems engineers.
# Table of Contents

Declaration ................................................................................................................... ii  
Acknowledgements .................................................................................................... iii  
Abstract ....................................................................................................................... 1  

Chapter 1. Introduction ............................................................................................... 3  
1.1 What is architecture within IT? ......................................................................... 4  
1.2 What are architects within IT? .......................................................................... 8  
1.3 Why is the study of capabilities of IT Architects important? ......................... 9  
1.4 Overarching research questions and approach .............................................. 11  
1.5 Contributions ..................................................................................................... 12  
1.6 Thesis overview ................................................................................................. 14  

Chapter 2. IT Architects in context ............................................................................. 17  
2.1 Characteristics of people in IT .......  
2.2 The relationship of IT Architect to other IT roles ........................................... 19  
2.2.1 1960s and before ......................................................................................... 22  
2.2.2 1970s .......................................................................................................... 22  
2.2.3 1980s .......................................................................................................... 22  
2.2.4 1990s .......................................................................................................... 24  
2.2.5 2000s .......................................................................................................... 26  
2.3 How are architect’s skills being taught? .......................................................... 30  
2.3.1 Relevant curriculum recommendations .................................................... 30  
2.3.2 Australian and New Zealand architect education ....................................... 31  
2.4 Summary ........................................................................................................... 34  

Chapter 3. Research design ......................................................................................... 37  
3.1 Nature of research ............................................................................................... 37  
3.2 Drivers of research design .................................................................................. 38  
3.2.1 Purposes of research ................................................................................... 39  
3.2.2 Pure or applied research .....  
3.2.3 Quantitative or qualitative data collection and analysis ................................ 40  
3.2.4 Time dimension ......................................................................................... 40  
3.2.5 Units of analysis ......................................................................................... 41  
3.2.6 Environment ............................................................................................... 42  
3.2.7 Ethics ......................................................................................................... 42  
3.3 Research design ................................................................................................. 43  
3.3.1 Sub-question 1: What are characteristics of highly-skilled IT Architects? .... 44  
3.3.2 Sub-question 2: What capabilities distinguish highly-skilled IT Architects? .... 49  
3.3.3 Sub-question 3: Can some IT Architect capabilities be improved in a university subject? 54  
3.4 Rigour, relevance and reliability of our research .............................................. 57  
3.5 Summary ........................................................................................................... 59  

Chapter 4. IT Architect characteristics ...................................................................... 60  
4.1 Interview approach and interviewees ................................................................. 60  
4.1.1 Interviewees ................................................................................................. 60  
4.1.2 Preparation and conduct of interviews ...................................................... 62
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>Interview processing and analysis</td>
<td>63</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Characteristics coding and initial identification</td>
<td>64</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Characteristics classification</td>
<td>64</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Important characteristics determination</td>
<td>65</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Characteristic consolidation</td>
<td>66</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Alternative analysis approach</td>
<td>70</td>
</tr>
<tr>
<td>4.2.6</td>
<td>Research tasks timeline</td>
<td>70</td>
</tr>
<tr>
<td>4.3</td>
<td>Interview results</td>
<td>70</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Background</td>
<td>70</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Personality traits</td>
<td>71</td>
</tr>
<tr>
<td>4.3.3</td>
<td>Capabilities</td>
<td>72</td>
</tr>
<tr>
<td>4.4</td>
<td>Discussion</td>
<td>76</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Background</td>
<td>76</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Personality traits</td>
<td>77</td>
</tr>
<tr>
<td>4.4.3</td>
<td>Capabilities</td>
<td>77</td>
</tr>
<tr>
<td>4.4.4</td>
<td>Comparison to industry expectations</td>
<td>79</td>
</tr>
<tr>
<td>4.4.5</td>
<td>Comparison to pre-conceptions</td>
<td>79</td>
</tr>
<tr>
<td>4.4.6</td>
<td>Limitations</td>
<td>80</td>
</tr>
<tr>
<td>4.4.7</td>
<td>Other observations</td>
<td>80</td>
</tr>
<tr>
<td>4.5</td>
<td>Summary</td>
<td>81</td>
</tr>
<tr>
<td>5.1</td>
<td>Survey construction</td>
<td>84</td>
</tr>
<tr>
<td>5.1.1</td>
<td>Capabilities for which no survey instrument match was attempted</td>
<td>85</td>
</tr>
<tr>
<td>5.1.2</td>
<td>Search process for survey instruments for remaining capabilities</td>
<td>86</td>
</tr>
<tr>
<td>5.1.3</td>
<td>Capabilities for which no survey instrument match was identified</td>
<td>87</td>
</tr>
<tr>
<td>5.1.4</td>
<td>Capabilities for which matching survey instruments were found</td>
<td>89</td>
</tr>
<tr>
<td>5.1.5</td>
<td>Survey construction</td>
<td>92</td>
</tr>
<tr>
<td>5.2</td>
<td>Target cohort details</td>
<td>94</td>
</tr>
<tr>
<td>5.3</td>
<td>Administration and response processing</td>
<td>96</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Administration</td>
<td>96</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Initial handling of missing or erroneous responses</td>
<td>97</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Response summary</td>
<td>98</td>
</tr>
<tr>
<td>5.3.4</td>
<td>Missing value processing</td>
<td>99</td>
</tr>
<tr>
<td>5.3.5</td>
<td>Outlier processing</td>
<td>101</td>
</tr>
<tr>
<td>5.4</td>
<td>Results analysis</td>
<td>101</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Overall response characteristics</td>
<td>101</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Norms analysis</td>
<td>104</td>
</tr>
<tr>
<td>5.4.3</td>
<td>Different groups analysis</td>
<td>110</td>
</tr>
<tr>
<td>5.4.4</td>
<td>Post hoc power analysis</td>
<td>119</td>
</tr>
<tr>
<td>5.4.5</td>
<td>Factorial comparison</td>
<td>120</td>
</tr>
<tr>
<td>5.5</td>
<td>Discussion</td>
<td>121</td>
</tr>
<tr>
<td>5.5.1</td>
<td>Discussion of more detailed analysis</td>
<td>121</td>
</tr>
<tr>
<td>5.5.2</td>
<td>Other comments</td>
<td>122</td>
</tr>
<tr>
<td>5.5.3</td>
<td>Limitations</td>
<td>122</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Revisit interviews</td>
<td>123</td>
</tr>
<tr>
<td>5.6</td>
<td>Summary</td>
<td>124</td>
</tr>
<tr>
<td>6.1</td>
<td>Subject choice and description</td>
<td>125</td>
</tr>
<tr>
<td>6.2</td>
<td>Student interaction design</td>
<td>128</td>
</tr>
<tr>
<td>6.3</td>
<td>Survey development and pre-subject administration and &amp; processing</td>
<td>130</td>
</tr>
<tr>
<td>6.3.1</td>
<td>Survey development</td>
<td>130</td>
</tr>
</tbody>
</table>
6.3.2 Pre-subject survey administration & processing .......................................................... 131
6.3.3 Initial pre-subject analysis .......................................................................................... 131

6.4 Teaching .......................................................................................................................... 137
6.4.1 Teaching resources design and creation .................................................................. 137

6.5 Post-subject survey administration and processing ...................................................... 141
6.5.1 Post-subject norms analysis .................................................................................... 145
6.5.2 Pre-subject and post-subject comparison ................................................................. 146
6.5.3 Post-subject tutorial group comparison .................................................................. 147
6.5.4 Post-subject under-graduate and post-graduate comparison ............................... 148
6.5.5 Pre-subject and post-subject comparison ................................................................. 149

6.6 One-year later administration and processing .............................................................. 150
6.6.1 Post-subject norms analysis .................................................................................... 154
6.6.2 One-year later tutorial group comparison ............................................................... 156
6.6.3 One-year later under and post-graduate comparison ............................................ 157
6.6.4 Pre-subject and one-year later comparison ............................................................. 157
6.6.5 Post-subject and one-year later comparison ............................................................. 159
6.6.6 Only matched participants norms comparison ....................................................... 160
6.6.7 One-year later and both pre-subject and post-subject comparison ..................... 162

6.7 Power analysis for different student responses ............................................................ 163

6.8 Discussion ......................................................................................................................... 164
6.8.1 Implications ............................................................................................................ 164
6.8.2 Limitations .............................................................................................................. 165
6.8.3 Revisit interviews .................................................................................................. 166

6.9 Summary ......................................................................................................................... 167

Chapter 7. Conclusions and future work ............................................................................. 169

7.1 IT Architect characteristics findings and contribution .................................................. 170
7.2 Highly-skilled IT Architect distinguishing capabilities findings and contribution ........ 170
7.3 Experiences teaching IT Architect capabilities ............................................................. 172
7.4 Boundaries of this research ........................................................................................ 172
7.5 Suggestions for future work ......................................................................................... 173
7.6 Overall research contributions ..................................................................................... 176

Appendices ............................................................................................................................ 179
Appendix A. Interview guide ............................................................................................... 179
Appendix B. Material sent to interviewees ......................................................................... 185
Appendix C. Preconceptions and expected findings .......................................................... 192
Appendix D. Coding categories and descriptions .............................................................. 199
Appendix E. Transcript extracts and coding examples ...................................................... 205
Appendix F. Plain language statement and professional survey ........................................ 214
Appendix G. Overall response characteristics ................................................................. 222
Appendix H. Survey factorial ANOVA detailed results ...................................................... 225
Appendix I. Material for student participants .................................................................... 230
Appendix J. Rejected teaching design alternatives ............................................................. 236
Appendix K. Summary of teaching objectives for tutorials ................................................. 238
Appendix L.  Pre-subject matched respondents’ norm analysis................................. 245
Appendix M.  Detailed post-subject analysis................................................................. 246
Appendix N.  Post-subject factorial ANOVA detailed results..................................... 247
Appendix O.  Acronyms used within thesis................................................................. 251
References......................................................................................................................253
### Table of figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Overall thesis structure</td>
<td>15</td>
</tr>
<tr>
<td>3-1</td>
<td>Overall research design</td>
<td>44</td>
</tr>
<tr>
<td>4-1</td>
<td>Work relationships between interviewees</td>
<td>62</td>
</tr>
<tr>
<td>5-1</td>
<td>Different group analyses</td>
<td>112</td>
</tr>
<tr>
<td>5-2</td>
<td>Results of different groups comparisons</td>
<td>121</td>
</tr>
<tr>
<td>6-1</td>
<td>Matched responses PSI norms comparison</td>
<td>161</td>
</tr>
<tr>
<td>6-2</td>
<td>Matched responses ZTPI norms comparison</td>
<td>161</td>
</tr>
</tbody>
</table>
Table of tables

Table 2-1 Evolving research in people characteristics related to IT Architects ........... 21
Table 2-2 Australian and New Zealand universities 2007 architecture degrees ........... 31
Table 2-3 Australian and New Zealand universities 2007 architecture subjects ......... 34
Table 4-1 Characteristics consolidation summary .................................................. 69
Table 4-2 Prior capabilities identified ........................................................................ 78
Table 5-1 Mapping of capabilities to concepts and instruments .................................. 89
Table 5-2 Target cohorts ............................................................................................ 95
Table 5-3 Response rate for each survey cohort ......................................................... 98
Table 5-4 IT Architect demographics March 2007 ................................................ 103
Table 5-5 Project Managers demographics May 2007 ........................................... 103
Table 5-6 Comparison of CSI norms data with research results ............................... 105
Table 5-7 All IT Architect PSI factors normative comparison .................................. 106
Table 5-8 All Project Manager PSI factors normative comparison ............................ 107
Table 5-9 All respondents PSI factors normative comparison ................................... 107
Table 5-10 Architect respondents ZTPI factors normative comparisons .................. 109
Table 5-11 Project Manager respondents ZTPI factors normative comparisons ....... 109
Table 5-12 All respondents ZTPI factors normative comparisons ............................ 110
Table 5-13 Comparison of survey responses between certified and uncertified IT Architects ................................................................................................................. 113
Table 5-14 Comparison of survey responses between certified and uncertified Project Managers........................................................................................................... 114
Table 5-15 Comparison of survey responses between uncertified respondents ........ 115
Table 5-16 Comparison of survey responses between certified respondents only ...... 117
Table 5-17 Comparison of survey responses between all IT Architects and Project Managers .............................................................................................................. 117
Table 5-18 Comparison of survey responses between all certified and uncertified respondents ........................................................................................................... 119
Table 5-19 Professional survey power analysis summary .......................................... 120
Table 6-1 Student pre-subject analysis (part 1) ........................................................... 131
Table 6-2 Student pre-subject analysis (part 2) ........................................................... 132
Table 6-3 Student pre-subject analysis (part 3) ........................................................... 133
Table 6-4 Student pre-subject norm analysis ............................................................. 134
Table 6-5 Students pre-subject tutorial one compared with tutorial two .................. 135
Table 6-6 Students pre-subject under-graduate compared with post-graduate ........ 136
Table 6-7 Student post-subject analysis (part 1) .......................................................... 142
Table 6-8 Student post-subject analysis (part 2) .......................................................... 143
Table 6-9 Student post-subject analysis (part 3) .......................................................... 144
Table 6-10 Student post-subject norm analysis .......................................................... 145
Table 6-11 Comparison of all responses pre-subject and post-subject ....................... 146
Table 6-12 Comparison of matched responses pre and post-subject ....................... 147
Table 6-13 Students post-subject tutorial one compared with tutorial two ............. 148
Table 6-14 Students one-year later responses overall ............................................... 151
Table 6-15 Students one-year later responses by tutorial .......................................... 152
Table 6-16 Students one-year later responses by original enrolment status ............. 153
Table 6-17 Summary of all responses ......................................................................... 154
Table 6-18 Student one-year later norm analysis ...................................................... 154
Table 6-19 Pre-subject, post-subject, one-year later norms comparison ................... 155
Table 6-20 One-year later tutorial comparison .......................................................... 157
Table 6-21 Comparison pre-subject and one-year later - all responses .................... 158
Table 6-22 Comparison pre-subject and one-year later - matched responses .......... 158
Table 6-23 Comparison post-subject and one-year later - all responses ................... 159
Table 6-24 Comparison post-subject and one-year later - matched responses ........ 160
Table 6-25 Common students: pre-subject, post-subject, one-year later norms comparison ................................................................. 160
Table 6-26 Student unmatched responses power analysis summary ............................... 163
Table 6-27 Student matched responses power analysis summary ................................. 164
Abstract

Information Technology (IT) systems have become essential components of our society. These IT systems have an internal structure called the system’s architecture. This architecture directly affects the system’s performance and ability to meet business objectives. The people who design this structure are called IT Architects. Investigating the capabilities that distinguish highly-skilled IT Architects contributes to IT knowledge and practice and supports improving the design of systems’ architectures as well as the selection and development of IT Architects.

This thesis examines some of the capabilities that distinguish highly-skilled IT Architects and applies the resulting understanding to the education of post-graduate IT students. By investigating selected capabilities of highly-skilled IT Architects, how this group of IT Architects differ from their colleagues with respect to highly-valued capabilities and how these capabilities could be taught, we clarify both a professional and an educational basis for improvement.

The research has a three stage, multi-method design. The initial stage, undertaken in 2004, consists of interview-based qualitative research with fourteen practicing IT Architects to understand the characteristics of highly-skilled IT Architects. The interviewees were chosen through personal relationships and subsequent snowball sampling and through the interviews and subsequent analysis, we identify eight capabilities, four personality traits and a range of experience that is valuable for highly-skilled IT Architects. These results support prior research that identified the importance of communications and business knowledge while extending the range of valuable characteristics for the IT Architect role.

The next quantitative stage surveys 82 practicing IT Architects and 97 other IT professionals using four psychological measures; the Cognitive Style Inventory (CSI), the Problem Solving Inventory (PSI), the Vividness of Visual Imagery Questionnaire (VVIQ), and Zimbardo’s Time Perspective Inventory (ZTPI). The analysis, undertaken in 2005, identifies two statistically significant differentiating capabilities
that distinguish highly-skilled IT Architects from less skilled IT Architects. The first capability is that the highly-skilled IT Architects approach problems differently and generate more alternatives before attempting solutions and spend more effort evaluating outcomes than the less skilled IT Architects. The second capability is that the less skilled IT Architects have a different attitude towards time and do not always act consistently with a longer term perspective.

The final stage of research investigates whether the teaching of material related to the two distinguishing capabilities improve students outcomes for these capabilities. In 2006 we measured the initial student capability level of 35 students, the level of 28 of these students at the conclusion of the subject, and again in 2007, one-year later 16 students were measured. We again use quantitative surveys with the PSI and ZTPI instruments and found that whilst we measure a change in student capability for problem solving, the two capabilities we targeted are not significantly affected through the teaching. Interviews with the participants indicate that the teaching is effective and the lack of significant differences in the targeted capabilities is because of external factors overriding what they are learning.

Our research contributes to the field of Computer Science and Information Technology by providing:

(i) the basis for improved identification and selection of IT Architects for industry and providing additional information to enhance their professional education through the identification of distinguishing capabilities of highly-skilled IT Architects;

(ii) information for educators about IT Architect capabilities and capability development that are important for highly-skilled IT Architects and some considerations when teaching these capabilities;

(iii) a foundation for research that compares and contrasts capabilities within other IT professions; and

(iv) results that can be used to improve the process of architecting IT systems.

More generally, the research contributes to the body of knowledge regarding IT skills and requirements for different roles.
Chapter 1. Introduction

Information Technology (IT) systems have become essential components supporting our society. All substantial IT systems have an internal structure that directly affects their performance and ability to meet business objectives, called the architecture of the system. Skilled IT people create this architecture. These people are called IT Architects and they create, design, communicate and maintain the architecture of IT systems. These activities are crucial to the effectiveness of the IT system and therefore so are the people who perform this role. To date the majority of IT Architecture research has explored technical aspects of architectures with limited exploration of the characteristics of the people responsible for the architectures. Understanding what makes some of the people more effective than others in the role of IT Architect will enable continued improvement in the development and delivery of IT systems.

The objective of this research is to increase understanding of some of the capabilities that characterise IT Architects, to investigate what distinguishes highly-skilled IT Architects from their colleagues, and to examine how to improve these capabilities within a tertiary educational environment.

The first three sections of this chapter explain what architecture within IT is, the role of IT Architects, and why the study of IT Architects is important. We then describe the research questions being investigated, and distinguishe our research from other
similar research. Finally, we describe the scope and main limitation of this research and then summarise the overall contributions and the remainder of this thesis.

### 1.1 What is architecture within IT?

The architecture of a system is the overall structure of the components of the system, the interactions and relationships between those components, and the changes in the system, components, and interactions over time. More formally, an architecture is:

> “the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution” (ANSI/IEEE 2000).

The architecture of a system is critical to its success; as Clements et al. (2003) say, “… success will be elusive if you fail to pay careful attention to its architecture.”

Much of the research into architecture has focused on technical not human issues with several leading researchers investigating these non-people aspects of creating an architecture (Ali Babar, Kitchenham & Gorton 2006; Boehm 2006; Garlan 2000; Krutch, Obbink & Stafford 2006; Perry & Wolf 1992; Shaw 2001, 2003; Shaw & Garlan 1996; Shaw & Clements 2006). Much of this research is oriented around Architecture Definition Languages and product lines (Garlan 2000). In addition, there is a concentration on the documentation and evaluation of architectures (Clements, Klein & Kazman 2002; Clements et al. 2003), how architectures are viewed and used (Smolander 2002a, 2002b, 2003; Smolander, Rossi & Purao 2005), and also on architectures for specific classes of problems, for example, embedded systems (Schmidt & Buschmann 2003). That is, research has focussed on the architecture not the people who design the architecture. Other researchers (Alter & Browne 2005; McBride 2007; Ylimäki & Halttunen 2005) emphasise the importance of a system’s architecture and note a lack of relevant research into the people creating architectures.

---

1 This thesis has been written in third person as per the guidelines of Zobel, J 2004, *Writing for Computer Science*, second edition, Springer-Verlag London Limited, London, England. Any use of we or the researcher refers to the author of this thesis. Where other people were involved for example, as interviewees, survey distributors or respondents, or students that involvement has been clearly identified and described.
Introduction

There are many different types of architectures described by academia and industry within the IT area. Most of these descriptions are focussed on the artefacts that make up the architecture. There are few definitions of IT Architectures and little agreement on what constitutes an IT Architecture, across both academia and industry. Definitions vary on scope, for example, does the architecture include just one company or all companies involved in a system, and the level of technical detail included within an architecture, for example, whether a software architecture includes full specification of all components or only the high-level components of a system (Bredemeyer Consulting 2003; Platt 2005).

There are two major types of architectures described in the research literature and industry publications, namely, Enterprise and Software. These are described below, followed by a list of other common types of architectures.

**Enterprise architecture**

*Enterprise architecture* is the overall architecture of the organisation or enterprise. That is, it is how all the business and IT systems are structured, how these systems interact and the planning for their change over time:

“**The enterprise architecture** is the organizing logic for business processes and IT infrastructure, reflecting the integration and standardization requirements of the company's operating model (where the operating model is defined as the necessary level of business process integration and standardization for delivering goods and services to customers). The enterprise architecture provides a long-term view of a company's processes, systems, and technologies so that individual projects can build capabilities - not just fulfill immediate needs” (Ross, Weill & Robertson 2006).

This description is similar to and representative of other descriptions, both within academic publications (Iyer & Gottlieb 2004; Op 't Land & Proper 2007; Rood 1994; Sowa & Zachman 1992; Strano & Rehmani 2005, 2007; Woods & Rozanski 2005; Zachman 1987), industry and text books (Bernard 2005; Bernus, Nemes & Schmidt 2003; Grigoriu 2006; Lankhorst 2005; McGovern, Ambler, Stevens, Linn, Sharan & Jo 2004; Spewak 1993), and other industry sources including magazines and representative organisations (MITRE 2004; Open Group 2006b; Parsons 2005).


There is also substantial government impetus behind Enterprise Architecture with the largest initiative being the US Federal Government Enterprise Architecture (FEA) created as a result of the Clinger/Cohen Act (*Information Technology Management Reform Act* 1996).

Enterprise architecture covers a wide range of different areas within an organisation or enterprise. However, definitions differ in what details are covered, what artefacts are produced and to what extent Information Technology is included within enterprise architecture. For example, Sowa & Zachman (1992) has extensive coverage of IT artefacts whereas Ross et al. (2006) has only limited coverage of any detailed IT aspects of enterprise architecture.

**Software architecture**

The second most common type of architecture is *software architecture*. Software architecture is the structure of the software components of a system, how those components interact, and how they can change over time. Software architecture has been the focus of academic research since the early 1990s, described as:

“The software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them.” (Bass, Clements & Kazman 2003)

This description is similar to those within different academic sources (Baragry & Reed 1998; Carriere, Woods & Kazman 1999; Cockburn 1996; Garlan 2000; Garlan & Perry 1995; Shaw & Clements 2006; Smolander 2002b; Smolander et al. 2005; Wolf 1997) and books, (Dikel, Kane & Wilson 2001; Hofmeister, Nord & Soni 2000; Rozanski & Woods 2005). Descriptions from industry are also similar (IASA 2007; WorldWide Institute Software Architects (WWISA) 2005) as are those from numerous websites of which one from Carnegie Mellon University (2007) has a wide ranging set of definitions and descriptions of software architecture.

None of these descriptions includes any consideration of the hardware implications for architecture and the majority only focus on an individual system or application not the software architecture of an entire organisation.
Other types of architecture

There are many other types of architecture mentioned or described in academia and industry. These different types include (in alphabetic order):

- **applications architecture** (Gale & Eldred 1996; Myerson 2001),
- **business architecture** (Business Architects Association 2007; McDavid 1999; Whittle & Myrick 2004),
- **computer architecture** (Agerwala & Chatterjee 2005),
- **data architecture** (Brackett 1994; Carbone 2002; Inmon 1992; Stephens 2003),
- **information architecture** (Information Architecture Institute 2007; Morrogh 2002; Wodkte 2002),
- **infrastructure architecture** (Method for an Integrated Knowledge Environment (MIKE 2.0) 2007),
- **integration architecture** (Carbone 2004; Gold-Bernstein & Ruh 2004; Simmons 2005),
- **network architecture** (Alliance for Telecommunications Industry Solutions (ATIS) 2001),
- **organisational architecture** (Sauer & Willcocks 2002, 2003),
- **security architecture** (CXO Media Inc. 2007; EDUCAUSE 2004; Texas State Library and Archives Commission 2001),
- **services architecture** (Hagel III & Brown 2001; SAP 2007; Woods 2003)
- **solution(s) architecture** (Bogue 2005; Tandon 2007; Wipro 2007), and
- **systems architecture** (Chorafas 2002; Gore 2003; Maier & Rechtin 2000).

There is also little agreement regarding the distinctions between different types of architectures such as those listed above. For example, the United States Government Federal Enterprise Architecture consists of five different architectures all based on different reference models (Office of Management and Budget 2007). These different reference models are a Performance Reference Model (PRM), a Business Reference Model (BRM), a Service Component Reference Model (SRM), a Technical Reference Model (TRM), and a Data Reference Model (DRM). However, each of the models is included within different types of architectures described above, for example both
data architecture and solution architecture often includes a data reference model (Bogue 2005; Brackett 1994).

1.2 **What are architects within IT?**

All of the above types of architecture are created and described by people performing the role of *architect*, where an architect is defined in *The Shorter Oxford English Dictionary on Historical Principles* as “one who designs or frames any complex structure” (Little, Fowler, Coulson, Onions & Friedrichsen 1978).

All of the types of architecture described above have corresponding types of architects, so for example as well as enterprise architecture there are enterprise architects (Parsons 2005). Also, different architects may produce different architectures of different types and major vendors and organisations have their own approaches and definitions, for example, Microsoft (2007) has three major classifications:

1. Solutions Architect (also known as Application Architect, Software Architect, Data Architect, Integration Architect),
2. Infrastructure Architect (also known as Technology Architect, Systems Architect), and

As this example shows, these classifications include some types of Architect that are described above and some that are not and this lack of alignment is common.

Since the early 1990s, another architect classification has become more common within industry, the *IT Architect*. This type of architect is used as a superset of all other architects and includes all aspects of those roles (Microsoft 2007; Ruest & Ruest 2006; Sylvia 2005). In this study we are investigating IT Architects.

While “…there are as many different opinions about the role and activities of an IT architect as there are people who have heard of or practiced the role” (IASA 2007), the definition we use is from The Open Group. The Open Group is the largest vendor-independent professional body in the field of architecture. Their IT Architect certification program at the end of the first quarter of 2007 had directly certified 1763
Introduction

professionals as IT Architects (Open Group 2007a). There are many thousands more certified as Open Group IT Architects through the accreditation of IBM and EDS (Open Group 2007b). Their definition for an IT Architect is:

“An IT Architect defines solutions to client business problems through the reasoned application of information technology. Those solutions are documented as architectures and can include systems, applications, and process components. They may also involve the application and integration of a broad variety of products; technologies, and services; various systems and applications architectures; and diverse hardware and software components.” (Open Group 2006b)

This is the definition we are using.

1.3 Why is the study of capabilities of IT Architects important?

Architects create, maintain, and communicate architectures, and the characteristics of the people creating the architecture influence an organisation’s likely success in achieving its goals (Grinter 1999). Recently there has been some interest in the people aspects of architecture although it has been limited to software architecture and primarily oriented towards technical aspects of the architect’s role (Bass et al. 2003; Clements, Kazman, Klein, Devesh, Reddy & Verma 2007; Fairbanks 2003; Medvidovic & Taylor 1998; Sarang 2007). Other recent articles have highlighted both the importance of the person in the role (Daniel 2007) and the skills of the person (Worthen 2005).

The related area of systems engineering has also undertaken some research into the people aspects (Frank 2000, 2006b; INCOSE 2006) with a focus on identifying the characteristics for success in critical engineering systems thinking and how to develop those characteristics (Davidz, Nightingale & Rhodes 2005; Di Carlo & Khoshnevis 2006; Eriksen 2006; Frank 2002, 2006a). Other research has investigated the people characteristics associated with the successful engineering of systems of systems (Jakobsson & Kingston 2006).
Additional research about characteristics of any of the people or roles within IT has been explicitly called for by Niederman et al. (1999), and identified by Luftman, Kempaiah & Nash (2006) who found that “attracting, developing, and retaining IT professionals” was a top issue (number 2) for IT executives in 2005. More simply, IT skills affect the success of an organisation’s use of IT (Byrd & Turner 2001; Byrd, Lewis & Turner 2004). In addition information systems development including IT Architecture is a social process, therefore the people and their capabilities are crucial (Hirschheim, Klein & Lyytinen 1995; Nakayama & Sutcliffe 2001). The importance of people related-research in IT is supported by the continued success of the Association of Computing Machinery’s Special Interest Group Management Information Systems conferences on Computer Personnel Research. This conference concentrates on research about people within computing and the 45th such conference was held in 2007.

Industry has also recently identified the importance of this area through the emergence of IT Architects as a profession with formal independent certification guidelines (IASA 2007; Open Group 2005).

Accordingly, in our research, we focus on some human aspects or characteristics of highly-skilled IT Architects. Characteristic is defined in The Merriam-Webster Dictionary as “a distinguishing trait, quality, or property” (Merriam-Webster 2004), and, as such includes capabilities, personality, and other aspects of a person. We specifically investigate the capabilities of IT Architects, where a capability is defined by Scott (1999a) as the:

“Combination of attributes, qualities, skills and knowledge that enables a person to perform to a high standard in a given context and role.”

This definition can be contrasted with usage of the term within the fields of organisational design and management, where capability is a characteristic of the organisation rather than an individual (Reich & Benbasat 2000; Ulrich & Lake 1990).

Competency is also used to describe aspects of people performance. The Australian Council of Educational Research (ACER) review (Curtis & McKenzie 2002) defines competency as “an observable behaviour performed to a specified level and therefore
Introduction

provides a basis for the assessment of performance.” We focus on capability as it is what enables performance to occur, whereas competency is what performance is observed.

There has only been limited investigation of capabilities of architects by different researchers (Fairbanks 2003; Smolander 2002b) which underlines the timeliness of this research.

1.4 Overarching research questions and approach

Increasing our understanding of characteristics of IT Architects and some distinguishing capabilities of highly-skilled IT Architects will support more effective selection and development of people in the role. In addition, this knowledge will increase our understanding of IT personnel overall, allow for improved curricula, and support improvement of business systems architectures. In line with this, the main research question of this thesis is:

Can we distinguish and improve important capabilities of highly-skilled IT Architects?

The research sub-questions are:

1. What are characteristics of highly-skilled IT Architects?
2. What capabilities distinguish highly-skilled IT Architects?
3. Can some capabilities of highly-skilled IT Architects be improved within a university subject?

Answering the first sub-question provides us with an understanding of the characteristics of IT Architects, including important capabilities. We then, through the second sub-question, investigate which of those capabilities distinguish the highly-skilled IT Architects from the less skilled IT Architects. Finally, through the third sub-question we explore whether we can measurably affect the distinguishing capabilities through teaching.²

² RMIT University ethics clearance has been obtained for all the research described in this thesis. The ethics approvals matched each research stage and the approval numbers were 36-04, 59-05, and 01-06.
Differences from related research
Most prior research relating to people characteristics has used a variety of research techniques including protocol analysis, interviews, and direct observation. Some examples are Adelson & Soloway (1985), Curtis, Krasner & Iscoe (1988), Downey (2006), and Guindon, Krasner & Curtis (1987). Most of this research was qualitative, focussed on students, in-house projects, and was based in North America (Sjoberg, Hannay, Hansen, Kampenes, Karahasanovic, Liborg & Rekdal 2005). In contrast, we combine qualitative and quantitative methods, use mainly industry participants, and base our research in Australia and New Zealand.

Limitation of this thesis
The main limitation is that our investigation is based on what IT Architects say they do, that is, their perception or understanding of what their capabilities are, not what their capabilities actually are in practice. There is often a gap between what people say and what they do, and this gap may be significant (Brown & Duguid 1991; Silverman 1998).

1.5 Contributions
Our contributions through this research are in four major areas. First, our summary and analysis of the development of the role of IT Architect provide insight into the role and its interaction with related IT roles. This information will enable the taxonomies and associated models for IT professions to be enhanced and extended to include additional roles and more relationships between roles.

Second, we identify and describe both the combination of characteristics for highly-skilled IT Architects and which characteristics are more important. These both enhance our knowledge regarding the important role of IT Architect providing a base for more detailed exploration of such characteristics, and also provide insights into career paths and development approaches for the role.

The third major contribution is the identification of two capabilities that distinguish highly-skilled IT Architects from the others. In this identification, we make available specific information that can be directly used to enhance the IT Architect role, the people who fill it and additionally provide insight into highly-valued capabilities of
Introduction

project managers. This identification process can also be the foundation for further detailed research into both the role of IT Architect and that of Project Manager. The first identified capability is that the highly-skilled IT Architects approach problems differently and generate more alternatives before attempting solutions and they spend more effort evaluating outcomes than the less skilled IT Architects. The second capability is that the less skilled IT Architects have a different attitude towards time and do not always act consistently with a longer term perspective.

The fourth major contribution is through the teaching of some capabilities of highly-skilled IT Architects within a post-graduate university subject and we have increased both the knowledge of these capabilities and the applicability of some capability teaching approaches. For educational institutions, improved understanding of the distinguishing capabilities of IT Architects and experiences of teaching these capabilities enables improved IT Architect related education and contributes to both subject content and curriculum development.

We also identify many areas for future work, addressing both the limitations of our research and highlighting areas suggested by our research that will enable additional valuable information on IT Architects to be collected, validated and communicated.

Overall, our results provide industry and academia with valuable knowledge. For industry, we provide a clearer description of both the overall characteristics and distinguishing capabilities of highly-skilled IT Architects. This allows organisations to more effectively select and develop IT Architects and thereby improve the resultant architectures that are developed. For academia, we increase the knowledge regarding the characteristics of IT people in general and IT Architects in particular, which supports further research and models of the people and characteristics within IT. In addition, we provide knowledge on the teaching of IT Architect capabilities and also information to support the development of more appropriate IT Architect education within individual subjects and overall curricula.
1.6 Thesis overview

The remainder of this thesis has six chapters; the relationship between these chapters is shown in Figure 1-1. (The arrows in the figure show which chapters influence or provide input to other chapters of the thesis.)

The second chapter is an overview of the research and theory related to the area, including the study of people characteristics in IT related to the role of IT Architect. We describe the origin of the role and the research focus and findings for the roles that preceded it. We summarise the relevant section of the recommended Information Technology, Information Systems, and Software Engineering curriculum and report on a survey of architect education within Australian universities.

The research design is presented in Chapter Three. It has two major sections. The first outlines the main drivers for research related to our overall research question. The second section includes the possible research techniques, the reasons for the choice of method we made, and describes the steps that were used to investigate each of the research sub-questions.
Chapter Four is a description of the first stage of the research, which involved fourteen expert interviews in 2004, to identify characteristics of IT Architects. We report on the interview structure, interviewee choice, and analysis of the interviews.

In Chapter Five, we report the second stage of the research, undertaken in 2005. In this stage, we chose survey instruments for four of the capabilities we had identified in the prior stage as important for highly-skilled IT Architects. Then we constructed a survey using these instruments, which we administered to 287 IT Architects and 402 IT Project Managers of differing skill levels. The survey results were analysed and the responses of the different participant groups compared.

The sixth chapter is the report of teaching in 2006 of two of the identified capabilities of highly-skilled IT Architects through specialised tutorials within a Systems Architecture University subject, and measuring and comparing the student capabilities
for the two distinguishing capabilities identified in Chapter Five. This measurement and comparison was at three points, before the subject was taught, after the teaching activities, and again, one year later, in 2007. The initial measurement involved 35 students, the second 28, while the final had sixteen participants.

Our conclusions, including discussion of limitations and suggestions for future work, are provided in Chapter Seven.
Chapter 2. IT Architects in context

Architecture is important within IT and while there are many different types of architectures, they are created, maintained and communicated by people undertaking the role of IT Architect. The characteristics of people undertaking roles within IT have been studied for over 40 years, however, the relatively new role of IT Architect has not been researched to the same degree neither has improving the characteristics of IT Architects been investigated.

This chapter analyses research related to IT Architects and has three sections. The first section summarises, critically analyses and classifies research related to the skills and characteristics of IT personnel. The second section summarises and analyses research into the characteristics of roles leading to that of IT Architect including the methods of investigation used and the major findings. Finally, the third section provides an overview and analysis of IT Architecture related teaching within Australia and New Zealand and describes research into the teaching of IT Architect skills.

2.1 Characteristics of people in IT

Although definition and agreement of standardised skills for IT are regarded as important (Rada 1999) there is no commonly agreed and accepted taxonomy of IT skills. One of the few studies of such taxonomies was a recent review by Nakayama & Sutcliffe (2007) which summarises the result of twelve different studies, including

---

3 Throughout this chapter and the complete thesis there are many acronyms used, Appendix O contains a full list of all acronyms and their expansion.
Bassellier & Benbasat’s (2004) and concludes that they used different types of skill taxonomies dependent on different factors including the level of the people studied, the timing of the study, and the focus of the study on employment or curriculum. They also describe three perspectives for IT skills: task-oriented, fundamental skills oriented, and socio-culturally oriented. They developed a proposed taxonomy for use in talent acquisition; however, this taxonomy has not yet been used for either research or employment. They argue that there is no agreed framework for IT characteristics related research for us to use.

Recent research into related IT people characteristics
Characteristics of IT people have been investigated through different techniques. Some examples are through analysis of newspaper job advertisements (Slaughter & Ang 1995; Todd, McKeen & Gallupe 1995) and more recently internet job boards (Litecky, Prabhakar & Arnett 2006; Nelson, Ahmad, Martin & Litecky 2007) and corporate website job advertisements (Lee 2005; Lee & Lee 2006). There have also been many survey oriented studies (Leitheiser 1992; Nelson 1991),

These studies have several potential limitations. Few countries have been studied and any findings may not be applicable elsewhere. There was also no analysis of what proportion of total available jobs were advertised, there is no analysis as to the fit between the advertisements and subsequent candidate selection, and no analysis as to whether the job was actually filled. In addition, several of the studies have limited sources of information, for example, Todd et al. (1995) only examined two newspapers, Litecky et al. (2006) only looked at a single job board, and both Lee et al. studies only looked at stock exchange listed Fortune 500 companies and what was posted on their websites. These limitations all may restrict the applicability to real-life employment situations. In addition, none of the studies targeted IT Architects.

Other studies have combined job boards and newspaper analysis, for example (Litecky & Arnett 2001), and while the sample is larger the other limitations described above are still present. Another study combined surveys and job advertisements analysis to research system analyst skills within Singapore (Hunter & Palvia 1996). Though this research did examine some aspects of the skills used on the job, the number of respondents and companies represented was small and staff were
instructed to complete the surveys by upper management. These are both aspects that may have influenced the results and made them less useful.

Despite the limitations described, these studies found similar characteristics are required for IT people. Technical skills were important in all the studies, as were communications, business knowledge and other non-technical skills. However, the relative importance of technical skills changed over time. The later studies found that non-technical skills were increasingly important and this is supported by recent workforce research (Abraham, Beath, Bullen, Gallagher, Goles, Kaiser & Simon 2006; Bullen, Abraham & Galup 2007; Zwieg, Kaiser, Beath, Bullen, Gallagher, Goles, Howland, Simon, Abbott, Abraham, Abraham, Carmel, Evaristo, Hawk, Lacity, Gallivan, Kelly, Mooney, Ranganathan, Rottman, Ryan & Wion 2006). Other recent research has confirmed the importance of people characteristics for the effective delivery of organisational capabilities (Fink & Neumann 2007) and when undertaking consulting within an IT environment (Joshi & Kuhn 2007).

2.2 The relationship of IT Architect to other IT roles

The growth in the use of Information Technology within both homes and businesses has created a corresponding expansion in IT roles. As well as this increase in roles, there has also been a move from general to more specialised roles. This change and expansion in roles means that some roles require new skills and other skills are no longer needed (Andrews & Niederman 1998). These changes are due to many different influences including technology and the sophistication of users (Niederman & Mandviwalla 2004). In addition, as organisations change their IT related maturity they have different requirements for IT skills, with increasingly sophisticated and complex skills required at higher maturity levels (Benbasat, Dexter & Mantha 1980). A further pressure is the requirement for organisations to handle IT projects “covering an increasing breadth of technologies [that] call for greater and more specialized skills” (Niederman, Brancheau & Wetherbe 1991). The breadth in technologies and roles continues to increase (SFIA Foundation 2005) with recent definitions including over 200 different IT job titles (NWCET 2003).

This change in scope, specialisation and variety of roles within IT has been reflected in the research of IT people and their characteristics summarised in Table 2-1 and
described in the following sections. While the title of *IT Architect* is relatively recent, some of the activities and responsibilities of people performing this role derive from those of System Analysts. Although there are many other IT roles, the following sections, organised by research decade, focus on the origins of the IT Architect role and the associated role of system analyst.

<table>
<thead>
<tr>
<th>Time</th>
<th>Overall roles during time period</th>
<th>Roles being researched</th>
<th>Focus of research</th>
<th>Research instruments and methods</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960s</td>
<td>Systems people</td>
<td>System analysts</td>
<td>Recommended competencies</td>
<td>Surveys</td>
<td>Business and communications skills important</td>
</tr>
<tr>
<td>1970s</td>
<td>Programmers and system analysts</td>
<td>Programmers and Data Processing (DP) people in general</td>
<td>Recommended skills and some psychology aspects</td>
<td>Purpose built, one-off surveys</td>
<td>Communications and technical skills important</td>
</tr>
<tr>
<td>1980s</td>
<td>Programmers, system analysts, and designers</td>
<td>System analysts and designers</td>
<td>Personality, characteristics and behaviour in teams</td>
<td>Myers Briggs Type Instrument (MBTI), field studies, case studies, interviews, and small laboratory experiments</td>
<td>Communications, more general skills important, with a continuing technical focus</td>
</tr>
</tbody>
</table>
**Table 2-1 Evolving research in people characteristics related to IT Architects**

<table>
<thead>
<tr>
<th>Time</th>
<th>Overall roles during time period</th>
<th>Roles being researched</th>
<th>Focus of research</th>
<th>Research instruments and methods</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990s</td>
<td>Programmers, system analysts, designers, architects, and projects managers</td>
<td>Information Technology (IT) and Information Systems (IS) people in general, system analysts and programmers</td>
<td>Characteristics for success, experts versus novices, recommended skills</td>
<td>Hand built surveys, case studies, repertory grids, interviews, laboratory experiments, job advertisement studies, and psychological instruments such as Adjective Comparison List (ACL)</td>
<td>Differences in personality from general population, increasing importance of business skills, breadth in technical skills</td>
</tr>
<tr>
<td>2000s</td>
<td>All of the above, with the emergence of specialised architect roles, including enterprise architect, and software architect.</td>
<td>IT and IS people in general, some coverage of architects</td>
<td>Success characteristics, important skills for industry</td>
<td>Surveys (mainly purpose built), job advertisement studies, with some small Delphi studies and interviews</td>
<td>Increasing focus on senior roles away from technology, continued focus on communications, broad range of skills recommended, and importance of specific industry experience</td>
</tr>
</tbody>
</table>
2.2.1 1960s and before

The term system analysis was used by the Rand Corporation (1996) as part of its more than 50 years long project with the United States Airforce and covered a range of disciplines including quantitative analysis and modelling. During 1960s the need for the systems man (Zubryd 1966) and growing use of IT for business automation led to the term being adopted within IT (Shrout 1970). There was only limited research into the role and other IT roles during this decade with surveys being the primary technique. For example, Shrout found that business and communications skills were important through the use of a survey she constructed and administered.

2.2.2 1970s

During the 1970s, the research into IT roles increased in both amount and breadth. There was focus on programmers with concepts such as chief programmer teams (Baker 1972; Mills 1971) being described and some results of using them being reported. Some research used concepts from psychology, such as Herzberg’s Motivation-Hygiene Theory (Herzberg, Mausner & Synderman 1959) and the idea of the psychology of programming (Weinberg 1971) was discussed. Purpose built surveys (Cheney & Lyons 1980) and expert opinion were the main techniques used and the major findings again were that communications skills and technical skills were both important. There were no significant differences found in the motivations of Data Processing (DP) people compared with non-DP people, other than a stronger awareness of self actualisation for DP people (Fitz-Eng 1978).

2.2.3 1980s

While the terms system analysis and design and the associated activities had started to be used within industry from the middle 1970s (DeMarco 1979; Gane & Sarson 1977; Page-Jones 1980; Yourdan & Constantine 1975), the 1980s saw one of the first definitions of system analyst. This was derived from other prior work, by Vitalari & Dickson (1983) who said “... the term systems analyst refers to an individual who analyzes organizational requirements for information and designs a computer-based information system to collect, store and disseminate data in support of organizational goals.”
IT Architects in context

This definition, the Association of Computing Machinery’s recommended curriculum material, and other research at the time all emphasise three major aspects of the system analyst role. These are the analysis of requirements, the design of the corresponding solution and the management of the project to deliver the solution (Nunamaker, Couger & Davis 1982; Vitalari 1985). Additional specialised skills were recommended, including people skills, modelling and systems skills, computer skills, organizational skills, and societal skills (Green 1989; McCubbrey & Scudder 1988).

The term design continued to evolve within the context of IT in the mid to late 1980s as well as the study of people, individually and in teams, performing that role (Adelson & Soloway 1985; Curtis et al. 1988; Guindon et al. 1987). The terms systems architect (Mills 1985) and software architect (Curtis et al. 1988; Keen 1988) were becoming common within industry at this time. In addition, the concept of architecture for IT systems within an enterprise (Zachman 1987) was described and regarded as critical for organisations through the 1990s (Keen 1988). However, there was no clear description of the activities of an architect or their personal characteristics.

During this decade research using instruments from psychology such as the Myers Briggs Type Instrument (MBTI) (Myers, McCaulley, Quenk & Hammer 1998) was undertaken with different MBTI profiles being found to be more common for IT roles including system analysts (Buie 1988; Bush & Schkade 1985; Kaiser & Bostrom 1982; Lyons 1985; Smith 1988). As well as MBTI, many of these studies also used other research techniques including action research, protocol analysis, group observations when performing laboratory tasks and some field studies.

Finally, at the end of the decade, researchers and industry stated that additional skills were needed for system analysts and designers. As Cheney et al. (1990) said “the trend for system analysts/designers is toward an increased knowledge of people and problem-solving”. They also predicted that system analysts/designers would undertake less project management activities and move away from a purely technical focus.
2.2.4 1990s

During this decade the role of system analyst expanded due to increasing complexity and the increasing scope of systems. Descriptions from that time include other activities such as presentations and directing activities and staff:

“A systems analyst is a problem-solving specialist who works with users and management to gather and analyze information on current and/or future computer-based systems. With this information, the systems analyst, working with other MIS personnel, defines the requirements which are used to modify an existing system, or to develop a new system. The systems analyst identifies and evaluates alternative solutions, makes formal presentations, and assists in directing the coding, testing, training, conversion and maintenance of the proposed system.” (Misic 1996)

This perspective was derived from associated studies exploring the system analyst’s role and responsibilities (Graf & Misic 1994).

It was evident through the 1990s that the recommended skills for senior system analysts were changing. The order of importance of skills was changing with a far higher focus on soft or non-technical skills (Couger 1995; Doke & Williams 1999; Feeney & Willcocks 1998; Hunter 1994; Jiang, Klein & Means 1999; Norbjerg 1995; Sonnentag 1995; Stolterman 1991; Wynekoop & Walz 1996). It was also clearly understood that the role of system analyst was changing and would continue to do so (Niederman et al. 1999).

At the same time, a key aspect of changing IT roles was the significance of the designer. Although designers had been researched and described in the 1980s, during the 1990s there was an increase in the importance and types of designers and the study of them (Visser 1992; Visser & Hoc 1990). For example, one type of designer that emerged at this time was the database designer (Storey, Day, Ullrich & Sundaresan 1998; Teorey 1999). This role had become important due to the rise of large data storages and emergence of the relational data model. In general, designers are regarded as performing the more technical stages of systems development. As Hirschheim et al. (1995) delineate the roles “systems analysis is the process of collecting, organizing, and analyzing facts about a particular IS and the environment
IT Architects in context

in which it operates”, whereas, “Systems design is the conception, generation and formation of a new system.”

As specialisation and complexity increased, there was also growing recognition of importance of architecture, with a seminal definition of architecture from Perry & Wolf (1992). A key aspect of their work was a separation of architecture and design:

“We use the term “architecture”, in contrast to “design”, to evoke notions of codification, of abstraction, of standards, of formal training (of software architects), and of style.”

The importance of architecture for organisations was stated by Duncan (1995) who said “architecture … is the essence of the corporate IT strategy.”

There was also the identification of a new role by Trauth et al. (1993). This role was the integrator, with the key aspects being described as:

“a deep understanding of the business units in which they will work, interpersonal skills necessary to work with the end users, and an ability to effectively apply technology in seeking solutions to business problems.”

This combination of characteristics was also found to be important for the credibility of people within IT (Bashein & Markus 1997).

The importance of these roles was formalised by industry in 1992 with the first identification of a new career path within IBM, called IT Architect. This was in “response to client demands for expertise…” (Sylvia 2005). As stated further by Sylvia:

“The IBM IT Architect exists to … Define the principles-based structures of solutions – architectures … Drawing upon broad skills and experience which enable, as necessary, the application and integration of a variety of business and IT components, technologies and service elements.”

Therefore the IT Architect includes the role of integrator as described by Trauth et al. (1993). Hewlett-Packard established a similar profession in the late 1990s (Hewlett-Packard 2002). This industry recognition of the role of architect is also evident through magazine articles (Maglitta 1994) and conference presentations (Krutchen 1999).
Therefore, at the end of the decade, the role and recommended skills of the system analyst had moved away from design and technical aspects. At the same time, there had been the emergence of a new role, the IT Architect, which overlapped that of system analysts but included integration and higher-level technical skills but did not include a requirements focus.

Research methods during this time incorporated all the methods and tools used in prior decades including additional psychological instruments such as the Adjective Comparison List (Gough & Heilbrun 1983) being used in a program of research into personality characteristics of IT people including system analysts and other roles (Walz & Wynekoop 1997; Wynekoop & Walz 1998, 1999). Research using the MBTI also continued (Teague 1998). Some research was also undertaken investigating system analysts using repertory grids (Hunter 1997) and Delphi studies (Snoke & Underwood 1999; Wynekoop & Walz 1999, 2000).

There was also research during the 1990s focusing on differing expectations of IT professionals between industry and academia (Eirman & Schultz 1995; Lee, Trauth & Farwell 1995; Orr & von Hellens 2000; Snoke & Underwood 2001; Turner & Lowry 1999). Other research investigated personalities appropriate for particular roles with the focus mainly on programmers (Bishop-Clark 1995) with some investigation of personalities of system analysts (Schenk, Vitalari & Davis 1998).

### 2.2.5 2000s

Throughout the decade, the range of IT roles in industry continues to expand. Amongst the roles that continued to be important or have additional focus were project managers, system analysts, designers, programmers, testers, and architects.

**Early in the decade**

As well as the increase in different roles, specialisation of existing roles increased. Some of the activities previously identified with system analysts (Misic 1996) were now more commonly the responsibility of project managers (Yeates & Cadle 2004).

The importance of architecture continued to increase (Garlan 2000), evident in the growing influence and publications regarding software architecture from Carnegie...
IT Architects in context

Mellon’s Software Engineering Institute (Bass et al. 2003; Clements et al. 2002; Clements et al. 2003; Shaw & Clements 2006). Aside from this work, most of the architecture research in the early part of the decade was focussed on technology or architecture artefacts. One exception was the work by Witt & Baker (2002) who used General Mental Ability (Herrnstein & Murray 1996) when researching the selection of high performing IT professionals.

Within industry at this time there was an increased specialisation in industrial architecture roles with the use of terms such as system architect, described as “…the key solution leader who designs, devises and creates the outcomes of a project that will meet the expectations of the system owner.” (Gore 2003)

**Middle of the decade**

There continued to be a separation of responsibilities and increased specialisation. The system analyst role narrowed to focus on requirements, the “main purpose of system analysis is to identify and document the requirements for an information system to support organizational activities.” (Iivari, Parsons & Hevner 2005) The designer was now responsible for aspects previously included in the system analysis, such as “the process of defining the software architecture, components, modules, interfaces, and data for a software system to satisfy requirements specified during systems analysis” (Iivari et al. 2005). This separation of duties was commonly accepted (Whitten, Bentley & Dittman 2004).

**IT Architect Certification**

Within industry the role of architect continued to gain in importance with an increasing focus on certification of architects through independent organisations (GEAO 2007; Open Group 2006b; SCIA 2002) and within companies such as Microsoft (2006) underlining the importance of technology-independent architects. While there are minor differences in the certification processes and criteria for the different organisations, the overall process and steps are common. Candidates for certification prepare a submission package, usually of a specified format. The candidate submits this to the certifying organisation or company, where it is checked and if the minimum criteria for experience, included projects, and skill levels are met then the package is accepted and passed to a review board. The review board is
Information Technology Architect Capabilities

comprised of already certified architects, they examine the package, and each board member interviews the candidate. The members then meet, discuss the interviews and the package, and decide whether to certify or not the candidate. Feedback is provided to the candidate, whether successful or not, and this feedback usually clearly specifies what areas the candidate needs to improve or focus on. Certification with an external organisation such as The Open Group usually involves a fee. In addition, regardless of whether the certification was obtained from the candidate’s employer or an external company, certification lapses after a designated time, commonly three years, and the candidate must then reapply.

Again, while there are some differences in the skills that each certifying organisation states as most important for the role of IT Architect, there is a large overlap in the requirements. The majority of the programs requests skills such as leadership, communication, conflict resolution or negotiation, use of modelling techniques, application of IT standards, management of stakeholder expectations, assessment of technical solutions, management of technical elements of an IT project plan, and the ability to perform as a technology advisor.

Later in the decade

There was also an increasing specialisation in architect roles with The Open Group using the term ‘discipline’ to distinguish different types of architect (Open Group 2006b). In parallel with this was an increasing focus on professionalism of architects with the British Computer Society (Hughes & Thompson 2007) and associated organisations (SFIA Foundation 2005) focussing on the importance and recommended skills of the architect role.

As the decade progresses the skills required by industry are also changing with recent research (Abraham et al. 2006; Gallagher, Kaiser, Frampton & Gallagher 2007) showing an increase in the requirements for additional architecture skills and also in the personal characteristics such as communication (Mackay 2003) and business knowledge. These skills have been identified as crucial to keep in-house and not be outsourced (Zwieg et al. 2006).
While there is limited published research detailing the characteristics for IT Architects within industry during the 2000s, there is agreement on the important required characteristics (Bredemeyer Consulting 2002; IASA 2007; Muller 2006; Open Group 2006b). These are communications, technical knowledge, leadership, interpersonal skills, project management, business understanding, modelling, knowledge and use of methodologies, stakeholder management and being visionary. As Bredemeyer (2006) says “The good architects, then, are good technologists and command respect in the technical community, but also are good strategists, organizational politicians (in the best sense of the word), consultants and leaders.”

Throughout the decade the focus of research has been on architectures and the associated artefacts, not the different architect roles and the people performing them. There is an “unfulfilled need for a comprehensive look at what it means for someone to be a competent architect in all dimensions” (Clements et al. 2007) and this gap in research and knowledge has been previously described by Downey (2006). There was some research into usage of methodologies including architecture development (Huisman & Ivari 2002; Kautz 2004; Kazman, Nord & Klein 2003; Maxwell, Parakhine & Leaney 2005; Ylimäki & Halttunen 2005) and the architect profession however it was either limited in geographic scope (Ylimäki & Halttunen 2005) or primarily based on expert opinion (McBride 2007).

The research throughout this period has been similar to other decades in the use of interviews (Hellstrom & Hellstrom 2003), some Delphi studies (Surakka 2007), observation of laboratory tasks (Barrow, Frampton, Hamilton & Crossman 2004, 2005), case studies (Smolander 2002a) and surveys (Cappel, Prybutok & Varghese 2005; Medlin, Dave & Vannoy 2001; Misic & Graf 2004). Major criticisms of software engineering research at this time was the reliance on students as participants (Sjoberg et al. 2005), statistical reporting and experiment design (Dyba, Kampenes & Sjoberg 2006; Kitchenham, Pfleeger, Pickard, Jones, Hoaglin, El Emam & Rosenberg 2002), and inappropriate usage of the MBTI (McDonald & Edwards 2007).

The sections above describe different approaches and findings in the recommended skills and personal characteristics for architects and related roles within IT. In
summary, there has been limited research into the personal characteristics of architects at any time since the role emerged.

2.3 How are architect’s skills being taught?

Given the importance of IT Architects and the characteristics of people undertaking those roles, education of IT Architects is important. The importance of educating and developing architects is supported by the emergence of company development programs. These programs usually include a combination of classroom education, apprenticeships, internships, and mentoring (Borrmann & Paulisch 1999; Muller 2007; Vickers 2004). The topics covered in the classroom education of these programs is similar to those provided within specialist architect training courses (Bredemeyer Consulting 2007; Sundblad 2007). This section describes the relevant curriculum material and summarises related university education within Australia.

2.3.1 Relevant curriculum recommendations

The relevant under-graduate curriculum for Information Technology (SIGITE Curriculum Committee 2005), Information Systems (Joint IS 2002 Curriculum Co-Chairs 2002) and Software Engineering (The Joint Task Force on Computing Curricula 2004) have only limited architecture-related knowledge areas or topics. As architect is a mid-level or senior role within industry this is not unexpected. The graduate Information Systems (IS) curriculum does have some additional relevant material (Gorgone, Gray, Feinstein, Kasper, Luftman, Stohr, Valacich & Wigand 2000) although it is not recent. None of this relevant material relates to architect characteristics or capabilities. This lack of relevant material is supported by Duggins & Thomas (2002) in their review of graduate software engineering education. Their summary is that since the initial proposal for a software engineering education by Freeman et al. (1976) there has been limited or no focus on architecture and no coverage of the characteristics and capabilities of architects and what is required to be successful in the role.

In addition to curriculum recommendations there are related developments such as the Software Engineering Body of Knowledge (IEEE 2004) and the Enterprise Architecture Body of Knowledge (MITRE 2004) however these also have only limited material on architect characteristics and capabilities. More recently software
architecture education research has suggested more focus on people skills (Lago & van Vliet 2005; Shaw & Vliet 2005), which is supported by Noll & Wilkins (2002), while Fraga & Llorens (2007) have suggested an ontological basis for teaching new architects but these suggestions have not been empirically tested.

2.3.2 Australian and New Zealand architect education

Given the importance of IT Architects, we expected that there would be subjects and degrees offering education for aspiring IT Architects and those looking to enhance their architect capabilities and knowledge. Accordingly, we examined the degrees and then the individual subjects offered by all universities within Australia and New Zealand, regardless of faculty, department, school, location, or mode of delivery. (We used information in the public domain for this investigation and analysis.)

<table>
<thead>
<tr>
<th>University</th>
<th>Degree</th>
<th>Main topics or capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edith Cowan University</td>
<td>Graduate Certificate in Business (Enterprise Integration) – no specific subjects</td>
<td>Business processes and supply chain</td>
</tr>
<tr>
<td>Monash University</td>
<td>Master of Information Technology (enterprise architecture track) – one specific subject only and eleven general subjects</td>
<td>Business issues, design, strategic thinking, communication, and overseeing implementation</td>
</tr>
<tr>
<td>RMIT University</td>
<td>Masters of Technology (Enterprise Architecture)$^4$ – four specific subjects and eight general subjects</td>
<td>Business strategy, enterprise architecture concepts and frameworks, communication and marketing of architectures, governance</td>
</tr>
<tr>
<td>University of New South Wales</td>
<td>Masters of Science (Enterprise Architecture specialisation)</td>
<td>No description available</td>
</tr>
</tbody>
</table>

Table 2-2 Australian and New Zealand universities 2007 architecture degrees

Architecture degree offerings analysis

There were four degrees being offered by four universities and these are summarised in Table 2-2. There are two common objectives for the degrees; business knowledge

---

$^4$ The researcher was involved in the initial design, development, and delivery of this degree until December 2006.
and communication, which, as described above, are both important for the role of IT Architect.

**Architecture subject offerings analysis**

We examined each architecture specific subject offered for universities within Australia and New Zealand against two criteria:

1. Did the subject include IT Architecture or systems architecture within its description and student learning outcomes or objectives? This was to ensure that the subject matched as closely as possible our research area. (Systems architecture was also used it is similar to IT Architecture as previously described.)

2. Has the subject been offered already or was the subject being offered for the first time in 2007?

We also checked if the subject was taught over at least one semester, not just a short course. Finally, we confirmed that the subject was offered at post-graduate level as IT Architects are senior positions building on foundational IT knowledge therefore post-graduate level material was relevant.

Only fourteen of the universities had subjects that met any of the criteria. There was only one subject in Australia and New Zealand that satisfies all the criteria, this was Systems Architecture, offered by RMIT University. Some universities offered subjects in two main, related, areas:

- software architecture, and
- architecture for a specialised area, such as an internet or distributed systems, or enterprise architecture.

However, these did not cover all the areas of IT Architecture and neither of these subject types covers the full responsibilities of an IT Architect. The majority of Australian and New Zealand universities did not offer a specialised subject even in these areas. We also examined hardware or computer architecture subjects but found they covered less of the IT Architects areas of responsibility.

---

5 Many of these subjects were available in general degrees however not all were. This was not important for our analysis.

6 The researcher was involved in the initial design and delivery of this subject prior to 2006 and has had no involvement since then.
IT Architects in context

The summary of our subject analysis as at 16th September 2007 is in Table 2-3. The universities are listed in alphabetical order. The universities subject identifier is included, as well as the subject name and we have highlighted the column of subjects most relevant for our research.

There was only limited information available for each of the subjects. This information used different terms, organisation, and terminology. Most of the subject descriptions other than those from RMIT University did not include competencies, skills, capabilities, or other personal characteristics. The focus was on the tasks of architecture and the artefacts to be produced.

<table>
<thead>
<tr>
<th>University</th>
<th>Software architecture subject?</th>
<th>Specialised architecture subject?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian National University</td>
<td>Advanced Software Architecture (COMP8150)</td>
<td>None</td>
</tr>
<tr>
<td>Charles Sturt University</td>
<td>None</td>
<td>Introduction to Information Architecture (INF440)</td>
</tr>
<tr>
<td>La Trobe University</td>
<td>Software Architecture (CSE4SAR)</td>
<td>None</td>
</tr>
</tbody>
</table>
| Monash University                   | Software Systems Architecture (FIT5004)
  |                                  | None                              |
| Queensland University of Technology | None                            | Enterprise Software Architecture (ITN717) |
| RMIT University                     | None                            | 1. Enterprise Architecture (ISYS2377)
  | 2. Enterprise Architecture Case Studies (ISYS2379)
  | 3. Systems Architecture (ISYS1088) |
| Swinburne University of Technology  | Large Scale Design (HIT8157)    | None                              |

7 Not yet offered.
<table>
<thead>
<tr>
<th>University</th>
<th>Software architecture subject?</th>
<th>Specialised architecture subject?</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Canterbury</td>
<td>Distributed Systems: Model Driven</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architecture and Standards (COSC 403)</td>
<td></td>
</tr>
<tr>
<td>University of Melbourne</td>
<td>None</td>
<td>1. Information Architecture (306-623)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. E-Business Applications &amp; Architectures (615-671)</td>
</tr>
<tr>
<td>University of New South Wales</td>
<td>Architecture of Software Systems (COMP9117)</td>
<td>None</td>
</tr>
<tr>
<td>University of Newcastle</td>
<td>Software Architecture (SENG4420)</td>
<td>None</td>
</tr>
<tr>
<td>University of Queensland</td>
<td>None</td>
<td>Service-Oriented Architectures (INFS7204)</td>
</tr>
<tr>
<td>University of South Australia</td>
<td>None</td>
<td>Software Architecture and Software Engineering for Web-based Applications (COMP4029)</td>
</tr>
<tr>
<td>University of Technology</td>
<td>1. Software Architecture (31278)</td>
<td>1. Distributed Computing Architecture (31470)</td>
</tr>
<tr>
<td>Sydney</td>
<td>2. Software Architecture (32038)</td>
<td>2. Networked Enterprise Architecture (31276)</td>
</tr>
<tr>
<td></td>
<td>– (Different description from 31278)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2-3 Australian and New Zealand universities 2007 architecture subjects

Where information on capabilities, objectives, and skills to be acquired was present, it covered five main non-technical areas:

1. critical analysis and evaluation,
2. problem solving,
3. communication, both oral and written,
4. teamwork, and
5. leadership.

2.4 Summary

This chapter has summarised and critically analysed three bodies of research related to IT Architects. The first body of research literature relates to the skills and characteristics of IT people in general. The next collection of literature analysed
described the origins of the role of IT Architect and its relationships with other roles with IT. This analysis is organised chronologically from the initial study of systems analysis in the 1960s through to recent reflections on skills for IT consulting in 2007. Finally, we surveyed and critically analysed literature related to the teaching of architecture within IT and then summarised the current degree and subject offerings from universities within Australia and New Zealand relevant to the IT Architect role.

Although we introduce additional relevant literature in subsequent chapters, the introduced literature does not directly relate to the analysis described within this chapter and is limited to only the section of the chapter in which it appears. For example, literature relating to possible survey instruments for Stage Two of the research is not described in this chapter but included within Chapter Five and literature related to the teaching design for the two capabilities that are the focus of Chapter Six is described within that chapter not within this chapter.

There is limited coverage of topics and capabilities relating to architecture within the recommended curriculum for Information Systems, Information Technology, and Software Engineering, and even less relating to the role of IT Architect. This is reflected in the limited number of subjects with any relevance to architecture and IT Architects offered by universities within Australia and New Zealand. Therefore, our research, which aims to identify and target teaching of some IT Architect capabilities, is both useful and timely.

This analysis has shown that there is an explicit gap in knowledge relating to the required characteristics for IT Architects and how they might be taught. In the next chapter we describe our research design that will address what are key characteristics of IT Architects, which capabilities distinguish highly-skilled IT Architects, and experiences with teaching two of these distinguishing capabilities.
Information Technology Architect Capabilities
Chapter 3. Research design

The previous chapter provided an overview of the literature relevant to the research aim of investigating the capabilities of IT Architects. This led to identification of a gap in current knowledge relevant to the primary research question of this thesis:

*Can we distinguish and improve important capabilities of highly-skilled IT Architects?*

This chapter describes the design of the research to investigate this question. The construction of a research design is driven principally by the research question and influenced by an understanding and consideration of other research issues.

This chapter is presented in three major sections. The first section is a description of the nature of research and the chosen research viewpoint, followed by an overview of other significant drivers for research design. The second section describes the research design resulting from our chosen viewpoint, these significant drivers, and our research question. This second section is organised into three sub-sections, each outlining the design for investigating the research sub-questions identified in Chapter One. Then the third section of the research design describes how we have addressed the requirements for relevance, rigour, and reliability in this research.

3.1 Nature of research

The aim of undertaking research is to contribute to knowledge and any research is based on underlying assumptions about the nature of reality and how knowledge about that reality can be obtained (Hirschheim 1992). While there is little agreement about the definition of different approaches and which paradigms are appropriate to
Information Technology Architect Capabilities

adopt, many researchers agree that there are three main approaches. These are positivist, interpretivist, and critical (Klein & Myers 1999).

Positivist research assumes that there is an objective reality and that it can be described, observed and measured (Neumann 2000). A key aspect of positivist research is that it uses variables with quantifiable measures, and extrapolates results from a sample to draw inferences for a phenomenon to a stated population (Orlikowski & Baroudi 1991). In contrast, interpretivist research assumes that there is no single truth, that any knowledge is socially constructed; and all research subjects and results are interpreted through the researcher’s world view. An interpretivist approach is appropriate for developing a rich understanding, and exploring the context, and social and community interactions of the research subjects (Klein & Myers 1999; Walsham 1993). The third major paradigm for research is critical research which focuses on understanding the historical construction of situations and context and how people can or cannot impact the situation (Brooke 2002; Hirschheim & Klein 1994). This third research approach is appropriate where the researchers plan to intervene in the research environment and make comparisons with the original or historic situation under study. This approach does not have agreed criteria for rigour and validity and it is neither generalisable nor repeatable (Ngwenyama 1991; Orlikowski & Baroudi 1991).

A positivist approach accords with the our world view and so was taken.

3.2 **Drivers of research design**

The primary driver of any research design is the research question. While the choice of underlying research approach, positivist, interpretivist or critical, strongly influences this design there are many additional influences including the purpose of the research, temporal issues, the nature of the research (pure or applied), the units of analysis, the environment within which the research is being conducted, ethical considerations, and the criteria for interpreting the findings. Each of these influences and their implications are described below.
Research design

3.2.1 Purposes of research

The purpose of any research may be classified as exploratory, descriptive or explanatory (Babbie 2004; Neuman 2003). In *exploratory* research, the objective is to learn about a new area or to formulate questions that future research can answer. Exploratory research includes becoming familiar with the basic facts, setting, and concerns and creating a general picture of conditions with an aim to formulate and focus questions for future research, generate new ideas, conjectures, or hypotheses, or even to determine the feasibility of conducting research (Babbie 2004). As part of this determination of feasibility, the researcher may develop techniques for measuring and locating future data or overall approaches for later exploration. Exploratory research is generally used to answer “what” questions and is often used as an initial step or as part of a larger study to support the development of hypotheses or to gain understanding and insights for later, more detailed, investigation (Stebbins 2001; Yin 2003).

For *descriptive* research one objective is to describe in more detail the subject of the research, often through the creation of categories or classifying types and by answering questions such as “what”, “when”, “where”, “how” and “who” about the phenomenon. Other objectives of descriptive research are to create a detailed, highly accurate picture of an area or topic, to locate new data that contradicts past data, to clarify a sequence of steps or stages, to document a causal process or mechanism, and to report in detail on the background or context of a situation. Often descriptive research is conducted with the researcher determining and selecting the relevant variables from the phenomenon that have already occurred or currently exist, and analysing their relationships without introducing any manipulations to the variables. A limitation of descriptive research is that it cannot describe what caused a situation; it can only provide understanding about the situation, not how it arose (Babbie 2004; Leedy & Ormrod 2001; Neuman 2003).

The third purpose of research is *explanatory*, where a primary objective is to find causes and reasons for what has been observed or determined, that is, to answer the question “why”. Thus, explanatory research may test a theory’s predictions or principles, elaborate and enrich a theory’s explanation, determine which of several
possible explanations is more reliable, and extend a theory to new issues or topics. In addition, explanatory research may support or refute an explanation or prediction, link issues or topics with general principles and evaluate which of several explanations is best (Creswell 2002; Neuman 2003).

3.2.2 Pure or applied research

A second major influence on the research design relates to its orientation: either pure research, also known as basic research, or applied research (Babbie 2004; Neuman 2003). The primary aim of basic research is a fuller knowledge or understanding of the subject under study, rather than a practical application. Applied research is oriented towards understanding an issue or problem within a context such as industry or society, and is often practice-based. Applied research is often designed to solve practical problems of the world, rather than to acquire knowledge for knowledge's sake and such research is also used to study the applicability of theories or principles to problem solutions. The difference between the two is encapsulated by Bush (1945):

“Basic research is performed without thought of practical ends. It results in general knowledge and understanding of nature and its laws. The general knowledge provides the means of answering a large number of important practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers.”

3.2.3 Quantitative or qualitative data collection and analysis

A further dimension of research is whether it is quantitative or qualitative for both data collection and analysis. Qualitative research is concerned with describing and understanding the reasons behind the phenomenon under study and is focussed on human behaviour and artefacts. The primary instrument of data collection and analysis is the researcher (Janesick 2000). Data may be collected from a variety of different sources, including interviews, observations, case studies, documents, sound and video with the focus on gaining understanding and collection of rich information rather than identification and measurement of facts (Marshall & Rossman 2006). In contrast quantitative research is focussed on collecting numeric data and then analysing that information through techniques that involve counting or statistics. The
Research design

focus of quantitative data collection is the identification of variables and facts that can be measured, and then collecting those measures. Common techniques for this collection include scales, tests, surveys, and questionnaires.

Analysis of data collected using quantitative approaches is usually performed using statistical techniques with the choice of techniques being guided by characteristics of the data being collected and other factors including the number and type of variables that are being investigated. While the separation of data collection and analysis for qualitative research is not always clear (Babbie 2004), analysis of data collected using qualitative approaches can be performed with both qualitative and quantitative techniques. Most commonly, qualitative techniques are employed (Creswell 2002). The intention of these techniques is to uncover patterns and meaning within the data that has been collected. These patterns may be commonality between different sources, recurrent changes over time or frequent potential relationships between different concepts. Examples of techniques that are used for such analysis are Grounded Theory (Strauss & Corbin 1998) and content analysis (Krippendorff 2004). Quantitative analysis techniques can also be used with data collected through qualitative approaches, for example, the occurrence of terms or concepts can be counted from collected data and these measurements can be analysed using statistical approaches (Creswell 2002).

3.2.4 Time dimension

Time is an important dimension of any research, with three major types of time orientation in research design being cross-sectional, longitudinal and retrospective (Babbie 2004; Neuman 2003). Cross-sectional research involves observations at a single point in time; longitudinal involves the collection of data at multiple points in time, whereas retrospective research involves the generation and analysis of data at a series of different times in the past. Cross-sectional research is valuable in gaining an initial understanding for exploratory or descriptive research, excellent for descriptions across a large population sample at a given time, and also for understanding immediate causes in explanatory research. A weakness of cross-sectional studies is that they do not capture changes over time. A strength of longitudinal research is that it captures the dynamics of processes and changes through observations at more than one time although such studies are often more complex and expensive to undertake.
In retrospective research, the researcher looks backward in time using comparisons made between the past and the present through data estimations for the area under study. In effect, the researcher simulates or approximates a longitudinal study using generated data about the past and may use several different research viewpoints to undertake that activity, each of which influences the results (Cox & Hassard 2007).

3.2.5 Units of analysis
The unit of analysis is the main entity under study and is defined by the grouping at which analysis is being undertaken. In contrast, the unit of observation or collection is the grouping at which the researcher collects the data (Babbie 2004). The unit of analysis is the “what” or “who” that is being studied and different units of analysis can be used for research involving people. The three main units for such research are individual, a group or organisation, and society (Markus & Robey 1988). Several factors influence the selection of a unit of analysis. These include the availability of prior research in the area and at what level any decisions are made for the factors being studied. For example, if there is no prior research in the area, then analysis at the lowest level may provide an appropriate foundation for other levels of units of analysis. However, if decisions are made at a higher level of unit of analysis, for example at the organisation level, then analysis at that level may be more appropriate than at a lower level, such as the individual level (Babbie 2004). For example, if the research is investigating the characteristics of a society rather than an individual then analysis at the society level is more appropriate, even though the data may have been collected at the individual level.

3.2.6 Environment
People exist within an environment, that is, the surroundings and conditions that affect and influence their actions, feelings, and behaviours. Therefore, whether the research participants are within their usual environment or not is relevant information, as that can affect the reality or artificialness of the research (Neuman 2003). The characteristics or constraints of the environment of any research also influence that research. For example, different environments, such as personal or organisational workplaces, may have different privacy, confidentiality, and accessibility considerations. In addition, different organisations and work locations have different
Research design

cultures, political structures and other characteristics that may influence any research. As a result, planned data collection and analysis must acknowledge and take into account such differences.

3.2.7 Ethics

Ethical considerations are an important aspect of any research design (Babbie 2004; Berg 2004; Neuman 2003). Critical ethical aspects include voluntary participation with the right to withdraw at any time, informed consent including the right of participants to know what is and is not being collected and stored about them, and agreed anonymity and confidentiality. Other critical ethical aspects are appropriate participant protection from physical, financial or psychological harm, and consideration of any power relationships between the researchers and participants (Davison, Kock, Loch & Clarke 2001). Ethical considerations may affect aspects of the research including the feasibility of research, access to suitable participants, and choice of research techniques. In particular, research with groups with perceived lesser power such as patients, minors, or students often has significant constraints and considerations regarding both the design and subsequent conduct of the research.

3.3 Research design

Our views of reality and how the reality can be understood shaped the research design. In particular, an underlying positivist paradigm (Klein & Myers 1999) that posits an objective reality that is ordered by universal laws, knowledge of which is gained from empirical examination, shaped the design. In addition, since the outcomes of the research are intended to be useful for industry and academia, an applied research orientation was chosen and this orientation together with the scarcity of information relating to the area under study was a significant influence on all of the research design.

The design was constructed in three stages, one stage for each research sub-question. This structure is illustrated in Figure 3-1 and presented in the next three sections of this chapter.
Figure 3-1 Overall research design

3.3.1 Sub-question 1: What are characteristics of highly-skilled IT Architects?

The objective of the first research stage was to develop an initial understanding of the characteristics of highly-skilled IT Architects. As described in Chapters One and Two, there is very limited research examining the characteristics of IT Architects and what differentiates highly-skilled IT Architects from less skilled ones. As a result, this stage constituted exploratory research.

Similarly when looking for initial understanding and where there is little or no prior reference information available, research at a single point in time, that is cross-sectional, is appropriate (Babbie 2004). Both longitudinal and retrospective research are suitable for understanding either changes over time or processes and require an initial starting point for comparison. The aim of the research was not to look at change over time. While some information on the changing role of IT Architects was described in Chapter Two, there is no detailed information available on distinguishing characteristics of highly-skilled IT Architects available for use. Consequently those approaches were not employed.
Research design

In order to develop a first understanding of IT Architect characteristics there were several options available. These included analysis of job descriptions and advertisements for IT Architects, collection and analysis of perceptions of IT Architect characteristics by people who worked with them, and collection of such characteristics from people successfully undertaking the role. As described in Chapter Two, job description and job advertisement analysis have several limitations in terms of understanding what is required in a role. As an example of such a limitation, it is not clear if what is advertised is what is required for success in the role. Also many roles are not advertised and so would not be included within the analysis and thereby skew the results. Secondly, gathering data from people who worked with IT Architects was rejected, as the research is focussed on looking at what characteristics, both internal and external, distinguished highly-skilled IT Architects and some of those characteristics may not have been evident to people not performing the role. Therefore, we chose to collect data directly from highly-skilled IT Architects.

Gathering information and opinions from industry experts can be accomplished through a variety of research methods. Those with greater engagement with research participants include interviews or focus groups, while those with lesser engagement include surveys. As this is exploratory research where there is little certainty about the area of interest, a more engaged research approach was chosen (Babbie 2004; Neuman 2003).

Focus groups seek to capture group interactions, opinions and perceptions, while interviews seek to capture an individual’s opinions, interactions and perceptions. Interviews were selected for three main reasons. First, if participants are from competing organisations, market competition could preclude a potential participant from being involved or limit their freedom to contribute. In addition, interviews allow more flexibility in logistics than focus groups. Third, while focus groups allow interchange of ideas and can spark additional thoughts and observations from participants, they can also lead to ‘group think’ and polarisation of attitudes (Neuman 2003), although this can be mitigated through skilled facilitation. As this is exploratory research, diversity in views not convergence is sought.
Having selected interviews as the technique to answer the research sub-question we considered three major types of research interviews (Minichiello, Aroni, Timewell & Alexander 1995). These types are structured, semi-structured, and unstructured and each has different advantages and disadvantages (Berg 2004; Fontana & Frey 2003; Mason 2002).

Structured, or standardised, interviews are where the interview structure and questions are prescriptive, strictly followed and may have numeric responses. This type of interview is useful where the interview results will be closely compared with each other, the interviewers are not experienced, or where there are different interviewers and the intention is to standardise what is asked and collected in the interviews. Structured interviews are also useful in research situations where there are significant ethical concerns, and all questions require prior approval, in which case, having them documented, and not permitting deviation during the interviews can mitigate those concerns. Significant drawbacks of structured or standardised interviews are that they do not readily allow for new insights and information to be gathered, and often the interviewee has no opportunity to express their real opinions and feelings if the questions do not permit it. In addition, as described above, we are looking for engagement and structured interviews are similar to surveys in that, although face to face, they limit engagement.

In contrast, unstructured or un-standardised interviews may not have any prepared questions, rather a number of themes or areas to explore. Amongst the advantages of unstructured interviews as used in exploratory research are that key concepts and issues may be contributed by participants and, in common with semi-structured interviews, the interviewer can follow up unexpected answers or areas of discussion. In addition, it is possible to collect rich data with few pre-conceptions on the part of the interviewer. Finally, the interview may be more comfortable for the interviewee as it is often arranged as a conversation. Such interviews have several disadvantages; often they yield data that is difficult to compare, summarise or evaluate, they require skilled interviewers, and training these interviewers and evaluating their effectiveness may add to the cost of the study compared with structured interviews.
Research design

The third interview technique, semi-structured or semi-standardised, commonly has topics and suggested questions; however, discussion related to the topic, but not specifically requested, is encouraged and permitted. The advantages of such interviews include that, in common with structured interviews, they can elicit the information that the researchers are pursuing, the audience is specifically targeted, and the use of some structure allows for simpler comparison between interviews and analysis of common findings and concepts from the different interviews. At the same time, this type of interview also allows the interviewer the freedom to explore general views or opinions in more detail while constraining the interview to the main areas of discussion. Disadvantages include that the interviewer must be skilled and preferably knowledgeable about the subject area, and analysis of the data is more complex than with structured interviews.

The focus of this research stage was to explore the characteristics that distinguish highly-skilled IT Architects. Of the various types of research interviews, the semi-structured interview was selected. The disadvantages were mitigated through the researcher having both prior interview training and experience and significant IT Architect knowledge and expertise.

Having chosen semi-structured interviews the next design question was the choice of interviewees. When using interviews for data collection, obtaining saturation is important (Minichiello et al. 1995; Strauss & Corbin 1990) and we therefore did not have a target number of interviewees, rather we chose to interview sufficient IT Architects until saturation was achieved. An initial set of interviewees was chosen and then snowball sampling (Berg 2004) employed to identify further interviewees. There were three criteria for selecting the initial set of interviewees. First the interviewee had to have been performing as an IT Architect for several years, second, they had to have been recommended by at least three executives or project managers who were familiar with their work, and finally at least half of the initial sample had to be unknown to the researcher prior to the interview. The use of these three criteria was to ensure highly-skilled IT Architects were interviewed and that bias through pre-existing relationship with the researcher was minimised. In addition, IT Architects were chosen from different, sometimes competing, organisations, genders, ethnic
groups, and background, in order to reduce any bias caused by similar background, gender, or race.

All interviews were held, by choice of the interviewee, at their workplace or the researcher’s office, both of which were usual environments for the people being interviewed. Each of these locations contributed to the interviewee being more relaxed and comfortable and producing a more natural interview. In addition, all research participants were capable, mature professionals able to give informed consent. Anonymity and confidentiality were both assured, and there were no power relations evident that would affect the research. As part of the informed consent, how the data would be used and held was communicated, as was the procedure for withdrawing from the research at any time. In addition, interviewees were informed that interviews would be recorded and subsequently transcribed for analysis.

Having chosen semi-structured interviews as our data collection method, and selected our interviewees, the next important consideration was an appropriate technique to analyse the interview transcripts. Analysis of interviews can be accomplished using two major approaches; those where findings are induced from the data and those that are based on pre-conceptions or pre-existing theories regarding the interview contents. In both approaches, the interview transcripts are analysed and common themes identified, these themes are then further analysed and interviews are re-visited to confirm the understanding of the themes that have been identified. The main difference between the approaches is that with inductive approaches no coding scheme is identified before any interview analysis whereas with the other main approach a preliminary coding scheme is developed and then refined during the interview analysis. Both approaches often use grounded theoretic methods (Strauss & Corbin 1998) as techniques for this analysis.

The second approach was used, where an initial coding scheme was developed before the interview analysis. An initial coding list was constructed using the researcher’s expertise as an experienced IT Architect and by reference to existing research in the area. This initial coding scheme was used for line-by-line analysis and three stages of coding of the interviews. These three coding stages were open coding, axial coding, and selective coding (Strauss & Corbin 1990).
The purpose of open coding is to identify the themes or concepts within the interview transcripts. Each separate concept in the data is labelled and similar ideas are grouped and labelled. The codes used are either those in the existing coding scheme or new codes are assigned where the researcher decides that an important new concept or theme, not in the coding scheme, is identified. As part of the iterative coding and analysis, codes may be collapsed into larger, more abstract codes, if the concept or theme is very similar. Following open coding, the next step is axial coding, where the aim is to assemble coding categories into larger conceptual groupings. This process is repeated until no additional categories are identified and all the interviews have been analysed. The third and final coding step is selective coding. Again, the interview transcripts are re-examined and the prior coding and grouping is revisited and verified or changed as required. A key aspect of selective coding was to identify appropriate supporting interview quotations and other supporting data for the categories and groupings of categories.

As we were engaging with the IT Architects as single people, the unit of collection for data was at the individual level. For the unit of analysis, we chose to analyse at both the individual level and at the IT Architect group level. Individual analysis was chosen to build foundations for subsequent research and allow consolidation into higher levels such as group, organisation, and overall IT industry for example. An understanding at the individual level is appropriate before seeking to research organisational or societal aspects of the same area, hence that is a major unit of our analysis. The use of groups as a unit of analysis was to support the use of our results in understanding and making observations regarding IT Architects as a group, not just as individuals.

In this section, the research design decisions for the first research sub-question were described. How this research was undertaken is described in Chapter Four.

3.3.2 Sub-question 2: What capabilities distinguish highly-skilled IT Architects?

The purpose of this stage was to identify capabilities that distinguish highly-skilled IT Architects from other IT Architects and build on the outcomes of Stage One of this
research. There were three main research design activities within this stage and the overriding approach we used was quantitative. As described by Miles & Huberman (2002) this was appropriate as we had already decided what we were looking for, namely distinguishing capabilities from the set identified in stage one, and we were now looking to test whether some or all of the identified capabilities distinguish highly-skilled IT Architects using a larger sample.

Capabilities were identified as the differentiating factor because, as described in Chapters One and Two, they directly relate to job performance. In addition, as the intention was to increase our initial understanding of such capabilities and to identify measurable distinguishing capabilities; this research is descriptive (Babbie 2004; Neuman 2003). Given that there is limited research into such capabilities we chose to undertake our research at a single point in time to build an initial understanding. This understanding could be subsequently used as a base for longitudinal or retrospective forms of study, both of which require an initial starting point.

As noted earlier, suitable techniques for descriptive research are interviews, surveys, Delphi studies (Erffmeyer, Erffmeyer & Lane 1986) and Repertory Grids (Fransella & Bannister 1977; Hunter 1997; Kelly 1991). Interviews, Delphi studies, and Repertory Grids are best suited for small groups of participants. Surveys are suited to a large sample of participants and as we aimed for several hundred participants for this stage they were selected (Babbie 2004; Galliers 1991; Neuman 2003).

Potential participants were surveyed as individuals, that is, the unit of data collection was the individual. However, the unit of analysis was at the group level. This was to minimise individual differences by analysing the responses as a group.

Having selected surveys as the research method, the next activity was the choice of who would complete the survey instruments. Self-reported surveys were chosen because a number of participants were expected to be located across a wide spread of locations. Survey instruments may be created for a study, an existing survey used, or existing surveys combined to meet the needs of the study and so the second survey design question was whether to create a new survey or to use an existing, pre-validated instrument, or combine several such instruments into a single survey. The
Research design

validity of newly constructed surveys can be established through different techniques including pilot testing or Cronbach’s alpha (Cronbach 1951; Cronbach & Meehl 1955; Kitchenham & Pfleeger 2002b, 2002c, 2002d). However, the use of previously validated instruments is likely to be more robust and have some normative responses for comparison. For these reasons, previously validated instruments were selected and then assembled into a final survey.

The process of selection of the instruments was the third design choice within this activity. There were several aspects to this selection. The first is that there is a trade-off between length of survey, and therefore amount of data collected, and time to respond, where the less time to respond the higher the response rates (McCarty, House, Harman & Richards 2006). The second aspect was that it should be possible to answer the survey on paper or with a word processor because it was anticipated that some of the potential respondents would not complete the survey while having access to a computer and therefore surveys requiring online interaction would not be suitable.

The fourth survey design question was the method of distribution. The major alternatives for survey research are mail, email, internet, and telephone (De Vaus 2002; Fink 1995; Salant & Dillman 1995). Of these alternatives, telephone was discarded due to the time required. Using physical mail surveys would have increased the cost and the logistical effort. In addition, as IT professionals, we assumed that the target survey participants would be extensive email and web users, so completing a survey in either format would be appropriate for their normal environment. Yun & Trembo (2000) found no significant differences in response rates between email or internet based surveys, however, the response rate for surveys improves if the participants can choose their environment and method of completion (Tourangeau & Smith 1996). Therefore email surveys were chosen as they were believed to provide more flexibility of choice of environment than internet delivery.

Having selected an email survey, important considerations were maximising the response rate, choosing the target respondents, administering the survey, and finally choosing the analysis technique.
Several actions have been shown to increase the responses rate for surveys (Fink 1995; Yun & Trumbo 2000). These include; clear support of the organisation whose staff are being surveyed, early notice of the survey topic and purpose, incentives to complete, invitation to respond from a senior and well respected person either inside or outside the company, and follow-up contact of the potential respondents (Dillman 2000; Sivo, Saunders, Chang & Jiang 2006).

IT Architects from IBM Australia and New Zealand were chosen as the target respondents. As described in Chapter Two, IBM is one of the first companies to articulate the role of IT Architect and so is particularly suitable as a site for the survey. In addition, IBM is one of the largest IT companies in Australia and New Zealand and a significant employer of IT Architects. Their IT Architects work in many industries on a wide variety of project sizes and types. At the same time, by selecting a single target organisation, IBM Australia and New Zealand, some of the potential differences relating to organisation culture that could be caused by people working for different companies are reduced. In addition, IBM has an IT Architect certification program that has been active for many years and as described in Chapter Two, all certified IBM IT Architects are also Open Group IT Architect Certified. Therefore, certification could be used to distinguish between IT Architects of differing skill levels.

In order to gain more understanding into highly-skilled IT Architects, we decided to survey another group of IT professionals and compare their results with those of the IT Architects. The criteria for this comparison group were that there was a similar certification process to distinguish members of differing skill levels, that the organisational culture was similar, and that they could be drawn from the same geographic regions to reduce the possibility of differences caused by country culture. One group that met these criteria was IBM Project Managers based in Australia and New Zealand. As well as meeting the criteria, confidential IBM research has shown that IBM’s Project Management profession has a similar education and employment history profile to IT Architects within IBM and therefore any differences in responses would be more likely to be related to role.
Research design

The third choice for this part of the design related to administering the survey. IBM approval was obtained for their staff to participate in the survey. A key consideration for the survey administration design was managing the anonymity of the participants. Although this could be managed through third party organisations and other approaches, IBM preferred that they managed the contact with the participants. Therefore a senior IBM contact acted as the intermediary for all interactions and communications with the survey participants, and ensured that no identifying or personal details were passed to the researchers.

The last design question in this stage was the choice of analysis techniques. We wanted to compare the difference in responses between the different survey respondent groups. This can be done by comparing the differences between the means of the responses for each group and determining if those differences are significant. While there are several techniques for such comparisons such as Mann Whitney U tests (Mann & Whitney 1947) and Wilcoxon signed-rank tests (Wilcoxon 1945), assuming the data is normally distributed, simpler techniques such as t-test are preferred (Moore & McCabe 2003). The t-test can be used for three different types of mean comparison. The first is to compare the means of two independent samples for example between two groups being compared on the same test or experiment. The second is to compare the means for two dependent samples, for example for ‘before and after studies’ or studies using matched pairs. Both of these types of t-test are two-sample t-tests, while the third, which is used to compare a sample mean, and a known mean is a one-sample t-test. As we are comparing the results of different groups, for example certified IT Architects and uncertified IT Architects, using the same test then a two-sample t-test is appropriate and was our choice for the comparisons between groups (Levin 1999; Moore & McCabe 2003). In order to determine if the groups surveyed were significantly different from prior respondents to the instruments we chose, the respondent group’s means were compared against normative means. As described above, one-sample t-tests are appropriate for this and so were used.

To increase our confidence in the results from the quantitative analysis and to ensure alignment with the results from Stage One we triangulated the statistical analysis results with the interviews described in Chapter Four. As Denzin (1978) says, triangulation is “the combination of methodologies in the study of the same
phenomenon”, while the purpose of triangulation is so that “the bias inherent in any particular data source, investigators, and particular method will be cancelled out when used in conjunction with other data sources, investigators, and methods”. Accordingly as recommended by Jick (1979) we chose to re-examine the interview transcripts to confirm that what we found from the quantitative analysis was either congruent or not with what was found in Chapter Four.

Details of the performance of Stage Two, including the choice of the instruments, subsequent survey construction, distribution and administration, and result analysis are included in Chapter Five.

3.3.3 Sub-question 3: Can some IT Architect capabilities be improved in a university subject?

Having identified distinguishing capabilities for highly-skilled IT Architects in Stage Two, the aim in Stage Three is to investigate whether these capabilities can be improved. The site for trialling this improvement was in a single university subject where IT Architecture is included within the curriculum. Investigating changes in the identified capabilities is preferably undertaken through measurement of the capabilities before and after any learning, educational activities, or other enhancement opportunities. Three research design issues were important for this stage. These were; the type of educational intervention, the measurement of capabilities, and the analysis of any differences in capabilities. Also, as this research was determining additional detail about the IT Architect capability findings determined in Stage Two it was exploratory in nature (Babbie 2004; Neuman 2003).

A key research design question was the criteria for choice of the subject within which the capabilities educational material would be included. There were three criteria for this subject choice. The first was the learning objectives of the subject, which had to include the coverage of an IT Architect’s role so that the inclusion of capabilities education would not be anomalous. Second, because the IT Architect role is an advanced one, the subject needed to be at either post-graduate or advanced undergraduate levels within a university. The third criterion was an ethical one in that the educational material on capabilities could not displace any of the already agreed material within the subject.
Research design

Having determined the approach for choosing the subject, the next research design question was the choice of learning style or approach for the capabilities material. This was constrained by two main factors, the first was that use of a style or approach that was not congruent with the existing style of the subject, material and approaches was not permitted by the university, and secondly, as per the ethics approval, none of the material could be linked to assessment or examples already in use within the subject. There were several different styles of teaching considered, including lectures, workshops, interactive, and Problem Based Learning. Of these, we chose to use Problem Based Learning (Boud 1985; Engel 1997).

In this stage, we were looking at measuring the difference between capabilities before and after educational intervention. As this would involve the collection of data at different points in time, it is longitudinal research with three snapshots. There are three main types of longitudinal research, trend, cohort and panel studies (Galliers & Land 1987). Trend studies target different groups of people from the same population at different times, while cohort studies compare two groups from the same population where one has a treatment applied or intervention made whereas the other group does not. In contrast, panel studies measure and compare the same sample from the same population at different points in time. As our research in this stage would be comparing the same group of participants before and after educational intervention it is a panel study (Menard 2002). We chose to measure the participants at three points. The first was as the subject commenced, the second was immediately after the teaching of the capabilities within the subject, and the third was one-year later. This was done to establish a baseline of the capabilities of the student under study, then to determine if there was any immediate impact from the teaching intervention, and finally, the third measurement, to determine if there may have been some impact over a longer period, and outside the university environment for some of the students, as they had graduated.

In addition, as we were measuring student capabilities this research was quantitative and the same range of candidate techniques as identified in Stage 2, interviews, surveys, Delphi studies and Repertory Grids, might be appropriate. We chose surveys for this stage. We also chose the same two instruments as used in Stage Two to
evaluate the capabilities that we are researching in this stage. We chose to use the same capability measurement techniques to enable comparison with Stage Two and with other studies using the same instruments. Again, our use of relevant previously validated instruments allowed us to concentrate on the area under study rather than instrument construction. The unit of collection for these instruments was the same as stage two, being the individual and again the unit of analysis was at the group level. This was because we planned to compare the impact of teaching of the capabilities across a range of different students with different characteristics while preserving anonymity. We also offered an incentive to the participants as such approaches have been shown to increase the response rate for surveys (Dillman 2000; Sivo et al. 2006).

Ethical considerations are always important with research and more so with groups such as students (Babbie 2004; Neuman 2003), and one important consideration of research with students is the potential impact of power relationships. In order to alleviate this, the researcher was not involved in the conduct, teaching or assessment of the subject and no relationship between assessment and participation was established for any of the survey completions.

Ethical considerations also significantly constrained the research design choices for the possible educational intervention. For example, all students had to have equitable access to all material that would be part of the research; therefore, a control group was not possible and also no power relationships were possible between any of the students and the researcher.

The third and final design question in this stage was the choice of analysis technique. Similar to Stage Two, t-tests were selected as we were comparing the means of groups (Moore & McCabe 2003), for example, we were comparing the students before the subject with the students immediately after the subject. As described above, the two-sample t-test can be used to compare the means for two dependent samples, for example for before and after studies as we were doing. We again chose to compare the means of the student responses to the means for the instruments we used in the surveys. For this comparison, we chose to use one-sample t-tests again as they were appropriate for such a comparison, as described above.
Research design

In a similar fashion to Stage Two, to provide additional insight into our results and to continue to ensure consistency between all stages of our research we chose to include triangulation (Denzin 1978; Jick 1979) as part of our research design. Accordingly, we revisited the interview transcripts and analysis and compared them with the results from this stage. In addition, we also interviewed several of the student participants and the tutors who led the Problem-Based Learning sessions to enhance this triangulation and provide additional insights into any results, both expected and unexpected.

In summary, the resulting design for Stage Three had four steps. First, survey assessment of the students’ capabilities related to some of the previously identified distinguishing capabilities for highly-skilled IT Architects. Second, application of teaching material that was designed to improve these IT Architect capabilities. Third, we administered the same survey at the completion of the subject, and the final step was a further administration of the same survey one-year later. The detailed description of these steps, their performance, and the analysis of the results are given in Chapter Six.

3.4 Rigour, relevance and reliability of our research

Three criteria for quality research are relevance, rigour, and reliability (Benbasat & Zmud 1999). Relevance is especially important for applied research. It has been described by many different authors in many different manners throughout information systems research, with some examples of these descriptions set out in a special issue of the Communications of the Association of Information Systems (Gray 2001) and other papers including ones by Lee (1999) and Robey & Markus (1998). Relevant research is described as being of use to practitioners, where those practitioners may be based in industry, or education, or academic institutions. A key aspect of usefulness or relevance of research is that it provides suggestions that can be followed or can stimulate further enquiry in the area under study (Benbasat & Zmud 1999). The research described in this thesis is relevant in that it addressed an important gap in research and practitioner knowledge that relates to distinguishing characteristics for a key IT role. It also examines how these characteristics can be evaluated and enhanced in an educational environment.
Research is rigorous to the extent that it follows acceptable practice for the research design and methodology it employs and that it is transparent and explicit (Mays & Pope 1995). Accordingly, while no research can be described as completely rigorous (Barbour 2001) our approach supported the rigour of these stages. For all stages our choice of data collection, associated instruments, sample selection, overall population, and analysis techniques was guided by and closely followed prior research and agreed practice as recommended by several researchers (Babbie 2004; Keen 1991; Strauss & Corbin 1998). In addition, our processes, techniques, and decisions are transparent and described within Chapters Four, Five and Six.

The third criterion is reliability, that is, whether the research outcomes can be depended on, or whether the measure is consistent or stable across different samples or populations (Lewis, Templeton & Byrd 2005). For qualitative research, such as we chose for stage 1, reliability can be described as the repeatability of observations or results. While this is less important for exploratory research such as we undertook, reliability can be enhanced through mechanisms including use of proven approaches, clear description of methods, and an inquiry audit (Lincoln & Guba 1985). We used all of these approaches during this research stage, thereby improving the reliability.

For quantitative research, such as we primarily undertook in stages two and three, reliability is the ability to derive the same results with the same instruments, regardless of the researcher. There are several methods for testing reliability. These include internal consistency (also known as Cronbach's alpha), split-half reliability, test-retest reliability, and uni-dimensional reliability (Straub, Gefen & Boudreau 2005). The instruments chosen were all previously validated and reliability measures had been reported as part of the initial development. Therefore Cronbach’s alpha, uni-dimensional reliability, or test-retest reliability were not determined to be suitable as part of this research. Examining split-half reliability was not necessary as its purpose is to determine any differences between instruments or items measuring the same constructs; each of our instruments only measured one construct and the number of items for the instrument had already been minimised and reported during the initial development of the instruments.
Research design

3.5 Summary

This chapter has outlined the overall research design, including major influences on research design, the research design itself, and how relevance, rigour and reliability of the research was addressed. The conduct of the three research stages is described in the next three chapters respectively, with the next chapter, Chapter Four, describing the first stage of the research, investigating characteristics of IT Architects.
Chapter 4. IT Architect characteristics

In the first stage of the research we investigate which characteristics distinguish highly-skilled IT Architects from less-skilled IT Architects. In Chapters One and Two, we described the developing role of IT Architect and identified the lack of research into the role. In Chapter Three we described our overall research design and now, in this chapter, we continue by investigating the characteristics of people effectively performing the role of IT Architect.

Therefore, this chapter is addressing the research question:

*What are characteristics of highly-skilled IT Architects?*

We investigated this question by interviewing both highly-skilled IT Architects and people who managed teams of IT Architects. This chapter outlines how we selected participants, explains the interview approach and interviewees’ attributes. We describe the interview analysis, and present and discuss the results of this analysis.

4.1 Interview approach and interviewees

4.1.1 Interviewees

The interviewees were selected through snowball sampling (Berg 2004) where the researcher commenced with a group of IT Architects that they knew; and these IT Architects recommended others as potential interviewees. Snowball sampling is suitable for groups such as highly-skilled IT Architects as likeability does not influence perception of performance within the IT industry (Sonnentag 1998).
IT Architect characteristics

The fourteen interviewees were highly-skilled IT Architects, all had been performing as IT Architects for a minimum of five years and were still performing the role as part of their activities, even while managing other IT Architects. All had received written commendations and in many cases financial bonuses from their clients for successful architecture and associated project completion. Each had also been involved in or responsible for the architectures of more than five projects, with each project having a budget of more than Australian $250,000.

The interviewees were chosen to maximize the range of industries and backgrounds. The interviewees’ current employers ranged from a single-person boutique consultancy through to an international organisation with more than 20,000 employees in over 30 countries. The span of industries included government, IT services and outsourcing, software product development, distribution, and financial services. The interviewees ranged in age from 34 to 66 years old and most had been tertiary educated in a science discipline. Twelve males and two females were interviewed and most of the interviewees had worked in many different countries across the world.

Nine of the interviewees had current or prior work relationships with each other. Some of the interviewees managed others of the interviewees or had previously managed them, while other interviewees worked for the same manager, and other interviewees were clients of other interviewees. We show this range in relationships in Figure 4-1, where the numbers one through fourteen indicate the anonymised interviewee code. This range of relationships facilitated triangulation of opinions regarding highly-valued IT Architect characteristics; for example, two of the interviewees, numbers two and nine used the same person, interviewee number four, as an example of a highly-skilled IT Architect. The other five interviewees did not have any such relationships.
Figure 4-1 Work relationships between interviewees

4.1.2 Preparation and conduct of interviews

The three main areas of questions were:

1. Interviewee background
   - What is your education and work background?
   - What is your age and qualifications?
   - What is your current role and what are the upsides and downsides of that role?

2. What capabilities did they think makes them good at their job?
   - What makes them good at their job as an IT Architect?
   - What are their strengths and weaknesses as an IT Architect?
   - Thinking of a person you regard as a good IT Architect, what makes them good at their job?

3. What capabilities did they look for when choosing to train and hire other IT Architects?
   - Which of these are most important?
   - Which of these are the least important?
   - What might have you strongly recommend against them?

The interviews were structured in this manner for two reasons. The first was to build rapport between the interviewer and interviewees through questions about the interviewees themselves before asking about IT Architects in general. The second reason was to ask questions regarding capabilities of IT Architects from different perspectives to triangulate the interviewee’s opinions and thoughts regarding what were required for highly-skilled IT Architects. Prior to the interviews each interviewee was sent a letter confirming the interview time, date, and location and a copy of our definitions of capability and IT Architect which were extracted from the
IT Architect characteristics

Prior to conducting any interviews, we documented our pre-conceptions and expected findings. This included the characteristics we expected to be mentioned in interviews, possible answers to the main questions in the interview guide, and our thoughts as to the critical characteristics. The purpose of this document was to surface and act to reduce any bias or expectations both throughout the interview process and in the subsequent data analysis. A summary of these preconceptions and expected findings is in Appendix C.

The interviews were semi-structured and lasted between 40 and 95 minutes. All interviews were audio-recorded. The interviewees gave formal consent to the recordings and care was taken to ensure that the recordings did not include their personal details or other identifying information so that the interviewee’s anonymity was protected. An independent group then transcribed the interviews. This interview transcription and a later independent check coding of interviews, described in section 4.2.1, were the only activities described in this chapter that were not undertaken solely by the researcher. The audio recordings were compared to the transcriptions and some corrections made, which were mainly jargon and acronyms. In addition, field notes were taken in all interviews. As part of the initial interview analysis, these field notes included observations about the interview process, any thoughts about what was discussed in the interviews, interpretations of interviewee statements and an overall interview summary by the researcher. The field notes were reviewed within 24 hours of each interview and any required changes or additional material included.

4.2 Interview processing and analysis

The interviews were analysed in four steps. First, we examined the interview transcripts through coding to identify common characteristics of IT Architects. In the next step, the identified characteristics were classified into three groupings. Thirdly, the classified characteristics were analysed to identify the more important characteristics. The final step was the consolidation of these more important characteristics into a smaller coherent set. The field notes were used at each stage of the analysis to provide additional insight and clarification.
4.2.1 Characteristics coding and initial identification

As part of designing the interviews, a preliminary coding list of 46 characteristics was developed each with accompanying descriptions. These were derived from the research literature and professional experience and are included in Appendix D. These characteristics were mainly capabilities as defined by Scott (1999a), however other characteristics related to the architects’ experience and behaviours. The interview transcripts were initially analysed using a grounded theoretic approach with the use of this coding list, (please see Appendix E for sample transcripts and coded extracts from two of the interviews). This analysis was performed using line-by-line simple coding and content analysis (Berg 2004) and a content dictionary was constructed (Ryan & Bernard 2000; Strauss & Corbin 1997). The software package NVivo 7 (QSR 2006) was used to support this process.

In addition independent check-coding (Strauss & Corbin 1998) was performed by two different experienced researchers, one associated with and one not associated with our research. Both of these check-coding activities supported the coding integrity.

The first six interviews were coded in an initial coding pass to confirm that the coding scheme and approach was viable and that the interviews were covering information related to the research questions. The overall approach was confirmed and we added three additional characteristics and accompanying definitions to the coding list.

We then coded the remaining eight interviews. The primary coding technique was open coding. Axial coding and selective coding were also performed to confirm the themes identified and triangulate understanding as recommended by Strauss & Corbin (1998). Theoretical saturation was reached after coding the tenth interview as the coding of the last four interviews did not present or uncover any new information. According to Minichiello (1995) and Strauss & Corbin (1998) once saturation is reached further interviews would be of limited value.

4.2.2 Characteristics classification

The identified characteristics were classified into three categories: background, personality traits, and capabilities. All of the characteristics we considered fit into one of these three classes.
IT Architect characteristics

*Background* includes an IT Architect’s education, experience, and possession of technical skills.

*Personality traits* are “a consistent pattern in the way individuals behave, feel and think” (Pervin & John 2001). A commonly used model for personality traits is known as the “big Five Factors” (Larsen & Buss 2002; Mischel, Shoda & Smith 2004). In this model, originally proposed by McCrae & John (1992) the traits are defined within five factors, each of which has a set of facets. These facets are most commonly described by an adjective set, or sentence, that describes a behavioural continuum that has been shown to be normally distributed across a wide population of individuals. We used these adjective sets or sentences to determine which of the non-background interview characteristics were best classified as personality traits.

*Capabilities* are as defined in Chapter One by Scott (1999a) and are the particular skills necessary for the IT Architect role as distinct from the general skills that are classified as background.

### 4.2.3 Important characteristics determination

During the interviews, each interviewee stated their opinions of the important characteristics for success of an IT Architect. In total 34 characteristics were identified as being important. While the interviewees mentioned many other characteristics, they very clearly stated which were and which were not important. The number of times an interviewee mentioned a characteristic was not used to determine importance of any characteristics. This was because some of the interviewees specifically mentioned the key capabilities, behaviours, and experiences in priority order. One interviewee only mentioned their highest priority capability a single time in the entire interview and explicitly described it as such at the time, as they said, “… that one was an overriding winner, the next tier there’s a few...”.

The transcripts were further examined to filter the 34 characteristics identified as important into a more compact group. We did this by examining which of the 34 characteristics were identified by more than one interviewee as important. This resulted in 20 critical characteristics.
To support the validity of results of this analysis, we performed an alternative data analysis approach to investigate the importance of characteristics. For this approach, we examined each interview transcript and identified which characteristics the interviewee identified were of high, medium, and low relative importance. In some interviews, this was obvious, as the interviewee had stated their responses in that manner, while in others this relative priority was determined by the order of mentioning and through examination of all question responses in the interview. We then assigned a ranking of one for each characteristic identified as high importance, two for medium importance, and three for low importance. We then summed those rankings for all characteristics identified in the interviews and ranked the characteristics using the sum from lowest total to highest total. The results of this analysis supported the selection of the critical list of 20 characteristics; no more characteristics were identified as important using this analysis approach.

4.2.4 Characteristic consolidation

The final step involved consolidating some of the important characteristics that were either similar, or were a subset of another characteristic. We performed this consolidation through detailed reference to the interview transcripts. After the consolidation one characteristic, Intelligence Quotient (IQ), was removed from further consideration. We discarded this as other research has shown that “…test score is a better predictor of job performance than any other single measure” (Herrnstein & Murray 1996). There are existing measures and research on IQ or General Mental Ability (GMA) and our focus is to identify other distinguishing characteristics and those that could be improved through education and other development activities.

This final consolidation resulted in two background characteristics, four personality traits, and eight capabilities; fourteen characteristics in total. In addition, we changed one capability’s name from “political awareness” to “situational politics” to reflect more accurately the interviewees’ intention after further review of the transcripts. As one interviewee stated “I think architecture is about politics as much as it’s about anything else because what you’re doing is forcing people to decide about what’s important to them”, while another said “a weakness is that I don’t always, I probably haven’t always seen or read correctly the politics of a particular situation.”
Table 4-1 shows the initial 34 characteristics, identified as important by one of the interviewees, the 20, in alphabetic order, that resulted from the initial round of consolidation and the final set of characteristics. The table also includes notes commenting on the reasons for consolidation or change of name or a representative quotation for the interviews. Within the table, the following codes are used for type of characteristic:

- B – Background,
- C – Capability,
- N/A – Not applicable, and
- P - Personality Trait.

<table>
<thead>
<tr>
<th>Identified characteristic</th>
<th>Type</th>
<th>Finalised set</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to see/understand from multiple viewpoints</td>
<td>C</td>
<td>Conceptualisation</td>
<td>Usage in interviews similar to conceptualisation therefore combined with conceptualisation, as described by one interviewee “as being, um, conceptualization, or concept-building, concept, seeing concepts, working with concepts… from different perspectives.”</td>
</tr>
<tr>
<td>Analysis</td>
<td>C</td>
<td>Analysis</td>
<td>“logical way of seeing things”</td>
</tr>
<tr>
<td>Big picture thinking</td>
<td>C</td>
<td>Business related</td>
<td>Usage in interviews similar to visionary therefore combined with visionary</td>
</tr>
<tr>
<td>Business related</td>
<td>C</td>
<td>Business related</td>
<td>“they need to understand what the business problem is “, “the business acumen type “, “understand the business drive”</td>
</tr>
<tr>
<td>Communication</td>
<td>C</td>
<td>Communication</td>
<td>“it comes back to communication”</td>
</tr>
<tr>
<td>Conceptualisation</td>
<td>C</td>
<td>Conceptualisation</td>
<td>“to be able to visualize what is going on”</td>
</tr>
<tr>
<td>Creative</td>
<td>P</td>
<td>Creative</td>
<td>“can come up with new ideas”</td>
</tr>
<tr>
<td>Identified characteristic</td>
<td>Type</td>
<td>Finalised set</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------</td>
<td>---------------</td>
<td>-------</td>
</tr>
<tr>
<td>Credibility</td>
<td>B</td>
<td></td>
<td>Combined with experience as interviewees described as derived from prior roles and projects, as stated by one interviewee, “you know have the respect of the developers, so that they’ll listen to you”</td>
</tr>
<tr>
<td>Experience</td>
<td>B</td>
<td>Experience</td>
<td>“you’ve got different experiences to draw on”</td>
</tr>
<tr>
<td>Full SDLC</td>
<td>B</td>
<td></td>
<td>Combined with experience as usage similar in interviews. For example, one interviewee said IT Architects need to be experienced with “…everything from business development work through to proposing and designing and architecting solutions and building solutions, using…”</td>
</tr>
<tr>
<td>Generalist</td>
<td>B</td>
<td>Generalist</td>
<td>“relatively shallow expertise in a number of things”</td>
</tr>
<tr>
<td>Identifying what is critical</td>
<td>C</td>
<td></td>
<td>Usage in interviews similar to analysis therefore combined with analysis, as two different interviewees said, “The ability to look at something in a critical fashion”, and “… can understand his capacity to critically analyse a problem”</td>
</tr>
<tr>
<td>IQ</td>
<td>N/A</td>
<td></td>
<td>This was not investigated further as it was not the subject of the research. (Included in section 4.2.4 is the brief discussion about this decision)</td>
</tr>
<tr>
<td>Identified characteristic</td>
<td>Type</td>
<td>Finalised set</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Middle-ground</td>
<td>C</td>
<td>Middle-ground</td>
<td>“you also have to be able to translate those sort of business terminology”</td>
</tr>
<tr>
<td>Open-minded</td>
<td>P</td>
<td>Open-minded</td>
<td>“dogmatism is also a showstopper”</td>
</tr>
<tr>
<td>Passionate</td>
<td>P</td>
<td>Passionate</td>
<td>“still tremendously passionate”</td>
</tr>
<tr>
<td>Political awareness</td>
<td>C</td>
<td>Situational politics</td>
<td>Name changed after review of interview notes</td>
</tr>
<tr>
<td>Problem solving</td>
<td>C</td>
<td>Problem solving</td>
<td>“set your mind to the problem in the abstract”</td>
</tr>
<tr>
<td>Resilient</td>
<td>P</td>
<td>Resilient</td>
<td>“their psychologically resilience I’d be looking for”</td>
</tr>
<tr>
<td>Visionary</td>
<td>C</td>
<td>Visionary</td>
<td>“a lot of foresight when it comes to projects”</td>
</tr>
<tr>
<td>Enthusiastic</td>
<td></td>
<td></td>
<td>None of these characteristics was mentioned as important by more than one interviewee.</td>
</tr>
<tr>
<td>Curious</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negotiation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pragmatic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple roles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management/leadership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify IT opportunities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong willed/persistent/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>determined</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reflective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4-1 Characteristics consolidation summary
4.2.5 Alternative analysis approach

To confirm our analysis, we performed a second analysis using a different approach over twelve months after the first analysis. In this approach, there was no categorisation of characteristics into background, personality traits, and capabilities before we consolidated any concepts. Instead we examined the initial 34 characteristics and through reference to the interviews and previously documented definitions, we consolidated them into 20 characteristics. We then used the same process as described before to consolidate and classify those 20 characteristics into background, personality traits, and capabilities. The resulting breakdown of characteristics was the same as the initial analysis and therefore the initial analysis was confirmed.

4.2.6 Research tasks timeline

We conducted the research described in this chapter over a fifteen month period, from June 2004 through August 2005. There were four main periods of activity during this time. First we prepared for the interviews and developed the list of preconceptions from June till August 2004; we then conducted the interviews during August and September 2004. We then analysed the interviews from September 2004 until January 2005, and finally, in August 2005 we re-analysed the interviews using the alternative analysis approach described in the preceding section.

4.3 Interview results

This section describes in more detail the fourteen characteristics identified through analysis in the previous section. They are organised into background, personality traits and capabilities. (The characteristics in each category below are presented in alphabetic order, not in any implied importance.)

4.3.1 Background

Experience

All the interviewees stated that an IT Architect requires experience of all facets of the software development life cycle, and that less than ten years of relevant experience was insufficient to perform the role. That experience ideally includes maintenance of existing systems and project management. They also stated that an IT Architect required credibility, in particular technical credibility, and this is gained through
experience over time. One interviewee said, “IT people had difficulty believing my credibility because ... I hadn’t got as much depth in programming as they had so therefore they thought that I couldn’t really conceive of all the issues.” Interestingly according to the interviewees, current technical credibility was not essential, instead, the IT Architect had to either be an expert now or has been regarded as one in the past. Another interviewee said, “they will be known through the company as being good, because they have been” (emphasis added). Breadth of experience is also important, “So staying within the one business unit, within the one style of solution, sticking with your own solutions and extending it just a little bit all the time. It’s eventually not a recipe for a successful architect.” As another interviewee stated, “hiring an IT architect, experience, in terms of being through and seeing a number of different issues and problems within different organisations and so forth” was crucial.

**Generalist**

Twelve of the fourteen interviewees also stated that being a generalist was far more important than being an expert in just a few forms of technology or problem domains. One interviewee stated that balance was important and further said, “I think when people are overly specialist, it doesn’t make you good for this sort of work.” An IT Architect had to be able to “do everything from business development work through to proposing and designing and architecting solutions and building solutions.” This also supports the breadth of expertise described in the previous sub-section.

### 4.3.2 Personality traits

**Creative**

The interviewees described creative in terms such as being able to think outside the box, having unusual ideas and innovative thoughts, and to be able to put things together in new and imaginative ways. One interviewee stated that “just about every solution they must provide is always going to be unique, regardless of whether you can take some previously known solution, you still have to modify it and make it suit what it is the client is asking for.” Another interviewee was more succinct, simply stating, “I don’t want textbook answers”, while another was also very clear “Absolutely, definitely, they have to be creative.”
Open-minded
Eleven of the fourteen interviewees stated that open-mindedness was important and described it as the IT Architects being ready and able to entertain new ideas, in addition to generating new ideas. To illustrate this, one interviewee who has managed many architects, as well as working extensively as an architect, stated, “you got to be really, really open, as an architect, you got to be really up for someone else having a better idea.” Another stated that, they would not hire a candidate as an IT Architect “if they weren’t open to new ideas and possibilities.”

Passionate
Being passionate was identified as important by the majority of interviewees and was described using terms such as expressing passion; strong in feeling or desire; or vehement. One interviewee clearly described this when he said, “You’ve got to actually have a passion for understanding and getting excited about things.” Two other interviewees were also clear when they said “You have to have a passion for architecture to do it” and “you have to be passionate.” In addition, one interviewee clearly described why they thought an IT Architect needed to be passionate when she said, “you have to be passionate about it because you will face resistance.”

Resilient
The interviewees described resilience as being able to recover readily from adversity, depression, or the like. The most commonly stated reason was that because IT Architecture was usually a long-term proposition there would be setbacks and the person would need to rebound from those. For example, one interviewee said, “I'm looking for somebody who's picked themselves up from a bang”, while another said “a key psychological thing that you need is that sort of resilience that you can bounce back from … minor set backs or whatever.” Another interviewee stated that when considering hiring an IT Architect a key aspect was “their psychological resilience.”

4.3.3 Capabilities
Analysis
A vital capability for IT Architects is being able to break material down into its component parts to see interrelationships and hierarchies of ideas. In addition, they have to be able to consider issues while drawing on relevant concepts and values in
IT Architect characteristics

arriving at a critical assessment of them. One interviewee said, “it’s the relationships between different objects that are very complex”, while another stated that it was crucial for an architect to have “that kind of analytical skill, that ability to identify various alternatives, alternative approaches and analyse the implications of going down one path against another.”

Business related

The majority of interviewees described highly-skilled IT Architects as requiring an understanding of the purposes, objectives, strategies of the business, and the implications of this information. Different interviewees expressed this capability in different manners. One interviewee said, “they need to understand what the business problem is”, while another stated that IT Architects needed “the business acumen.” Other interviewees said “without thinking of global business model implications... is a bit naïve”, “need to understand ... what is the business model that I’m trying to work within”, and “the good architects are the ones who come from a business perspective as well.” Another interviewee when speaking about candidates for an IT Architect role said, “I’d put more value, in terms of the business acumen.”

Communication

The key identified capability for IT Architects was communication. Communication was described as including oral, visual, written and presentation components and all of these stated as being essential to the role. As one interviewee stated, “if they can’t communicate nothing else matters.” Other interviewees said that “communications is a really strong skill that you need to have”, “the ability to describe concepts at the right level of detail, in the right way, to the different stakeholders”, and “communicate on many levels.” These opinions were also common when describing the capabilities for candidates for IT Architect roles with the interviewees saying, they “look for the ability to be able to communicate”, and “being able to communicate effectively.”

Conceptualisation

A capability described by all interviewees was conceptualisation, where this was described as inventing or contriving an idea or explanation and formulating it mentally. This was explained by one of the interviewees who said, “even when I’m
Information Technology Architect Capabilities

thinking of a problem which is completely abstract, completely semantic or philosophical it’s pictured in colour in my mind and looked at from all angles.” Another stated that a key differentiator for highly-skilled IT Architects was “the ability to visualise complex structures in their mind”, while other interviewees identified the “capacity to imagine, visualize a solution”, “the ability to conceptualise things”, and “conceptualization, or concept-building, seeing concepts, working with concepts.” Another interviewee clearly described the importance when they said that a critical capability “would be conceptualisation or conceptual skills or those imagining skills that allow you to think in terms of models or concepts and allow you to form relationships between those concepts and even think about and build abstract machines in your mind’s eye.”

Middle-ground
There were many statements by the interviewees about the importance of IT Architects in being able to stand between IT and the business, or between other organisation or political units, even if it means being a “queue of one.” One interviewee described this when they said, “architects really link the business and the developers.” Another stated, “I can interpret between technical speakers and business users, and I think that’s the greatest strength an architect has.” This is similar to communication, however, the interviewees specifically differentiated between the capabilities. The difference was that this capability not just involved communication but also negotiation, translation and accommodation as was evidenced by statements from interviewees such as “you also have to be able to translate those sort of business terminology”, “bringing those two views together”, and “the IT architect is connecting business to information technology.” This capability also differed from facilitation in that it involved the application of judgement, as stated by one interviewee, “to work out what makes a quality outcome you have to be able to balance the needs of a wide range of people and the ability to see through other people’s eyes.”

Problem solving
The interviewees described problem solving as the creative application of rules, procedures, techniques, or principles to solve complex problems where there is no single correct answer. This capability was distinguished from skills in a language or
technology. As one interviewee stated, “they’re looking towards, ‘how do we solve this, this problem, how do we architect it?’”, not, ‘how do we do it in C++, or how do we do a UML, or how do we do it to objects?’” The interviewees emphasised the consideration of alternative solutions with statements such as “the role demands an ability to identify the potential solutions”, and “When you set your mind to a problem in the abstract, you can often come up with multiple ways of solving it, and, generally speaking, you can look at those alternatives and you can work out pros and cons to all of them.” Similar comments when the interviewees were speaking about candidates for the role of IT Architect included the candidate having the capability of “working out you know how you get there from the steps”, and whether “can they solve a problem instead of doing a task.”

**Situational politics**
A significant capability is situational politics, which is understanding the politics of the situation including the organisation, your work environment, and how that may influence the architectures you are involved with or the people you are interacting with. An illustrative statement from the interviews was, “you can actually judge the likelihood of it working, given the context it has to work in”, while another interviewee stated “I think architecture is about politics as much as it’s about anything else.” A further interviewee clearly described the capability by identifying one of their weaknesses with the words “I probably haven’t always seen or read correctly the politics of a particular situation, so I tend to go in with perhaps a slightly naïve view at times.”

**Visionary**
This is the capability of a person to imagine how an organisation, system, or industry will develop in the future and to plan in a suitable way, or being able to take a macro view of the entire area, not just the minutiae of the problem or domain at hand. Interviewees described the importance of this capability with statements such as “it’s getting people to look at the big picture” and “can see things broadly and strategically and has this vision about going ahead and doing things that I think is really good.” Another interviewee described as important “the vision of what we were trying to achieve.” One interviewee described why this was important when they said, “to influence things the longer vision you need to have.”
4.4 Discussion

Two important characteristics identified in this stage of the research were communications capability, and broad experience. While prior research had identified these as important for related roles (Curtis et al. 1988; Lee et al. 1995; Mills 1985; Walz, Elam & Curtis 1993), IT Architects were not the subject of that research. We have also introduced an additional set of highly-valued criteria for an IT Architect, namely personality related characteristics. In addition, the combination of personality, capability and background has not been previously described for IT roles.

These findings support previous research by Mills (1985), who wrote “In short, the system architect is the whole-system designer, a fire fighter, mediator, and jack-of-all-trades.” In addition, the significant number of ‘soft skills’ required to be a highly-skilled IT Architect is similar to other IT roles as they have developed over time (Agarwal & Ferratt 2002; Cash, Yoong & Huff 2004; Strano 2006). The importance of these non-technical skills is supported by recent research on skills for the IT Workforce (Abraham et al. 2006; Zwieg et al. 2006).

4.4.1 Background

The importance of an IT Architect’s background in terms of breadth of experience and generalist skills supports prior research (Curtis et al. 1988). The interviews showed that being a generalist is more important than being a specialist. Technical skills alone are not sufficient. This supports White & Leifer’s (1986) research into successful system development and research by Cash et al. (2004) who found that what is needed is “Greater technical breadth, less technical depth” and while technical background is required for credibility, being too technical is counter-productive for the role.

Our findings support the work by Ericsson (1998, 2002) who found that at least ten years of experience in a field is necessary to be able to perform as an expert in an area. The majority of the interviewees stated that a minimum of ten years of the appropriate experience is needed to be a highly-skilled IT Architect.
IT Architect characteristics

An interesting side note was that most of the interviewees stated they would not hire a person into an IT Architect role unless they had a failed project and could explain that they had learnt from it. Examples included, “bearing the scars of things that have gone wrong”, while another stated “you may have delivered something and failed, and you've learnt from it or you've delivered something that worked and you've subsequently learnt from it when it failed.” As a comment, people very rarely include failed projects on a job application or in their curriculum vitae. The interviewees said they often explicitly ask about failures during job interviews.

4.4.2 Personality traits

As described in Chapter Two, although identified as important (Witt & Burke 2002) there is only limited research into the personality traits of IT Architects. The descriptions by the interviewees and the comments they made such as, “I’m a sceptical optimist”, support the importance of personality traits in success in this role. While the interviewees described these traits as important for success in the role of IT Architect, there were only limited comments in comparison with the important capabilities for IT Architects.

4.4.3 Capabilities

The focus of this research is on IT Architect’s capabilities. While prior research, described and analysed in Chapters One and Two, and organised into the capabilities we identified in Table 4-2, has reported capabilities similar to those we identified, that research was focused on different roles. None of the prior research found the combination of capabilities that our interviewees stated as important for highly-skilled IT Architects. In addition, as was evident in the interviewee’s comments, the capabilities are inter-related and not clearly delineated, reflecting the nature of the IT Architect work.

The interviewees stated that communication is the critical capability for people in senior technical roles, such as IT Architects. As Table 4-2 shows, this result supports the work of many other people, as does the importance of business knowledge. Our results also support meta-studies by Nakayama & Sutcliffe (2001) and Niederman et al. (1999) which found that in many papers presented at the ACM Special Interest
Group on Computer Personnel Research (SIGCPR) the combination of business knowledge and communications were important.

Several capabilities previously found to be valuable for similar roles were either not mentioned or described as not important in the interviews. For example, we expected that IT Architects would be capable small-team leaders, and have significant cross-cultural awareness; however, these were not mentioned by the interviewees as important.

<table>
<thead>
<tr>
<th>Capability</th>
<th>Research previously identifying a capability as valuable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>(Joshi &amp; Kuhn 2007; Orr &amp; von Hellens 2000; Strano 2006; White &amp; Leifer 1986)</td>
</tr>
<tr>
<td>Conceptualisation</td>
<td>(Stolterman 1991)</td>
</tr>
<tr>
<td>Creativity</td>
<td>(Couger 1995; Joshi &amp; Kuhn 2007; Sonnentag 1995; White &amp; Leifer 1986; Wynenkoop &amp; Walz 1996)</td>
</tr>
<tr>
<td>Future orientation</td>
<td>(Feeney &amp; Willcocks 1998; Hellstrom &amp; Hellstrom 2003)</td>
</tr>
<tr>
<td>Middle-ground</td>
<td>Described by Cash et al. as “greater ability to clarify technical jargon and “speak through the techno-babble” (Bashein &amp; Markus 1997; Cash et al. 2004; Grinter 1999)</td>
</tr>
<tr>
<td>Problem solving</td>
<td>(Grinter 1999; Lee 2005; Strano 2006; Vitalari &amp; Dickson 1983)</td>
</tr>
<tr>
<td>Situational politics</td>
<td>(White &amp; Leifer 1986)</td>
</tr>
</tbody>
</table>

Table 4-2 Prior capabilities identified
4.4.4 Comparison to industry expectations

Our findings are supported by different industry publications and sources (Bredemeyer 2006; Hewlett-Packard 2002; Microsoft 2006; Sylvia 2005; Worthen 2005). As Rehkopf & Wybolt (2003) write, “architects who cannot explain the utility of the architecture in simple business-friendly language risk disenfranchising their constituents” and “although technical competencies are important, architects must balance them by relationship building.” Other supporting comments include those by Hewlett-Packard (2002) who state that the Architect needs to be “‘multi-lingual’, understanding and communicating to business leaders, marketing, customers, and developers.” In addition, recent reported opinions from personal experience by a Philips expert supports these findings with the key discriminating characteristics for Architects being generalist, multi-tasking, exercise authority by expertise, and balance activities and recommendations between conceptual and pragmatic (Muller 2004, 2006).

At an overall industry level, recent workforce research underlines the requirements for softer skills and experience pre-requisites (Abraham et al. 2006; Booth 2007; Zwieg et al. 2006). In particular, as Abraham et al. (2006) state “The IT skill mix is shifting from technical to project management and business skills.”

4.4.5 Comparison to pre-conceptions

The findings from this stage of the research were also compared with the researcher’s pre-conceptions documented before commencing the interviews. There were two main areas of difference between the pre-conceptions and what we found when analysing the interviews. The first was the importance of situational politics from the interviews. The second was that we had expected to find that IT Architects would have to be skilled at abstraction at different levels. This was not mentioned by the majority of the interviewees and, when mentioned, was not described as important as the other identified characteristics. There were also characteristics, subsequently classified as personality traits, which we had initially expected to identify as important that were not. These included a tolerance for ambiguity, and being evangelical about the architecture or role. These differences provide indirect evidence that our analysis approach was not overly influenced by preconceptions and biases.
4.4.6 Limitations

We only interviewed a small set of people. However, the degree of convergence of identified characteristics was high. One important aspect is that the total population of highly-skilled IT Architects in Australia is small; hence, any subset would also be expected to be small. Secondly, all the interviews and much of the interviewees’ employment and education were within an Australian context, although many of the interviewees worked for international organisations and had significant overseas experience. Finally, we did not interview any IT Architects from companies such as SAP and Oracle who supply software packages for organisations. All the interviewees were either working for organisations that were the customers of the package suppliers or working with systems that were being constructed, rather than purchased. IT Architects from package supplier companies have only limited influence on the architecture of the business systems as it has already been established within the package, prior to implementation within companies in Australia. As such, IT Architects from those companies may have a different profile of characteristics.

4.4.7 Other observations

During the course of the interviews, the interviewees made other interesting statements that did not directly relate to the research question underpinning this work. These statements illustrated other aspects of the role that would be suitable for further research and investigation. For example, one interviewee stated that the role of an IT Architect was a “job for extroverts best done by introverts.” In discussion, this was described as the balance between the level of detail, introspection, and thoroughness, which seemed best performed by introverts, but with communications capability being the most critical characteristic and the interviewee thought this was more appropriate for an extrovert. This, and other personality traits, would be suitable for further investigation, however, that is outside the scope of this thesis.

Other comments included one interviewee saying that the “patron saint of architects is Don Quixote”; while another stated that the role required “naive cynicism”. All of the interviewees showed an excellent sense of humour, although it is not clear whether this is caused by other factors or is a required characteristic of the role. In addition, all of the interviewees had at least one non-work interest about which they were passionate. It is unknown whether this is different for people in similar IT roles.
IT Architect characteristics

4.5 Summary

The focus of this stage of research was eliciting experienced practitioners’ perceptions of the characteristics of highly-skilled IT Architects. This was done by interviewing fourteen highly skilled IT Architects and analysing and consolidating their responses with regard to what are the characteristics that distinguish highly skilled IT Architects. These characteristics were classified into three categories, experience, personality traits, and capabilities. The most important capability is communication, while being a generalist is preferable to being a technical specialist. Capabilities alone are not sufficient and other attributes of highly-skilled IT Architects are not technical, or as one interviewee stated, “aptitude makes the difference, not the technical qualifications.”

Our findings within this chapter have been mapped to the literature described analysed within Chapters One and Two and comparisons between prior research findings and ours have been drawn. Some of the other characteristics, such as a minimum number of years of experience, are previously unreported and we found that the role included the requirement for specific personality traits.

In the previous chapter we described the drivers of our research design and the research design itself. In the next chapter, Chapter Five, we investigate whether some of the identified capabilities are differentiating factors between highly-skilled and less skilled IT Architects within an international IT company. This is done using surveys constructed from previously-proven measurement instruments.
Information Technology Architect Capabilities
Chapter 5. IT Architect distinguishing capabilities

Determining some of the capabilities that distinguish highly-skilled IT Architects is both useful for academia and industry and the objective of the second research stage described in this chapter. The first stage, described in the previous chapter identified characteristics of skilled IT Architects. These characteristics were classified into background, personality traits, and capabilities. This second stage focuses on one characteristic type, capabilities. It features a quantitative investigation to examine whether some of the capabilities identified in Chapter Four are significant as differentiators between IT Architects of different skill levels and between IT Architects and some other IT professionals.

The research question addressed by this stage of the research is:

*What capabilities distinguish highly-skilled IT Architects?*

The question was investigated through a survey of two groups of IT professionals: IT Architects, and IT Project Managers.

The first step in this investigation was the selection of four of the eight capabilities identified in Chapter Four. These capabilities were analysis, conceptualisation, problem solving, and visionary. As described later in this chapter, in Section 5.1, a targeted literature search identified previously used and validated instruments corresponding to these four (Allinson & Hayes 1996; Heppner 2000; Marks 1973; Zimbardo & Boyd 1999) and a survey was created from the instruments.
The second step was the selection of the cohorts for the survey, and the administration of the survey to four groups of professionals. These were:

- Two groups of skilled IT Architects with one group more skilled than the other, and
- Two groups of skilled Project Managers, again with one group more skilled than the other.

We analysed the results in the third step. If the capabilities identified in our earlier work were important for IT Architects we would expect that the more highly-skilled IT Architects to have higher ‘scores’ on the instruments. In addition, the comparison of IT Architects with Project Managers will enable us to understand which, if any, of the distinguishing capabilities are specific to IT Architect or whether they are related to overall IT professional skills.

This remainder of this chapter describes these steps and discusses the results.

5.1 Survey construction

In this stage of the research, we chose to focus on capabilities rather than characteristics. This was for two reasons. One aim of our research is to improve IT Architect performance through education. While there has been suggestions that personality and background are suitable for improvement through project courses (Kuhn 1998), this has not been confirmed, hence we concentrate on capabilities. Secondly, the improvement through education was researched through enhancing a subject at RMIT University and is described in Chapter Six of this thesis. As RMIT University’s focus is on developing student capabilities (RMIT Teaching and Learning 2002) not personality traits, further investigation of distinguishing capabilities was appropriate.

The research presented in the previous chapter identified, in alphabetic order, the following eight capabilities stated by the participants as being important:

- analysis
- business knowledge
IT Architect distinguishing capabilities

- communication
- conceptualisation
- middle-ground
- problem solving
- situational politics
- visionary

There were three key constraints for the survey. First, the time taken to complete the survey would be less than 30 minutes. This is because the participants were senior people whose time is limited. Second, the survey would be suitable for answering either with a word processor on a computer or on paper. (We anticipated that due to their mobility, some of the participants would respond while not having access to a computer). The third constraint was ethics considerations. For example, no questions on gender could be asked, as we knew from industry contacts that there was only a small number of female IT Architects within the target cohort. Therefore, there would a threat to participant’s anonymity and the small number of female IT Architects meant that even if all responded to the survey there would still be insufficient to make any statistically significant gender-based comparisons.

We created the survey in several steps. These steps were:

1. selecting the capabilities we would not search for an instrument,
2. identifying suitable survey instruments, and
3. constructing the survey including finalising the chosen instruments, testing and refining the survey, and finalising the format of the survey.

5.1.1 Capabilities for which no survey instrument match was attempted

We eliminated two of the identified capabilities; these were *business knowledge* and *communication*. Both of these capabilities have been identified as essential for senior IT positions in general, not just for IT Architects.
Business knowledge
Further, we eliminated this capability for two reasons. First, this has frequently been identified as critical for many senior IT positions (Adelson & Soloway 1985; Bassellier & Benbasat 2004; Leitheiser 1992; Peppard et al. 2000; Ross et al. 1996; Sawyer, Eschenfelder, Diekema & McClure 1998; Todd et al. 1995). Second, the capability as described in Chapter Four is particular to each different industry, and as such does not lend itself to investigation through a survey across industries.

Communication
Many previous studies have identified communication as a critical capability for many senior IT positions including IT Architects (Curtis et al. 1988; Lee et al. 1995; McBride 2007; Nakayama & Sutcliffe 2001; Orr & von Hellens 2000). Therefore, we did not research any instruments for this capability.

5.1.2 Search process for survey instruments for remaining capabilities
The psychology literature was reviewed to identify suitable measurement instruments. This was because our definitions of the remaining six capabilities relate to concepts and terms within that domain. The primary research tool for choosing instruments was Goldman & Mitchell (1995). This was used as it identifies and describes non-commercial psychological measures from the fields of psychology, sociology, and education that have been devised by researchers and published in over 35 top journals. Many of the measures published in the initial volumes have since been commercialised and used in multiple studies.

The selection of possible instruments was conducted by developing a list of synonyms for the identified capabilities and then searching the indexes in Goldman & Mitchell using the original definition and the synonyms. We read the papers found in the index and searched the references from those papers to identify further relevant instruments iteratively. We only concluded this process when we had identified sufficient, suitable instruments.
Several criteria guided the final choice of instruments; each instrument had to:

- have good internal validity,
- good test-retest reliability,
- have been used with adults, not just students,
- have been used by other researchers in their work, preferably in different countries and with different cultures, and reported in refereed conferences and journals,
- either be public domain, or available at no cost for the research,
- be self-reporting, and
- formulated as a survey.

We used these criteria to evaluate each possible instrument and only if they were all satisfied was the instrument considered for inclusion in the final survey.

The filtering mechanism was whether our definition matched that of the capabilities applied in this thesis. If there was a possible match, we then further examined the paper and instrument. All the instruments described in Section 5.1.4 met all the other criteria listed above.

5.1.3 Capabilities for which no survey instrument match was identified

The search for instruments did not find any that were satisfactory for two of the capabilities identified in Chapter Four.

Middle-ground

We identified no suitable instrument for middle-ground. This was previously described in an interview as “being able to stand between IT [department] and the [rest of the] business, or between other organisation or political units.” There was no instrument identified in the literature on negotiation or translation. The psychology literature did comment on the concept but we found no self-reporting survey to evaluate the capability. Within the area of negotiation there was only very limited focus on the people aspects and the different research instruments focussed on cultural or business differences between organisations rather than on the people involved. Finally, the research in the area of translation did not have survey instruments
investigating the people aspects because the focus was on language and cultural differences.

Several surveys were investigated and an initially promising area was called the “Problem-solving approach in negotiation” (Graham, Mintu & Rodgers 1994; Mintu-Wimsatt & Graham 1998; Mintu-Wimsatt & Lozada 1999). However, surveys in this area were not suitable, as the descriptions of concept were not the same as middle-ground in the interviews. Within the interviews, related terms were “translation” and “interpretation” rather than negotiation. We also reviewed the literature relating to interpreting and the instruments found related to concepts such as accuracy of translation between languages and cultures, not within a single culture with different stakeholders, such as the environment experienced by IT Architects.

**Situational Politics**

We also found no suitable instrument for *situational politics*. One interviewee described this as "*actually judge the likelihood of it working, given the context it has to work in.*" We described this in the previous chapter and this was the capability to understand the political forces and context within which the IT Architect was working and also being able to decide what would be appropriate given that political context. It was not an understanding of organisational politics in the abstract or solely people politics; it was only within the context of the IT Architect.

Several surveys were investigated. The surveys that were closest to the concept as described in the interviews were:

- Perception Of Organizational Politics (POPS) (Ferris & Kacmar 1992; Kacmar & Ferris 1991; Kacmar & Carlson 1997) - this survey was unsuitable as it was designed and used to measure people’s attitudes to organizational politics, not their knowledge or awareness of them.

- Machiavellianism surveys (Christie & Geis 1970) - the closest concept that this capability mapped to was Machiavellianism, which was described as “a person who manipulates others for his own purposes” (Moore & Ward 1998). These surveys were unsuitable as they only investigated the respondent’s opinions on Machiavellian attitudes.
5.1.4 Capabilities for which matching survey instruments were found

We matched the remaining four capabilities to instruments as described in Table 5-1. (Where not attributed, the quotations in the table are from the interviews in Chapter Four.):

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Description: “an IT Architect has to be able to break material down into its component parts to see interrelationships and hierarchies of ideas”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mapped concept</strong>: Analytic cognitive style, is described as “Judgment based on mental reasoning and focus on detail”, “depend on systematic methods of investigation” (Allinson &amp; Hayes 1996)</td>
</tr>
<tr>
<td></td>
<td><strong>Instrument</strong>: Cognitive Style Inventory (CSI) (Allinson &amp; Hayes 1996)</td>
</tr>
<tr>
<td>Conceptualisation</td>
<td><strong>Description</strong>: “the ability to visualise complex structures in their mind”</td>
</tr>
<tr>
<td></td>
<td><strong>Mapped concept</strong>: Ability to visualise, is described as “imagery is clear and vivid” (Marks 1973)</td>
</tr>
<tr>
<td></td>
<td><strong>Instrument</strong>: Vividness of Visual Imagery Questionnaire (VVIQ) (Marks 1973)</td>
</tr>
<tr>
<td>Problem solving</td>
<td><strong>Description</strong>: “application of rules, procedures, techniques, or principles to solve complex problems”</td>
</tr>
<tr>
<td></td>
<td><strong>Mapped concept</strong>: Problem solving, described as “highly complex, often intermittent, goal-directed sequence of cognitive, affective, and behavioral operations for adapting to what are often stressful internal and external demands” (Heppner, Witty &amp; Dixon 2004)</td>
</tr>
<tr>
<td></td>
<td><strong>Instrument</strong>: Problem Solving Inventory (PSI) (Heppner 2000)</td>
</tr>
<tr>
<td>Visionary</td>
<td><strong>Description</strong>: “the capability of a person to imagine how an organisation, system, or industry will develop in the future and to plan in a suitable way”</td>
</tr>
<tr>
<td></td>
<td><strong>Mapped concept</strong>: The closest identified concept is a factor (ZTPI-F, or Future orientation) within time perspective. Where time perspective is “personal and social experiences are assigned to temporal categories, or time frames, that help give order, coherence, and meaning to those events.” (Keough, Zimbardo &amp; Boyd 1999).</td>
</tr>
<tr>
<td></td>
<td><strong>Instrument</strong>: Zimbardo’s Time Perspective Inventory (ZTPI) (Zimbardo &amp; Boyd 1999)</td>
</tr>
</tbody>
</table>

Table 5-1 Mapping of capabilities to concepts and instruments


**Analysis**
The Cognitive Style Inventory (CSI) (Allinson & Hayes 1996) has 38 questions with a true/undecided/false response for each question. It produces a single scale that assesses how analytic or intuitive is the respondent’s self-reported cognitive style. Many studies have successfully used the inventory and it has proven reliability, for example in management education (Armstrong 2000; Moore, O’Maidin & McElligott 2003) and amongst computer systems students (Moore et al. 2003). One study by Hodgkinson & Sadler-Smith (2003) indicated that the unitary scale was too simple and two separate scales for analytic and intuitive aspects respectively would be more informative. However, to date that revised scoring approach has not been used in other studies or further validated and therefore we did not use it.

**Conceptualisation**
The Vividness of Visual Imagery Questionnaire (VVIQ) (Marks 1973) uses a 5-point Likert (1932) scale and has sixteen questions. It assesses a person’s self-reported ability to create visual images and the clarity of those visual images and provides a single score for this assessment.

**Problem Solving**
The Problem Solving Inventory (PSI)\(^8\) (Heppner & Petersen 1982) has 35 questions with a 6-point Likert (1932) scale. The instrument assesses the respondent’s perceptions of their problem solving ability as well as behaviours and attitudes associated with problem solving. As well as an overall PSI score, three contributing factors are measured:

(a) Problem Solving Confidence (*PSC*). *PSC* is an individual’s self-assurance, beliefs, and trust in his or her ability to cope effectively with a wide range of problems.

(b) Approach-Avoidance Style (*AAS*). *AAS* refers to a general tendency to approach or avoid different problem solving activities.

(c) Personal Control (*PC*). *PC* is believing one is in control of one’s emotions and behaviours while solving problems.

---

\(^8\) The PSI is a trademark of CPP inc., formerly Consulting Psychologists Press and we used the instrument with permission.
IT Architect distinguishing capabilities

This inventory has been extensively used as is described in a recent major article describing its content and development (Heppner et al. 2004). One reason for using this instrument was that it reported additional granularity for the concept of “problem solving” thereby allowing additional insight into the capability.

**Visionary**

The Zimbardo Time Perspective Inventory (ZTPI) (Zimbardo & Boyd 1999) comprises 56 questions in a 5-point Likert (1932) scale that provides measures related to the respondent’s attitudes toward time. The ZTPI has been used in many different studies by many different researchers (Aronowitz & Morrison-Beedy 2004; Boniwell 2005; Harper, Zimbardo & Boyd 2003; Hodgins & Engel 2002; Keough et al. 1999). It reports on time perspective as five separate factors.

(a) The Past-Negative Scale (PN). The first factor of the ZTPI reflects a generally negative, pessimistic view of the past. Because of the reconstructive nature of the past, we cannot be certain to what extent this negative attitude is due to the actual earlier experience of negative events or to the current negative reconstruction of benign events.

(b) The Present-Hedonistic Scale (PH). The second factor reflects a hedonistic, risk-taking, “If it feels good do it” attitude toward time. These items suggest an orientation toward present pleasure or immediate benefit with little concern for future consequences.

(c) The Future Scale (F). The third factor reflects a general future orientation. The future scale suggests that present behaviour is dominated by a striving for future goals and rewards. In contrast to the present-hedonistic scale, these items suggest an orientation away from focusing on immediate benefits and toward calculating future gains and costs.

(d) The Past-Positive Scale (PP). The fourth factor reflects an attitude toward the past that is different from that captured by the first factor. The first factor, Past Negative, suggests trauma, pain, and regret, the Past Positive reflects a warm, sentimental, nostalgic attitude toward the past. As with all factors, the past positive captures a respondent’s belief about the past without speculating on the veracity and accuracy of these beliefs.

(e) The Present-Fatalistic Scale (PF). The fifth and final factor of the ZTPI reveals a fatalistic, helpless, and hopeless attitude toward the future and life. Items on
this factor suggest little relation between present behaviour and future costs or benefits.

For analysis and problem solving, we identified no other possible instruments that met all our criteria. For both conceptualisation and visionary, we did identify other possible instruments. We describe both the instruments and the reasons we did not select them below.

**Other possible conceptualisation instruments**
We identified one other possible instrument for the conceptualisation capability. This was the Verbalizer-Visualizer (Richardson 1969). We did not select this instrument as the focus was on the whether the respondent’s primary cognitive mode was verbal or visual, not whether they were effective visualisers or conceptualisers.

**Other possible visionary instruments**
We also identified another possible instrument for the visionary capability. This was the Consideration of Future Consequences scale (Strathman, Gleicher, Boninger & Edwards 1994). We did not select this because results with it have been inconsistent prompting other researchers to modify or simplify the scale (Petrocelli 2003).

**5.1.5 Survey construction**
Having selected the instruments for the survey it was then completed through assembly, testing and refinement, and finalised with additional introductory and concluding sections being added.

**Survey assembly**
After selecting the four instruments, we assembled the initial version of the survey. An introduction describing the purpose of the survey and who to contact for more information, was written by the researchers, and added as the first section. The next four sections were the four chosen instruments. A concluding section, requesting demographic information, was written by the researcher and added as the final section. The first of the four instruments, the Cognitive Styles Inventory was selected as the first only because it related to analysis, the first capability alphabetically.
IT Architect distinguishing capabilities

order of the next three instruments was chosen to maximise the differences in format to assist the respondents in identifying when the instruments changed.

Survey testing and refinement
The survey was pilot tested in three iterations by seven people in total who were not otherwise involved in the research. Key aspects of the testing were understandability of the questions and instruments, appropriateness of the language used, and time taken to complete the survey. The first version of the survey included another instrument, the MACH IV scale (Christie & Geis 1970). Testers said that it took too long to complete and the MACH IV scale included questions that might be offensive and biased for the planned respondents. The revised version, without this scale, took all testers less than 30 minutes to complete (it was tested in two further iterations and the introductory wording and overall format were refined).

Survey finalisation
Following the guidelines of Fink (1995) and others (Kitchenham & Pfleeger 2002b, 2002c, 2002d; Kitchenham, Pfleeger & Fenton 1995; Pfleeger & Kitchenham 2001) the above instruments were used to construct the final survey.

The final version of the survey comprised six sections.

- section 1. An introductory section
- sections two – five. Four sections then followed, being the instruments for assessing the four capabilities as identified above. We modified the format of these four sections to be more consistent but did not modify the ordering and wording of any questions. In addition, we reversed the response scale for the Zimbardo’s Time Perspective Inventory (ZTPI). This was to make all survey sections consistent in response order. That is, all the other sections response scales were from most agreement to least agreement, so we reversed the response template to match that order. We also ordered the different instruments to maximise the differences in format to support the respondents in identifying when the instrument changed.
- section six. The final section of the survey requested some non-identifiable personal information, including age range, years in current company, and
years in the IT industry. The age range had four discrete divisions, less than 30, 30 to 39, 40 to 49, and over 49. Years in current company and years in the IT industry both requested a number.

The collection of demographic information was not only for subsequent analysis but also as shown by Crampton & Wagner (1994) including such information on a self-reporting survey improves the reliability of other self reported values.

The plain language statement, required by the RMIT Human Research Ethics Committee, and the survey are included in Appendix F. However, because the CSI and PSI are both copyright, only the instructions and one example question is included for each instrument. The actual survey used included all the questions for each instrument.

5.2 Target cohort details

Our aim was to use the survey to identify whether there were any significant differences in the reported capabilities of IT Architects of different skill levels and between IT Architects and some other skilled IT professionals. As we described in Chapter Three, we chose to survey IBM Australia and New Zealand IT Architects and Project Managers.

Each of the IBM IT Architects and Project Managers groups included both certified and uncertified members. Therefore, there were four groups within the survey cohort:

1. certified IT Architects,
2. uncertified IT Architects,
3. certified Project Managers, and
4. uncertified Project Managers.

Certification has been chosen as a distinguishing characteristic of the survey groups because the purpose of professional certification within IBM is to “… provide a worldwide standard of excellence for each profession based on demonstrated skills, experiences, and success within the profession” (Cozzi 2003b). Table 5-2 summarises these four target cohorts for the survey.
IT Architect distinguishing capabilities

<table>
<thead>
<tr>
<th></th>
<th>IT Architects</th>
<th>Project Managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified</td>
<td>91 Certified IT Architects</td>
<td>213 Certified Project Managers</td>
</tr>
<tr>
<td>Uncertified</td>
<td>196 Uncertified IT Architects</td>
<td>189 Uncertified Project Managers</td>
</tr>
</tbody>
</table>

**Table 5-2 Target cohorts**

The IBM architect profession has been formally established for over fourteen years (Sylvia 2005) and all certified IBM IT Architects are now also certified as Open Group IT Architects (Asaravala 2005; Open Group 2005, 2006a, 2007b). The full details of The Open Group IT Architect certification process, criteria, and intentions are available on The Open Group Website (Open Group 2006b).

The IBM Project Manager certification has been established for over ten years and is more extensive than current independent project manager certifications such as from the Project Management Institute (Project Management Institute 2006). For example, IBM’s Project Manager certification requires more extensive experience and evidence of at least three successful projects where the client of the project, not the certification applicant, defines success (IBM 2006).

The IBM certification process is independent of the applicants’ position, managers, and work location, and is administered outside the promotion process. In addition, IBM architects and Project Managers are not constrained to use IBM solutions. All the people surveyed were practicing IT Architects or Project Managers with at least five years experience in the IT industry. Therefore, the survey result of certified and uncertified IT Architects and Project Managers within IBM provides a comparison between groups of IT Architects and Project Managers with different levels of assessed capability.

The research had the approval and active support of IBM. IBM agreed to review the survey, organise internal publicity for the survey, and communicate the value and intentions to IBM executives both inside and outside Australia.9

---

9 Most of these activities were done by Mr. Bruce Crossman, Executive Architect, IBM Australia.
We surveyed the complete population of IT Architects and all certified Project Managers within IBM Australia and New Zealand, that is, there was no sampling. However, not all the uncertified Project managers were targeted for the survey, instead a systematic sample was selected (Kitchenham & Pfleeger 2002a). We took every fourth name from the complete list of uncertified IBM Australia and New Zealand Project Managers ordered by surname for the sample. This was because the complete population was extensive and we wanted to survey a similar number of uncertified Project Managers as certified Project Managers thereby ensuring that there were sufficient responses while managing the overall workload of the research.

We did not collect any data about race or culture, as we are not investigating those aspects and IBM did not permit this on privacy and ethical grounds.

5.3 Administration and response processing

The surveys were administered and processed in three stages. First, the surveys were sent to an IBM contact. This contact then distributed the surveys to the target cohorts and received the responses. When the contact received the responses, they anonymised the responses and passed them to the researcher. When the responses were received by the researcher, all certified and uncertified IT Architect responses were scored, missing values processed and normal distribution confirmed. This was then repeated for all Project Manager responses. Finally, all responses were combined and the total responses set confirmed to be of normal distribution.

5.3.1 Administration

The administration of the survey had the following major steps:

1. Two weeks before the survey was distributed, the IBM contact included an article in the quarterly newsletter of both the IT Architects and Project Managers alerting the survey recipients in the target cohort. This article included the survey’s purpose, affirmed IBM’s support and the distribution was through the standard IBM internal profession newsletters. The purpose of this step was to alert the survey target population before the survey was distributed to increase the response rate (Fink 1995; Yun & Trumbo 2000).

2. The researchers produced the finalised survey in rich text format, to remove the possibility of macro viruses, and sent it with a plain language statement (in
IT Architect distinguishing capabilities

PDF form) to an IBM contact who was coordinating the distribution of the survey. The IBM contact constructed a cover email that re-iterated IBM management’s support of the survey and sent the cover email, survey, and plain language statement to the target cohorts. (Initially, the respondents were given three weeks to complete and return the survey.)

3. Two weeks later the IBM contact sent a follow-up email to all of the survey recipients, both those who had responded and those who had not responded. This email included both the survey and plain language statement again.

4. The IBM contact sent a further follow-up email, again with the survey and plain language statement attached, to all of the target cohort members, respondents and non-respondents, one week after sending the initial follow-up email. This email extended the response time by one week. Therefore, the total submission response time for each survey distribution was four weeks.

5. The IBM contact was the recipient for all the initial responses. For electronic responses, he saved the response with a unique identifier, removed any comments, and constructed a new email with the response and any comments attached in order to send the response without any identifying information. If the response was paper then he erased any comments, scanned the response and sent the scanned images attached to an email with a unique identifier. In both cases, the email was sent to the researcher. (Comments were removed or erased to ensure anonymity of the survey respondent’s.)

6. We then printed, uniquely identified, and processed each response.

To encourage response there was a small incentive of an A$75 book voucher for two random respondents for each survey administration. In addition, the IBM contact for survey administration and response was both very senior and well known within IBM Australia and New Zealand and respected by the survey recipients. This fortunate situation, combined with the use of an incentive and the remaining survey administration design have been shown to be effective in maximising response (Dillman 2000; Sivo et al. 2006).

5.3.2 Initial handling of missing or erroneous responses

If there was an error or a missing response then the respondent was asked to correct or complete the problem. We did this by providing the unique respondent number and
details of the omission or error, including the text of the relevant question, to the IBM contact who then sent the request for correction or completion to the respondent. If the respondent later provided an update to the IBM contact, the contact removed any identifying information and sent the updated question responses with the original unique identification number to the author, who then updated the survey response(s) for the respondent accordingly.

When all responses had been received then we calculated the individual factor scores which were then entered into a computer file for analysis using SPSS Version 13 (SPSS 2006). All analysis used SPSS unless otherwise stated.

### 5.3.3 Response summary

The responses were handled in two groups, IT Architects and Project Managers. All IT Architects responses, both certified and uncertified, were processed as a single group. We received 22 certified IT Architect responses and 60 uncertified IT Architect responses. Then all Project Manager responses, both certified and uncertified, were processed as group. There were 58 certified Project Manager responses received, and 39 nine uncertified Project Manager responses. The response rates for each cohort are shown in the Table 5-3. According to Tabachnick & Fidell (2001) these numbers of responses is sufficient for the analysis we undertook as there were more responses in each category than the twelve variables being examined.

<table>
<thead>
<tr>
<th></th>
<th>IT Architects</th>
<th>Project Managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified</td>
<td>24.18%</td>
<td>27.23%</td>
</tr>
<tr>
<td>Uncertified</td>
<td>30.61%</td>
<td>20.63%</td>
</tr>
</tbody>
</table>

Table 5-3 Response rate for each survey cohort

One interesting aspect of the survey was the degree of comments and feedback from the survey respondents. While the comments were removed from the surveys before the completed surveys were sent to the researcher, the IBM contact stated that at least 20% of survey responses had comments regarding the survey and these comments expressed a large degree of interest in the results. The comments included “caused me to think about my role” and “interesting survey, I would be interested in the
IT Architect distinguishing capabilities

results.° These comments were not analysed in any manner as they were unavailable as they had been stripped from the surveys by the IBM contact to ensure anonymity of the respondents.

5.3.4 Missing value processing

The remaining missing values had values calculated for them, as described below, and the surveys updated with those values. We processed all missing values on a profession-by-profession basis, that is, we processed all IT Architects as a single group, and all Project Managers as a separate group.

We performed this calculation in a different manner for each major section of the survey, and we describe those calculations next.

**Cognitive Style Inventory missing values**

Each question on this survey can only have three responses being Y/?/N. The middle value, ‘?’ was used for every missing value in this section of the survey, which translates as ‘1’ for the calculations as it was neutral.

**Problem Solving Inventory missing values**

All three sub-factors of this inventory, Problem Solving Confidence (PSC), Approach Avoidance Style (AAS), and Personal Control (PC) were handled in the same manner. In all cases that there was a missing value, only one sub-factor was affected. That is, as the value for a single response could be one through six only, then the overall value for any sub factor could only vary from a value of x+1 to x+6, where x was the value of the sub-factor without the missing value and all values were whole numbers. To determine the actual value, we used the SPSS missing value calculation with the EM algorithm to generate an initial missing value. If the calculated missing value was within the range x+1 to x+6 then the value was rounded and used for the missing value. If the calculated value was lower than the range we used x+3 as the value, if it was higher, then x+4 was used as the value, effectively the middle of the range rounded towards the calculated missing value from SPSS. This process was used to

---

° We summarised these responses and the findings of survey within a short document and sent that to the IBM contact who distributed the document to all the target cohorts for the survey and also to IBM Human Resources and the IBM profession owners for IT Architects and Project Managers.
ensure that the result was within the possible range of values for the missing factor while ensuring that the missing value calculation did not skew the results through always returning boundary values (Tabachnick & Fidell 2001). We used the sum of the PSC, AAS, and PC factors to calculate the PSI Total, not missing value analysis.

**Zimbardo’s Time Perspective Inventory missing values**

We used the same manner of processing missing values for the PSI sub-factors for the ZTPI factors. For all the responses for the ZTPI, no missing response affected more than one factor. For any missing response where y was the value of that total for the complete factor calculation, then the actual total considered the missing response could only be y+1 through y+5. To determine the actual value, we used the SPSS missing value calculation, using the EM algorithm to generate an initial missing value. If the calculated missing value was within the range y+1 to y+5 then the value was rounded and used for the missing value. If the value was outside the possible range of y+1 to y+5 then we used the mid-point of the range, y+3, for the value.

**Other missing values**

For the other variables in the survey, we used the following processes to handle missing values:

- Vividness of Visual Imagery Questionnaire (VVIQ): – if the response was missing or erroneous, then we omitted it. There was only one such response in all returned surveys.
- Profession: if the profession was missing, then we asked the IBM contact what profession was the response. We could do this anonymously as previously described, and we then used the profession type provided by the IBM contact for the missing value.
- Age Range: If the age range response was missing then treated that item as omitted in all analysis.
- Certified: If the respondent had not stated whether they were certified or not, we assumed they were uncertified as certification has significant internal prestige and promotion opportunities within IBM.
- Years in IBM: If this was not provided, we treated that item as omitted in all analysis.
IT Architect distinguishing capabilities

- Year in industry: If this was not provided, we treated that item as omitted in all analysis.

5.3.5 Outlier processing

After processing all missing values for a profession, we checked all responses for outliers. We used SPSS Explore, with cases excluded pairwise. The first was whether there were any outliers as reported by SPSS. We removed any outliers from subsequent processing. We then ran SPSS Explore again and no further outliers were detected for each profession’s responses.

5.4 Results analysis

The analysis of the survey results was undertaken in five steps. The first was determining whether the responses were normally distributed and thus suitable for subsequent analysis. The second step was comparing the responses to previous published responses for those surveys to assess if the respondents to this survey were similar or different to previous respondents. The third step was comparing different groups of respondents to investigate whether there were distinguishing characteristics for any one group as compared to another. The fourth analysis step was post hoc power analysis to determine the likelihood of any significant differences between response groups that we did not find. In the fifth, and final, analysis step we performed factorial ANOVA analysis to assess if there were any interaction effects between the key variables for the overall responses to the survey.

5.4.1 Overall response characteristics

Means and standard deviations for all variables for each of the cohorts and the total respondents were calculated. The data is in Appendix G. (Please note that while the skewness divided by skewness standard error ratios indicate that there is some data that is not normally distributed, as described by Moore & McCabe (2003), all the data sets are suitable for use with t-tests as the number of respondents in each set is greater than fifteen.)

Although we collected years in IBM in the survey, after analysis and discussion with IBM contacts, we agreed that this was not a meaningful differentiator or factor for consideration for analysis. This was because there were many people with the same
number of years in IBM. This was caused because when different outsourcing deals that IBM had undertaken were started the staff had transferred to IBM as a group at that time, thereby having their joining dates the same as many other people.

An important criterion in our usage of existing and previously used instruments was to be able to compare our results against those prior studies using the instruments. Accordingly, and in-line with prior usage of the instruments, we did not perform factor analysis between each survey section or between questions as they were treated as independent to each other and if we had made any changes to the questions or surveys then comparison with prior research would have not been possible. The original derivation of the instruments and corresponding measures used factor analysis and other internal consistency techniques to analyse interaction effects and to group factors affecting variables and minimise the number of variables. In addition, we did not calculate Cronbach’s alpha (1951) for the combination of surveys as each survey was evaluated independently and had previously been used and validated by other researchers.

The analysis of the survey resulted in the following thirteen calculated variables or data points for each respondent group:

- Cognitive Style Index
  1. CSI
- Problem Solving Inventory
  2. Problem Solving Confidence (PSC)
  3. Approach Avoidance Style (AAS)
  4. Personal Control (PC)
  5. Overall (PSITotal)
- Vividness of Visualisation Questionnaire
  6. VVIQ
- Zimbardo’s Time Perspective Inventory
  7. Past Negative (ZTPI-PN)
  8. Present-Hedonistic (ZTPI-PH)
  9. Future (ZTPI-F)
  10. Past-Positive (ZTPI-PP)
11. Present-Fatalistic \((ZTPI-PF)\)

- Demographic

12. Years in IT

13. Age range

**Non-response analysis**

We performed benchmark non-response analysis (Rogelberg & Stanton 2007) for the IT Architects and Project Managers using the average age of the IT Architects as at March 2007 and Project Managers as at May 2007. The detailed age information of both the IT Architects and Project Managers at the time of the survey was unknown. When the 2007 details were provided, private and confidential communication from IBM stated that the demographics at the time of the survey were very similar to those provided in 2007. These values would translate to the ranges of the survey as shown in Table 5-4 and Table 5-5, which includes the actual survey range and averages for the relevant respondent groups.

<table>
<thead>
<tr>
<th></th>
<th>Uncertified IT Architects</th>
<th>Certified IT Architects</th>
<th>All IT Architects</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM provided average age</td>
<td>42.31</td>
<td>45.74</td>
<td>43.20</td>
</tr>
<tr>
<td>IBM provided range</td>
<td>2.78</td>
<td>3.02</td>
<td>2.87</td>
</tr>
<tr>
<td>Survey average age</td>
<td>43.22</td>
<td>46.80</td>
<td>43.80</td>
</tr>
<tr>
<td>Survey response range</td>
<td>2.84</td>
<td>3.09</td>
<td>2.91</td>
</tr>
</tbody>
</table>

**Table 5-4 IT Architect demographics March 2007**

<table>
<thead>
<tr>
<th></th>
<th>Uncertified Project Managers</th>
<th>Certified Project Managers</th>
<th>All Project Managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM provided average age</td>
<td>43.5</td>
<td>48.1</td>
<td>44.1</td>
</tr>
<tr>
<td>IBM provided range</td>
<td>2.9</td>
<td>3.36</td>
<td>2.96</td>
</tr>
<tr>
<td>Survey average age</td>
<td>45.0</td>
<td>48.53</td>
<td>48.27</td>
</tr>
<tr>
<td>Survey response range</td>
<td>3.0</td>
<td>3.39</td>
<td>3.24</td>
</tr>
</tbody>
</table>

**Table 5-5 Project Managers demographics May 2007**

We used t-tests to investigate whether these values were statistically different from the survey respondents’ values. These tests showed that the values were not
considered statistically significantly different at a level of 0.05. Therefore, we concluded that the Certified, Uncertified and combined populations of IT Architect and Project Manager respondents were representative of the relevant populations. That is, any non-responses bias is unlikely to have affected the results (Kitchenham & Pfleeger 2002a).

### 5.4.2 Norms analysis

Where data was available, we compared the results of each of the factors for the total population of respondents with normative or reported data for those factors.

#### CSI norms comparison

The results for the Cognitive Style Inventory were similar to results from other groups that had completed the CSI. That is, the responses for this survey are within the range of those from previous respondents with regard to this measure.

Table 5-6 shows the CSI results provided in June 2005 by Christopher Allinson, CSI co-developer (Allinson & Hayes 1996) with our results included and highlighted.

<table>
<thead>
<tr>
<th>Sample</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepalese managers</td>
<td>39</td>
<td>48.07</td>
<td>7.04</td>
</tr>
<tr>
<td>Jordanian managers</td>
<td>38</td>
<td>48.05</td>
<td>8.96</td>
</tr>
<tr>
<td>Workshop participants</td>
<td>22</td>
<td>46.67</td>
<td>16.13</td>
</tr>
<tr>
<td>Electronics operatives</td>
<td>64</td>
<td>46.53</td>
<td>14.03</td>
</tr>
<tr>
<td>Financial managers</td>
<td>13</td>
<td>45.46</td>
<td>13.06</td>
</tr>
<tr>
<td>Russian managers</td>
<td>71</td>
<td>44.06</td>
<td>9.64</td>
</tr>
<tr>
<td>Indian managers</td>
<td>59</td>
<td>43.83</td>
<td>12.27</td>
</tr>
<tr>
<td>Engineering operatives</td>
<td>78</td>
<td>43.36</td>
<td>11.25</td>
</tr>
<tr>
<td>Brewery managers</td>
<td>226</td>
<td>43.26</td>
<td>12.11</td>
</tr>
<tr>
<td>Uncertified Project Managers</td>
<td>39</td>
<td>43.20</td>
<td>12.04</td>
</tr>
<tr>
<td>Teachers</td>
<td>74</td>
<td>42.54</td>
<td>13.47</td>
</tr>
<tr>
<td>Canadian students</td>
<td>89</td>
<td>42.50</td>
<td>11.80</td>
</tr>
<tr>
<td>All uncertified</td>
<td>99</td>
<td>42.43</td>
<td>10.89</td>
</tr>
<tr>
<td>Health visitors (female)</td>
<td>39</td>
<td>42.13</td>
<td>12.78</td>
</tr>
<tr>
<td>Engineering managers</td>
<td>78</td>
<td>42.03</td>
<td>7.92</td>
</tr>
<tr>
<td>Sample</td>
<td>n</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>Uncertified IT Architects</td>
<td>60</td>
<td>41.85</td>
<td>10.30</td>
</tr>
<tr>
<td>Business Administration students</td>
<td>101</td>
<td>41.74</td>
<td>13.00</td>
</tr>
<tr>
<td>Business students</td>
<td>202</td>
<td>41.64</td>
<td>12.19</td>
</tr>
<tr>
<td>Singaporean managers</td>
<td>81</td>
<td>41.61</td>
<td>12.89</td>
</tr>
<tr>
<td>Hong Kong students</td>
<td>31</td>
<td>41.52</td>
<td>10.91</td>
</tr>
<tr>
<td>All IT Architects</td>
<td>82</td>
<td>41.17</td>
<td>10.28</td>
</tr>
<tr>
<td>Production managers</td>
<td>17</td>
<td>40.59</td>
<td>9.89</td>
</tr>
<tr>
<td>Marketing managers</td>
<td>26</td>
<td>40.42</td>
<td>12.62</td>
</tr>
<tr>
<td>Management students</td>
<td>128</td>
<td>40.38</td>
<td>13.23</td>
</tr>
<tr>
<td>Management students</td>
<td>225</td>
<td>40.32</td>
<td>15.18</td>
</tr>
<tr>
<td>All respondents</td>
<td>179</td>
<td>40.02</td>
<td>11.85</td>
</tr>
<tr>
<td>University lecturers</td>
<td>11</td>
<td>39.64</td>
<td>9.10</td>
</tr>
<tr>
<td>Certified IT Architects</td>
<td>22</td>
<td>39.50</td>
<td>10.50</td>
</tr>
<tr>
<td>Miscellaneous managers</td>
<td>130</td>
<td>39.48</td>
<td>7.08</td>
</tr>
<tr>
<td>All Project Managers</td>
<td>97</td>
<td>39.05</td>
<td>12.99</td>
</tr>
<tr>
<td>Construction managers</td>
<td>66</td>
<td>38.98</td>
<td>14.21</td>
</tr>
<tr>
<td>Australian students</td>
<td>85</td>
<td>38.59</td>
<td>11.57</td>
</tr>
<tr>
<td>IT managers</td>
<td>40</td>
<td>38.28</td>
<td>12.09</td>
</tr>
<tr>
<td>Human Resource managers</td>
<td>136</td>
<td>37.89</td>
<td>14.05</td>
</tr>
<tr>
<td>French students</td>
<td>80</td>
<td>37.79</td>
<td>9.81</td>
</tr>
<tr>
<td>Electronics managers</td>
<td>64</td>
<td>37.39</td>
<td>14.25</td>
</tr>
<tr>
<td>All certified</td>
<td>80</td>
<td>37.24</td>
<td>12.35</td>
</tr>
<tr>
<td>Certified Project Managers</td>
<td>58</td>
<td>36.43</td>
<td>12.94</td>
</tr>
<tr>
<td>German students</td>
<td>36</td>
<td>35.64</td>
<td>11.41</td>
</tr>
<tr>
<td>British managers (MBA students)</td>
<td>106</td>
<td>33.26</td>
<td>14.07</td>
</tr>
<tr>
<td>Personnel managers</td>
<td>15</td>
<td>31.07</td>
<td>12.49</td>
</tr>
</tbody>
</table>

Table 5-6 Comparison of CSI norms data with research results

**PSI norms comparison**

The PSI factors were compared with the results for males from non-distressed couples described by Sabourin et al. (1990). This group had the lowest PSI scores, that is, they self-reported the most effective problem solving expertise. We used this data instead of the PSI normative data within the Problem Solving Manual (Heppner 1988)
as it was more recent and the number of respondents was higher. The PSI total was not compared as means and standard deviations for these were not reported by Sabourin et al. (1990).

There were nine comparisons, described below, against the norms:

1. Uncertified IT Architects only, certified IT Architects only, and all IT Architects,
2. Uncertified Project Managers only, certified Project Managers only, and all Project Managers,
3. All uncertified respondents, all certified respondents, and all respondents.

For each of these comparisons, and all subsequent norm comparisons for PSI and ZTPI, we used the same method in this chapter and also the next chapter. The approach we used was one-sample t-tests in which we compared the means of the results we obtained with the means reported for the normative values. This approach is valid for normative comparisons of this nature (McClave & Sincich 2006; Mendenhall, Beaver & Beaver 2003; Wackerly, Mendenhall & Scheaffer 2002). Any result with a t-test significance of less than 0.05 is considered statistically significant and is highlighted.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertified IT Architects</th>
<th>Certified IT Architects</th>
<th>All IT Architects</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>t-test significance</td>
<td>mean</td>
<td>t-test significance</td>
</tr>
<tr>
<td>PSC</td>
<td>23.29</td>
<td>0.750</td>
<td><strong>20.43</strong></td>
<td><strong>0.030</strong></td>
</tr>
<tr>
<td>AAS</td>
<td><strong>40.22</strong></td>
<td>0.002</td>
<td>34.52</td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td>PC</td>
<td>14.12</td>
<td>0.033</td>
<td>12.86</td>
<td><strong>0.018</strong></td>
</tr>
</tbody>
</table>

Table 5-7 All IT Architect PSI factors normative comparison

Of the three factors, all groups of respondents were considered statistically different from the comparison group in both their perceived personal problem solving control (PC) and approach avoidance style (AAS). The Problem Solving Confidence (PSC) of the group of uncertified IT Architect respondents was not statistically different from the normative comparison group, but both the group of certified IT Architect
IT Architect distinguishing capabilities

respondents and the group of all the IT Architect respondents showed statistically significant higher levels of $PSC$ than the normative comparison group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertified Project Managers</th>
<th>Certified Project Managers</th>
<th>All Project Managers</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>t-test</td>
<td>mean</td>
<td>t-test</td>
</tr>
<tr>
<td>$PSC$</td>
<td>21.59</td>
<td>0.051</td>
<td>20.57</td>
<td>0.001</td>
</tr>
<tr>
<td>$AAS$</td>
<td>40.60</td>
<td>0.023</td>
<td>39.50</td>
<td>0.000</td>
</tr>
<tr>
<td>$PC$</td>
<td>15.09</td>
<td>0.619</td>
<td>13.69</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Table 5-8 All Project Manager PSI factors normative comparison

All three factors are considered statistically significantly different from the normative comparison group for the group of certified Project Manager respondents and the group of all the Project Manager respondents. That is, both these respondent groups have higher perceived $PSC$, $AAS$, and $PC$. However, only for $AAS$ are the group of uncertified Project Manager respondents considered statistically significantly higher, than the normative comparison group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All uncertified</th>
<th>All certified</th>
<th>All respondents</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>t-test</td>
<td>mean</td>
<td>t-test</td>
</tr>
<tr>
<td>$PSC$</td>
<td>23.17</td>
<td>0.567</td>
<td>20.56</td>
<td>0.000</td>
</tr>
<tr>
<td>$AAS$</td>
<td>41.06</td>
<td>0.000</td>
<td>38.00</td>
<td>0.000</td>
</tr>
<tr>
<td>$PC$</td>
<td>14.46</td>
<td>0.038</td>
<td>13.53</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 5-9 All respondents PSI factors normative comparison

Both the groups of all certified respondents and all respondents were considered statistically significantly higher, for all PSI factors than the normative comparison group. Both these groups perceive themselves as having greater Problem Solving Confidence ($PSC$), higher Approach Avoidance Style ($AAS$), and more personal problem solving control ($PC$). However, the group of uncertified respondents were
not considered statistically significantly different for the Problem Solving Confidence \((PSC)\) factor.

**PSI norms comparison summary**

The results of the different respondent groups for the PSI were significantly different to previously reported results. The respondents reported that they approached problems more than they avoided them, and that they had more personal control regarding problem solving. Given they all have senior roles and deal with significant issues as part of their usual duties this problem solving capability would be beneficial for success.

**VVIQ norms comparison**

For the VVIQ, no normative data is available so we performed no comparisons.

**ZTPI norms comparison**

We compared the five ZTPI factors to normative data provided by Zimbardo when we obtained the scoring details for the ZTPI. (Philip Zimbardo provides the scoring approach and normative data when requests are made.) We compared this with the respondent’s results using the same approach as for PSI normative comparison. Again, any result of less than 0.05 for t-test significance is considered statistically significant and is highlighted.

There were nine comparisons against the norms. The comparisons were:

1. IT Architects, uncertified, certified, and all IT Architect respondents in Table 5-10,
2. Project Managers, uncertified, certified and all Project Manager respondents in Table 5-11, and
3. All uncertified respondents, all certified respondents, and all respondents in Table 5-12.

From this comparison, we have found that the responding IT Architects, regardless of the cohort being analysed, are less negative about the past than the comparative norms. The uncertified IT Architects and the group of all IT Architects are less hedonistic in the present than the norms whereas the certified IT Architects were not
IT Architect distinguishing capabilities

significantly different from the norms. The certified IT Architects and the total group of IT Architects respondents are more oriented towards the future in comparison to the norms whereas the uncertified IT Architects respondents are not considered statistically different from the norms. Certified IT Architects, uncertified IT Architects and all IT Architect respondents were more positive about the past than the norms. With regard to being fatalistic about the present, none of the respondent IT Architect groups was considered statistically significantly different from the norms.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertified IT Architects</th>
<th>Certified IT Architects</th>
<th>All IT Architects</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>t-test significance</td>
<td>mean</td>
<td>t-test significance</td>
</tr>
<tr>
<td>PN</td>
<td>2.65</td>
<td>0.000</td>
<td>2.46</td>
<td>0.000</td>
</tr>
<tr>
<td>PH</td>
<td>3.20</td>
<td>0.001</td>
<td>3.30</td>
<td>0.235</td>
</tr>
<tr>
<td>F</td>
<td>3.51</td>
<td>0.668</td>
<td>3.75</td>
<td>0.001</td>
</tr>
<tr>
<td>PP</td>
<td>3.46</td>
<td>0.000</td>
<td>3.44</td>
<td>0.001</td>
</tr>
<tr>
<td>PF</td>
<td>2.41</td>
<td>0.546</td>
<td>2.23</td>
<td>0.156</td>
</tr>
</tbody>
</table>

Table 5-10 Architect respondents ZTPI factors normative comparisons

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertified Project Managers</th>
<th>Certified Project Managers</th>
<th>All Project Managers</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>t-test significance</td>
<td>mean</td>
<td>t-test significance</td>
</tr>
<tr>
<td>PN</td>
<td>2.69</td>
<td>0.014</td>
<td>2.73</td>
<td>0.001</td>
</tr>
<tr>
<td>PH</td>
<td>3.17</td>
<td>0.002</td>
<td>3.34</td>
<td>0.109</td>
</tr>
<tr>
<td>F</td>
<td>3.71</td>
<td>0.000</td>
<td>3.71</td>
<td>0.000</td>
</tr>
<tr>
<td>PP</td>
<td>3.69</td>
<td>0.821</td>
<td>3.59</td>
<td>0.100</td>
</tr>
<tr>
<td>PF</td>
<td>2.27</td>
<td>0.215</td>
<td>2.26</td>
<td>0.118</td>
</tr>
</tbody>
</table>

Table 5-11 Project Manager respondents ZTPI factors normative comparisons

For all three Project Manager respondent groups of certified, uncertified and all respondents the survey results were considered statistically significantly different, and both less negative about the past and more oriented towards the future than the norms. In comparison only the group of all Project Manager respondents was less fatalistic
about the present than the norms and only the certified Project Manager respondents group was more positive about the past than the norms. Two groups of respondents, all uncertified Project Managers, and all Project Manager respondents were less hedonistic in the present than the norms.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Uncertified mean</th>
<th>All Cenrtified mean</th>
<th>All respondents mean</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-test significance</td>
<td>t-test significance</td>
<td>t-test significance</td>
<td></td>
</tr>
<tr>
<td>PN</td>
<td>2.68</td>
<td>2.66</td>
<td>2.67</td>
<td>2.98</td>
</tr>
<tr>
<td>PH</td>
<td>3.19</td>
<td>3.33</td>
<td>3.26</td>
<td>3.44</td>
</tr>
<tr>
<td>F</td>
<td>3.57</td>
<td>3.72</td>
<td>3.64</td>
<td>3.47</td>
</tr>
<tr>
<td>PP</td>
<td>3.54</td>
<td>3.55</td>
<td>3.54</td>
<td>3.71</td>
</tr>
<tr>
<td>PF</td>
<td>2.36</td>
<td>2.25</td>
<td>2.31</td>
<td>2.37</td>
</tr>
</tbody>
</table>

Table 5-12 All respondents ZTPI factors normative comparisons

Only the group of all certified respondents was considered statistically different and less fatalistic regarding the present than the norms. For all other factors, all groups were considered statistically different from the norms. That is, all groups were less negative about the past, less hedonistic in the present, more oriented towards the future, and more positive about the past than the norms.

The ZTPI has been used with many different populations, including adults; however, the normative data provided was only for student responses. As the students would be, on average, younger than the respondents the differences in Present Hedonistic and Future could be expected (Zimbardo & Boyd 1999). For the other different variables, a lower Present Positive could reflect that significant portions of their jobs involve difficult situations, while the lower Present Fatalistic would reflect their confidence in being able to deal with those situations through their own efforts.

5.4.3 Different groups analysis

The third step in the analysis of the survey was to investigate if there were any differences considered statistically significant between any of the respondent groups for any of the variables or the demographic information. The first four analyses were:
IT Architect distinguishing capabilities

1. IT Architects only - Certified versus uncertified
2. Project Managers only - Certified versus uncertified
3. Uncertified respondents only - IT Architects versus Project Managers
4. Certified respondents only - IT Architects versus Project Managers

The remaining two analyses were for all respondents divided into two different sets of sub-groups and then comparison between those sub-groups. The analyses were:

5. All IT Architects versus all Project Managers.
6. All certified respondents versus all uncertified respondents

These six different analyses are illustrated in Figure 5-1 and described below.

**IT Architects**

The first analysis compared uncertified IT Architects and certified IT Architects. We performed this comparison for all thirteen variables using independent sample t-tests with SPSS. Use of independent t-test is suitable for comparison between two groups that are both normally distributed \(^{11}\) (McClave & Sincich 2006; Mendenhall et al. 2003; Wackerly et al. 2002).

No significant differences existed between the groups (significance >0.05) on ten of the measures. However, significant differences were found (significance <0.05) for three variables. These are bolded in Table 5-13 and were:

1. *ZTPI-F*, the Future Scale of the ZTPI
2. *AAS*, the PSI sub-factor of Approach Avoidance Style
3. *PSI* total score, the overall score for the Problem Solving Inventory.

Two possible hypotheses for the significance of the Future scale were that the results were not related to certification, and thereby skills, but instead age or experience in the IT industry. To test these hypotheses, we used bi-variate correlation for two pairs of variables:

1. *ZTPI-F* result and age
2. *ZTPI-F* result and years in industry

---

\(^{11}\) In all cases, if Levene’s test was less than 0.05 then we used the values for t and significance calculated for not normally distributed. In these cases the Levene’s test value has an * beside it in the tables.
There was no correlation considered statistically significant for either of these two sets of variables. Therefore, it appears that the discriminating variable was certification.

Figure 5-1 Different group analyses

The responding certified IT Architects have a lower result for AAS within the Problem Solving Inventory. That is, they generate more alternatives for any problem they are confronted with and they evaluate the results of possible and actual solutions more
IT Architect distinguishing capabilities

than uncertified IT Architects. In addition, the certified IT Architects perceive themselves as more accomplished problem solvers overall, as indicated by the result for PSITotal. The other significant result is that certified IT Architects respondents have a higher ZTPI-F response. That is they have a longer-term outlook or perspective on time than uncertified IT Architect respondents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Style Index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSI</td>
<td>0.984</td>
<td>0.367</td>
</tr>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>0.092</td>
<td>0.111</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>0.536</td>
<td>0.022</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>0.432</td>
<td>0.281</td>
</tr>
<tr>
<td>Overall (PSITotal)</td>
<td>0.434</td>
<td>0.040</td>
</tr>
<tr>
<td><strong>Vividness of Visualisation Questionnaire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VVIQ</td>
<td>0.965</td>
<td>0.602</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective Inventory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>0.677</td>
<td>0.164</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.819</td>
<td>0.453</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>0.377</td>
<td>0.012</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.030*</td>
<td>0.847</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.561</td>
<td>0.165</td>
</tr>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years in IT</td>
<td>0.473</td>
<td>0.148</td>
</tr>
<tr>
<td>Age</td>
<td>0.718</td>
<td>0.240</td>
</tr>
</tbody>
</table>

Table 5-13 Comparison of survey responses between certified and uncertified IT Architects

**Project Managers**

We calculated independent sample t-tests for all thirteen of the variables for comparison between the certified and uncertified Project Managers respondents. No
significant differences existed (significance >0.05) for eleven of the measures. However, differences considered statistically significant were found (significance <0.05) for Cognitive Style Index and Age of respondents. Table 5-14 shows a summary of the t-test analyses.

The certified Project Manager respondents were both more intuitive and older than were the uncertified Project Manager respondents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Style Index</strong></td>
<td>CSI</td>
<td>0.837</td>
</tr>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.231</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.829</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.592</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.458</td>
</tr>
<tr>
<td><strong>Vividness of Visualisation Questionnaire</strong></td>
<td>VVIQ</td>
<td>0.738</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective Inventory</strong></td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.787</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.760</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.194</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.822</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.414</td>
</tr>
<tr>
<td><strong>Demographic</strong></td>
<td>Years in IT</td>
<td>0.889</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.591</td>
</tr>
</tbody>
</table>

*Table 5-14 Comparison of survey responses between certified and uncertified Project Managers*
Uncertified respondents detailed analysis
The next comparison was between both groups of uncertified respondents. We calculated independent sample t-tests for all thirteen of the variables between the groups of uncertified IT Architects and uncertified Project Managers. No differences considered statistically significant existed between the groups (significance >0.05) on eleven of the measures. However, differences considered statistically significant (significance <0.05) were found for ZTPI-F, and ZTPI-PP.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSI</td>
<td>0.244</td>
<td>0.601</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>0.010*</td>
<td>0.175</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>0.536</td>
<td>0.931</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>0.614</td>
<td>0.322</td>
</tr>
<tr>
<td>Overall (PSITotal)</td>
<td>0.014*</td>
<td>0.669</td>
</tr>
<tr>
<td>Vividness of Visualisation Questionnaire</td>
<td>0.080</td>
<td>0.124</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>0.585</td>
<td>0.903</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.489</td>
<td>0.752</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>0.350</td>
<td><strong>0.009</strong></td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.373</td>
<td><strong>0.046</strong></td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.308</td>
<td>0.199</td>
</tr>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years in IT</td>
<td>0.628</td>
<td>0.530</td>
</tr>
<tr>
<td>Age</td>
<td>0.674</td>
<td>0.379</td>
</tr>
</tbody>
</table>

Table 5-15 Comparison of survey responses between uncertified respondents
Table 5-15 shows a summary of the t-test analyses. The uncertified Project Manager respondents were both more oriented towards the future and more positive about the past than the uncertified IT Architects.

**Certified respondents detailed analysis**

Following the comparison of the uncertified only respondents, we compared the groups of only certified respondents. Again, we calculated independent sample t-tests for all thirteen of the variables for comparison between the groups of certified IT Architects and certified Project Managers. No significant differences existed between the groups (significance >0.05) on twelve of the measures. However, a difference considered statistically significant (significance <0.05) was found for AAS, bolded in Table 5-16.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Style Index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSI</td>
<td>0.316</td>
<td>0.320</td>
</tr>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>0.435</td>
<td>0.925</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td><strong>0.782</strong></td>
<td><strong>0.043</strong></td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>0.294</td>
<td>0.460</td>
</tr>
<tr>
<td>Overall (PSITotal)</td>
<td>0.513</td>
<td>0.075</td>
</tr>
<tr>
<td><strong>Vividness of Visualisation Questionnaire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VVIQ</td>
<td>0.334</td>
<td>0.696</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective Inventory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>0.935</td>
<td>0.063</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.258</td>
<td>0.747</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>0.163</td>
<td>0.662</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td><strong>0.019</strong></td>
<td>0.138</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.816</td>
<td>0.764</td>
</tr>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years in IT</td>
<td>0.132</td>
<td>0.416</td>
</tr>
</tbody>
</table>
IT Architect distinguishing capabilities

The certified IT Architect respondents were lower than the certified Project Managers for Approach Avoidance Style within the Problem Solving Inventory. That is, the certified architects reported they generated more alternatives solutions for problems, and evaluated the outcomes both before and after attempting the solutions.

**All IT Architects and all Project Managers detailed analysis**

Next, the groups of all IT Architects respondents and all Project Manager respondents were compared using independent sample t-tests for all thirteen variables under study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style Index</td>
<td>CSI</td>
<td>0.042*</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.033*</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.339</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.415</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.004*</td>
</tr>
<tr>
<td>Vividness of Visualisation Questionnaire</td>
<td>VVIQ</td>
<td>0.053</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.818</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.232</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.043*</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.522</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.393</td>
</tr>
<tr>
<td>Demographic</td>
<td>Years in IT</td>
<td>0.006*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.247</td>
</tr>
</tbody>
</table>

Table 5-17 Comparison of survey responses between all IT Architects and Project Managers
No significant differences (significance <0.05) existed between the groups on nine of the measures. However, differences considered statistically significant (significance <0.05) were found for ZTPI-F, ZTPI-PP, Years in IT, and Age of respondent. Table 5-17 is the summary of the t-test analyses.

The Project Managers who responded were considered statistically significantly older and had more years in IT than the IT Architect respondents. In addition, the Project Manager respondents also were considered statistically different for the both the Future and Past Positive factors of the ZTPI. They were more oriented towards the future and more positive about the past. Previous ZTPI usage (Zimbardo & Boyd 1999) has shown that older groups are often more future-oriented so this result was not unexpected.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style Index</td>
<td>CSI</td>
<td>0.507</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>1.013</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.228</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.526</td>
</tr>
<tr>
<td>Vividness of Visualisation Questionnaire</td>
<td>VVIQ</td>
<td>0.603</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.158</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.374</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.228</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.940</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.020*</td>
</tr>
<tr>
<td>Demographic</td>
<td>Years in IT</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.051</td>
</tr>
</tbody>
</table>
IT Architect distinguishing capabilities

Table 5-18 Comparison of survey responses between all certified and uncertified respondents

All certified and all uncertified detailed analysis
The final analysis in this stage of the research was to compare all certified and all uncertified respondents using independent sample t-tests for all thirteen variables under study. No significant differences existed between the groups (significance >0.05) for eight of the measures. For five variables, the group of all certified respondents were significantly different from the uncertified respondents. The certified respondents were more intuitive, more confident in their problem solving, more oriented towards the future, were both older on average, and had more years in the IT industry than the uncertified respondents. Table 5-18 is the summary of the t-test analyses

5.4.4 Post hoc power analysis
We performed post hoc power analysis for each comparison we performed. This was to determine the likelihood of false negatives. That is, not finding a significant difference where there was one, this is called Type II error (Dyba et al. 2006; Miller, Daly, Wood, Roper & Brooks 1997). These analyses was performed using the tool GPower (Erdfelder, Faul & Buchner 1996; Faul, Erdfelder, Lang & Buchner 2007). Following Cohen (1988, 1992), for all calculations a medium effect size (d) of 0.5 was used, all the analyses were independent t-tests on means, an α of 0.05 was used, and all distributions were two-tailed. The numbers in each population were similarly distributed and as such do not violate the requirements for the power calculation.

The comparisons, the number of participants in each group, and the resultant Power (1-β) are all shown in Table 5-19. These values show that for the first four comparisons, although we found significant differences with the t-tests for some variables, there is a more than 30% chance that with additional respondents we may have found significant differences in additional variables. That is, due to the number of respondents, there may be other significant differences between the groups being compared that we did not determine (Cohen 1988, 1992; Kitchenham & Pfleeger
2002a). For the second two comparisons, the likelihood of finding additional significant differences was less than 10%.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>N1</th>
<th>N2</th>
<th>1-β</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Architects – certified versus uncertified</td>
<td>22</td>
<td>60</td>
<td>0.5088</td>
</tr>
<tr>
<td>Project Managers – certified versus uncertified</td>
<td>58</td>
<td>39</td>
<td>0.6664</td>
</tr>
<tr>
<td>Uncertified – IT Architects versus Project Managers</td>
<td>60</td>
<td>39</td>
<td>0.6725</td>
</tr>
<tr>
<td>Certified – IT Architects versus Project Managers</td>
<td>22</td>
<td>58</td>
<td>0.5049</td>
</tr>
<tr>
<td>All IT Architects versus all Project Managers</td>
<td>82</td>
<td>97</td>
<td>0.9123</td>
</tr>
<tr>
<td>All certified versus all uncertified</td>
<td>80</td>
<td>99</td>
<td>0.9111</td>
</tr>
</tbody>
</table>

**Table 5-19 Professional survey power analysis summary**

This analysis was post hoc, as we did not know what the actual response rate from all the populations would be as there had been no similar surveys performed or response data available from IBM. In addition, aside from the uncertified Project Managers, we surveyed all members of the populations.

**5.4.5 Factorial comparison**

In addition to the above analyses, we also performed factorial ANOVA analyses to investigate if there were any interaction effects between certification and profession. Factorial ANOVA is a subset of the analysis approaches called General Linear Models (GLMs) and is used when an experimenter wishes to investigate the combined effects of two variables on the responses (Moore & McCabe 2003). That is, in our case, was there any significant effect on any variable caused by the interaction of the respondents certification status, that is certified or not, and their profession, that is IT Architect or Project Manager. The results of these analyses showed that there was no significant interaction effect. The detailed results are in Appendix H.

SPSS, which we used for all statistical calculations, corrects for unbalanced data as part of its factorial ANOVA calculation (SPSS 2006). Therefore, although we had unbalanced numbers of respondents in the categories of certified and uncertified and IT Architect and Project Manager, our use of SPSS ensured that these differences did not affect our results.
5.5 Discussion

This section describes the implications of the analysis of the groups of respondents.

5.5.1 Discussion of more detailed analysis

A representation of the overall results is Figure 5-2 and shows the variables with significant differences between any groups.

![Diagram](image)

Figure 5-2 Results of different groups comparisons
Each arrow represents an explicit comparison between groups, for example the arrow labelled “1” is the comparison between Certified IT Architects and Uncertified IT Architects, whereas the arrow labelled ‘5’ is the comparison between all IT Architects and all Project Managers. The boxes that are pointing to arrows list the variables that were found to be significantly different for that particular comparison, not the characteristics. For example, the box with AAS pointing to the arrow labelled “4” shows that for this particular comparison, between Certified IT Architects and Certified Project Managers, the AAS result was considered statistically significantly different between the groups being compared.

5.5.2 Other comments

Our first research stage identified eight capabilities that were perceived as differentiating highly-skilled from less skilled IT Architects. This stage has shown that of the four capabilities evaluated - intuitive cognitive style, problem solving, visualisation, and future vision - only two were considered statistically significantly different between the two groups of IT Architects. The two that were not different were analysis, evaluated with the CSI, and conceptualisation, evaluated with the VVIQ. It is not clear why these capabilities were not significantly different in the survey responses, though we speculate that there were two different reasons. The first capability, analysis, is a necessary requirement for any level of IT Architect not a major differentiator between highly-skilled and skilled IT Architects. The second capability, conceptualisation, is directly related to visual activities which is possibly not well suited to a survey evaluation, even when self reported, and some other style of instrument might be more relevant.

5.5.3 Limitations

The people surveyed were from one company and from only one geographic area (Australia and New Zealand). While this is a limitation, the company, IBM, is one of the largest and most successful information technology companies across the world. This single company and geographic area meant that inter-company and inter-country differences were both minimised thereby enabling us to focus more on the differences between the highly-skilled and skilled architects. However, this differentiation is also a limitation as it relies on IBM’s certification processes and criteria. The criteria for certification are very similar to that of the Open Group (Open Group 2007b), are
openly communicated within IBM, and the overall process is open which mitigates this limitation.

Another limitation was that no information as to the cultural background and influences of any of the respondents was collected or analysed. Other researchers (Hofstede 2001; Trompenaars & Hampden-Turner 2000) have shown that attitude to time, amongst other things, varies by culture and as such that could affect our results. There was also no gender analysis of the respondents as the proportion of females was too small for a meaningful sample, again this could influence the result. In addition, the available data on norms for all factors was of variable relevance. For example, norms for Zimbardo’s Time Perspective Inventory are based on American college students, which could be significantly different from participants in our research.

5.5.4 Revisit interviews

At the conclusion of this stage of the research, the interview transcripts and field notes were all reviewed to investigate if there had been any comments or conclusions that would provide additional insight or supporting or contradictory information. This review supported the major findings of the survey response analysis and supported the importance of the problem solving characteristics of the architects and the requirement for future orientation.

As was stated in different interviews, alternative solutions and analysis of those solutions is critical. For example different interviewees emphasised “the problem and the likely solutions”, “you can look at those alternatives and you can work out pros and cons to all of them”, “also to look at it, problems from new perspectives”, “solve those complex problems in their mind” and “you go with tunnel vision and solve the wrong problem.” All of these quotations are aligned with the approach avoidance style of the Problem Solving Inventory (PSI). This factor of the PSI measures the respondent’s perception of their tendency to directly approach problems, generate alternatives for the problems, evaluate those alternatives, and evaluate the outcome of the problem solving intervention.

In addition, the interviewees emphasized the importance of the future factor of Zimbardo’s Time Perspective Inventory, which evaluates the respondent’s perception
of their attitude towards the future and how their actions align with longer-term outcomes. As they said, “can see things broadly and strategically and has this vision about going ahead” and “the longer vision you need to have.”

5.6 Summary

In this chapter we have used a survey and subsequent statistical analysis to determine whether four of the capabilities identified in Chapter Four are statistically significantly different between some populations of highly-skilled and less skilled IT Architects and Project Managers, also of differing skill levels.

The survey was developed using previously proven instruments and administered to IBM Australia and New Zealand IT Architects and Project Managers. The analysis of the responses showed that two of the capabilities measured by the instruments, problem solving and visionary were statistically different for the highly skilled IT Architects compared with less skilled IT Architects.

The next chapter, Chapter Six, describes the teaching within a post-graduate university subject of the distinguishing capabilities of problem solving and future vision found in this stage of the research and whether the teaching measurably affected those capabilities.
Chapter 6. Teaching IT Architect capabilities

The final stage of the research is described in this chapter. In the prior stage, Chapter Five, we identified two capabilities that distinguished highly-skilled IT Architects from less-skilled IT Architects and Project Managers. These were Approach Avoidance Style (AAS) for problem solving, and a future oriented time perspective (Zimbardo’s Time Perspective Inventory-Future ZTPI-F). In this third stage, we investigate whether we could enhance these two capabilities for individual students within a single university subject.

The research question addressed by this stage of the research is:

*Can some capabilities of highly-skilled IT Architects be improved within a university subject?*

We designed Stage Three in the following manner. A survey was administered prior to presenting specialized content. The content was then taught over a seven week period. The survey was then re-administered to assess whether the capabilities had changed. Finally, a follow-up survey was administered nine months later, to assess whether any longer-term effects were evident. The design is described in more detail in the following sub-sections.

**6.1 Subject choice and description**

The first step was the choice of a university subject that the intervention would be placed within. This choice had two main criteria. First, the learning objectives of the subject had to include the coverage of an IT Architect’s role, therefore including
knowledge of architecture wider than just software, one problem domain, or hardware. Second, because the IT Architect role is an advanced one, the subject needed to be at either post-graduate or advanced under-graduate levels within a university.

Several universities within Australia offer post-graduate subjects related to IT Architecture. However, as discussed in Chapter Two, all except one of these subjects are focussed on either software architecture only, or the architecture of a limited domain. Therefore, one candidate subject[^12] is a master’s level, Systems Architecture subject, offered by the School of Computer Science and Information Technology at RMIT University (RMIT University 2007a). The pre-requisite knowledge also matched the required criteria, as stated on the RMIT University website “You will be expected to understand key processes, knowledge and capabilities equivalent to those acquired in 004309 Software Engineering Fundamentals and 004337 Introduction to Programming.”

The subject structure included lectures and tutorials, each two hours long, allowing different opportunities for interventions with our capability teaching materials. An external expert taught the lectures and different tutors taught the two tutorial groups on the same day and time in different rooms. Both tutors had previously completed the subject, had tutored prior versions of the subject and one of the tutors has a university qualification in teaching.

The teaching was conducted in the first semester, February to June, of 2006. For this offering of the subject, teaching was over thirteen weeks, with twelve weeks of lectures and tutorials, and one week of mid-semester break. The two tutorials groups ran in parallel immediately after the lecture.

**Subject positioning**

The Systems Architecture subject is part of the software engineering specialist cluster within several different Masters Degrees at RMIT University, where a specialist cluster is “a group of four thematically-linked courses” (RMIT University 2007b).

[^12]: RMIT University uses the term course for a single semester delivery of a topic, referred to at many other universities as a subject. As described in Chapter One, we are using subject.
Teaching IT Architect capabilities

The subjects that can be chosen to make up the cluster were, as at the time of the research:

- ISYS2377 Enterprise Architecture
- COSC2275 Software Requirements Engineering
- ISYS1083 Object Oriented Software Design
- ISYS1081 Software Reuse
- ISYS1085 Software Testing
- ISYS1088 Systems Architecture
- COSC1182 Usability Engineering

The objectives of the software engineering specialist cluster are to “Equip students with a solid foundation in software engineering principles for continued learning and mastering of new software engineering paradigms and approaches. Students are prepared for future roles as software developers and testers, software architects and designers. This cluster also provides technical foundations for IT management roles.” (RMIT University 2007b)

Subjects from within the structure can also be chosen as electives during the final year of the under-graduate Software Engineering degree at RMIT University (RMIT University 2007d).

The Systems Architecture subject is also compulsory within RMIT University’s Master of Technology (Enterprise Architecture) (RMIT University 2007c). For that degree, the objectives are “Students will develop and demonstrate they have the following abilities, skills, knowledge and attitudes:

- An understanding of business strategy and of how to architect cost-effective Enterprise IT Architectures and systems to help to achieve the business goals of the Enterprise;
- The ability to communicate how an enterprise architecture supports the organization's strategic IT objectives and plans;
- The ability to communicate and market an enterprise architecture to the organization and oversee its implementation;
• The ability to develop an enterprise architecture for an organization, taking into account its strategic plan, current IT portfolio, and key business and ICT industry drivers and technologies, including hardware and software standards;
• The ability to maintain an enterprise architecture for an organization, taking into account its strategic plan, current IT portfolio, and key business and ICT industry drivers and technologies, including hardware and software standards;
• An understanding of the required governance for successful enterprise architecture development and adoption within organizations to support business & technology strategy.”

RMIT University developed this degree in response to industry requests to educate Enterprise Architects.

6.2 Student interaction design

The research design in this step has three major teaching objectives, these are to:
• Spread the material related to the capabilities being researched throughout the teaching period to reinforce the learning,
• Have two separate streams of material delivery, for material focussed on ZTPJ-F, the other on AAS, and
• Ensure equitable access for all students to both streams of material on the capabilities presented during the subject.

The required RMIT University Science Engineering and Technology ethics committee approval for this stage also guided several aspects of the overall design. In particular, ethical considerations restricted the possible alternatives for the teaching approaches and also the scope and type of measurement possible for the research. For example, due to the requirements of the ethics process to ensure equity, all students had to have access to teaching of both targeted capabilities, which meant that no control group was possible. In addition, no connection was permitted between the research focus and any assignments results, overall grade, or extra credit of any kind as this could have affected students’ voluntary participation. It was also necessary to avoid any power or dependency relationships between the students and researchers. Thus, none of the staff involved in the subject delivery or assessment of the subject
Teaching IT Architect capabilities

were involved in this research. (All references to ‘we’ within this chapter refer to the researcher, not the teaching staff or any other people involved with the subject.)

We had six major points of student interaction with the experiment.

1. First, the researchers briefed them on the overall experiment. This briefing included details of the tutorials’ differences and the focus of the material in each tutorial stream. At the briefing, they also received copies of the plain language statement and the informed consent forms (these are included in Appendix I).

2. Next, those deciding to participate completed and signed the informed consent form and then completed the pre-subject survey\(^\text{13}\).

3. The third interaction point was when, as part of the overall subject enrolment, the students selected one of the two tutorial streams. One stream focussed on AAS, while the other focussed on ZTPI-F. Both streams also exchanged material at the end of the stream to ensure each group received teaching about both capabilities. After this student interaction point, we analysed the results to confirm balanced tutorials. That is, we checked for all the variables being examined that one tutorial group was not already considered statistically significantly different from the other tutorial group. If one group was not in balance, we had planned and told the students that we would ask some to change tutorials groups, if they agreed.

4. The students then undertook the subject.

5. One week before the end of the subject the students who still consented to participate completed the same survey as at the start of the subject.

6. The sixth, and final, interaction point was in February 2007, when we asked students who had completed the first and second surveys to complete the survey for a third time.

This design met the objectives listed above and satisfied the ethical constraints. There were several alternative designs, described in Appendix J, which were analysed and rejected.

\(^{13}\) Each time the students completed the survey there was also an incentive to participate; with each respondent having a chance to win one of two A$75 book vouchers.
6.3 Survey development and pre-subject administration and & processing

The next step involved developing and administering the survey.

6.3.1 Survey development

The survey used was a reduced version of the survey we constructed for investigating four capabilities, as detailed in Chapter Five. There were five changes to that survey for this stage.

The first change was the removal of two of the scales, being the Cognitive Styles Index (Allinson & Hayes 1996) and the Vividness of Visual Imagery Questionnaire (VVIQ) (Marks 1973). Neither of these scales had shown any differences considered statistically significant between the different IT Architect respondent groups. The second change was in the range of the respondent’s reported ages, because the students had a different demographic profile from the respondents in the prior research. There were minor wording changes in the introduction to reflect the modified survey. The fourth change was a minor wording change in the introduction to the PSI due to potential cultural issues with members of the major student cohort, and the fifth change was in the wording of the conclusion to reflect the different target group. Therefore, the survey comprised four sections:

1. Introduction to the survey
2. Problem Solving Inventory (PSI) (Heppner & Petersen 1982)
3. Zimbardo’s Time Perspective Inventory (ZTPI) (Zimbardo & Boyd 1999)
4. Survey conclusion, including age range and student name to enable matching of the pre-subject and post-subject responses and tutorial allocation.

Wu et al. (1996) used a modified version of the PSI to investigate computer science students. We chose not to use this version because this instrument would not be comparable with other PSI usage and has no other reported use within academia or industry.
6.3.2 Pre-subject survey administration & processing

Participants completed the survey and then missing values were corrected and any outliers removed. We treated all students as a single group for this processing. There were two major reasons for this. The first was that while there were differences in survey responses of the post and under-graduates, both of these student groups were distributed across both tutorials. The second reason was that students could change tutorials without any notification and at any time during the subject. We performed missing values analysis and outlier removal for the survey responses in the same manner as described in Chapter Five.

6.3.3 Initial pre-subject analysis

Following the missing value and outlier processing we determined the distribution of the response data. If the data was normally distributed or if there were more than fifteen respondents then t-tests are appropriate for analysis (Moore & McCabe 2003). All the response data sets within this pre-subject analysis meet those conditions and therefore we used t-tests.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Skewness (Standard error is 0.41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>22.35</td>
<td>6.34</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>40.53</td>
<td>8.93</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>14.52</td>
<td>3.73</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>76.77</td>
<td>16.14</td>
<td>0.53</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.74</td>
<td>0.58</td>
<td>-0.1</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.31</td>
<td>0.49</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.75</td>
<td>0.48</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.47</td>
<td>0.49</td>
<td>-0.65</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.16</td>
<td>0.59</td>
<td>0.19</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td>2.45</td>
<td>0.79</td>
<td>1.35#</td>
</tr>
</tbody>
</table>

Table 6-1 Student pre-subject analysis (part 1)

Within the tables that include Mean and SD in this chapter, the use of an # attached to skew or skew standard error indicates that the ratio of the absolute value of skewness
to skewness standard error is greater than two and as such the data isn’t normally distributed (Moore & McCabe 2003).

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Tutorial 1</th>
<th></th>
<th></th>
<th>Tutorial 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skew</td>
<td>Skew std error</td>
<td>Mean</td>
<td>SD</td>
<td>Skew</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>22.35</td>
<td>6.84</td>
<td>-0.04</td>
<td>0.48</td>
<td>22.36</td>
<td>5.45</td>
<td>0.389</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>40.45</td>
<td>9.54</td>
<td>1.11#</td>
<td>0.49</td>
<td>40.70</td>
<td>7.90</td>
<td>0.292</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>13.95</td>
<td>3.91</td>
<td>1.06#</td>
<td>0.49</td>
<td>15.64</td>
<td>3.23</td>
<td>1.16</td>
</tr>
<tr>
<td>Overall (PSI Total)</td>
<td>76.57</td>
<td>18.45</td>
<td>0.48</td>
<td>0.50</td>
<td>77.20</td>
<td>10.58</td>
<td>1.16</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>2.66</td>
<td>0.55</td>
<td>-0.79</td>
<td>0.51</td>
<td>2.89</td>
<td>0.64</td>
<td>0.76</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.24</td>
<td>0.47</td>
<td>0.56</td>
<td>0.66</td>
<td>3.44</td>
<td>0.53</td>
<td>0.32</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>3.82</td>
<td>0.40</td>
<td>0.24</td>
<td>0.50</td>
<td>3.62</td>
<td>0.59</td>
<td>-0.02</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.42</td>
<td>0.49</td>
<td>-0.89</td>
<td>0.49</td>
<td>3.57</td>
<td>0.49</td>
<td>-0.26</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.14</td>
<td>0.57</td>
<td>0.23</td>
<td>0.49</td>
<td>2.20</td>
<td>0.64</td>
<td>-0.22</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td></td>
<td>1.78#</td>
<td>0.49</td>
<td>2.64</td>
<td>0.81</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table 6-2 Student pre-subject analysis (part 2)
Teaching IT Architect capabilities

There were 33 participants that we could determine their tutorial and two participants for whom we could not do so\textsuperscript{14}, making a total of 35 participants. The results of the initial analysis for all students who completed the first survey are shown in Table 6-1, organised by tutorial in Table 6-2, and organised by post-graduate or under-graduate enrolment type in Table 6-3.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Ugrad Mean</th>
<th>Ugrad SD</th>
<th>Ugrad Skew</th>
<th>Ugrad Skew std err</th>
<th>Pgrad Mean</th>
<th>Pgrad SD</th>
<th>Pgrad Skew</th>
<th>Pgrad Skew std err</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>21.65</td>
<td>5.55</td>
<td>-0.12</td>
<td>0.55</td>
<td>22.60</td>
<td>7.09</td>
<td>-0.04</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>41.12</td>
<td>9.99</td>
<td>0.80</td>
<td>0.55</td>
<td>39.69</td>
<td>8.09</td>
<td>1.31#</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>14.47</td>
<td>3.48</td>
<td>1.02</td>
<td>0.55</td>
<td>14.93</td>
<td>4.19</td>
<td>0.71</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>77.24</td>
<td>15.45</td>
<td>0.63</td>
<td>0.55</td>
<td>75.67</td>
<td>17.95</td>
<td>0.60</td>
<td>0.64</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.69</td>
<td>0.59</td>
<td>0.45</td>
<td>0.56</td>
<td>2.76</td>
<td>0.58</td>
<td>-0.41</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.22</td>
<td>0.49</td>
<td>0.68</td>
<td>0.55</td>
<td>3.42</td>
<td>0.49</td>
<td>0.23</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.93</td>
<td>0.49</td>
<td>-0.49</td>
<td>0.56</td>
<td>3.59</td>
<td>0.40</td>
<td>-0.72</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.67</td>
<td>0.36</td>
<td>-1.79#</td>
<td>0.55</td>
<td>3.27</td>
<td>0.54</td>
<td>0.10</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>1.99</td>
<td>0.55</td>
<td>0.14</td>
<td>0.55</td>
<td>2.29</td>
<td>0.59</td>
<td>0.37</td>
<td>0.58</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td>2.06</td>
<td>0.243</td>
<td>4.12#</td>
<td>0.55</td>
<td>2.93</td>
<td>0.96</td>
<td>0.15</td>
<td>0.58</td>
</tr>
</tbody>
</table>

\textit{Table 6-3 Student pre-subject analysis (part 3)}

\textsuperscript{14} Registration for tutorials is not enforced nor attendance recorded and adding such a process for this experiment was deemed not permissible when discussed with the ethics committee.
We did not perform non-response rate analysis. This was because the analysis used to compare the pre-subject and post-subject responses was paired t-tests with no sampling and such analysis is not necessary (Sivo et al. 2006).

**Pre-subject norms analysis**

We compared the participants’ responses for all the variables reported by the PSI and ZTPI to reported norms for those instruments. The method used for all norm comparison in this chapter is the same as described in Chapter Five and the same norms were used. The results of the first analysis, pre-subject comparison to the norms are in Table 6-4. Again, any t-test significance of less than 0.05 is considered statistically significant and is highlighted.

We performed all norms analysis with the complete participant group; this was because the teaching design included sections that were for both tutorial streams and activities where students changed tutorial groups. In addition, some of the student groups undertaking assignments comprised both post-graduate and under-graduate also meaning that any more granular analysis was not necessary.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Mean</th>
<th>t-test significance</th>
<th>Norm means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td><em>Problem Solving Confidence</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>(PSC)</em></td>
<td>22.35</td>
<td>0.436</td>
<td>23.21</td>
</tr>
<tr>
<td></td>
<td><em>Approach Avoidance Style (AAS)</em></td>
<td>40.53</td>
<td><strong>0.023</strong></td>
<td>44.32</td>
</tr>
<tr>
<td></td>
<td><em>Personal Control (PC)</em></td>
<td>14.52</td>
<td>0.169</td>
<td>15.43</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td><em>Past Negative (ZTPI-PN)</em></td>
<td>2.74</td>
<td><strong>0.028</strong></td>
<td>2.98</td>
</tr>
<tr>
<td></td>
<td><em>Present-Hedonistic (ZTPI-PH)</em></td>
<td>3.31</td>
<td>0.130</td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td><em>Future (ZTPI-F)</em></td>
<td>3.75</td>
<td><strong>0.002</strong></td>
<td>3.47</td>
</tr>
<tr>
<td></td>
<td><em>Past-Positive (ZTPI-PP)</em></td>
<td>3.47</td>
<td><strong>0.008</strong></td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td><em>Present-Fatalistic (ZTPI-PF)</em></td>
<td>2.45</td>
<td><strong>0.046</strong></td>
<td>2.37</td>
</tr>
</tbody>
</table>

Table 6-4 Student pre-subject norm analysis

The only difference considered statistically significant for the students from the norms for the PSI was for the *AAS*. The students were already significantly higher than the
Teaching IT Architect capabilities

norms for this variable. That is, they respond that they already generated more alternatives for any given problem and evaluated those alternatives prior to taking any problem solving actions. For the ZTPI variables there were four variables that were considered statistically significantly different for the participants from the norms. Those variables and some observations were:

- \( PN \) – The students are less negative about the past than the norm population, that is, they had less negative memories of the past.
- \( F \) – The students are already more oriented towards future than the prior norm respondents,
- \( PP \) – The students are less positive about the past than the norm respondents, that is, they are less likely to interpret past events in a positive manner when asked about them, and
- \( PF \) – The students are less present fatalistic than the norm respondents, that is, they think they have more control over events.

We also compared just the responses to the pre-subject survey of students who completed both the pre-subject and the post-subject surveys. The analysis of those responses are in Appendix L.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving</td>
<td>0.228</td>
<td>0.995</td>
</tr>
<tr>
<td></td>
<td>Confidence (PSC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance</td>
<td>0.691</td>
<td>0.944</td>
</tr>
<tr>
<td></td>
<td>Style (AAS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.558</td>
<td>0.228</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.032*</td>
<td>0.921</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.821</td>
<td>0.289</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic</td>
<td>0.608</td>
<td>0.292</td>
</tr>
<tr>
<td></td>
<td>(ZTPI-PH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.098</td>
<td>0.255</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.971</td>
<td>0.442</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.660</td>
<td>0.767</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.563</td>
<td>0.361</td>
</tr>
</tbody>
</table>

Table 6-5 Students pre-subject tutorial one compared with tutorial two
Pre-subject tutorial group comparison

We then compared the responses for each tutorial group to investigate if there was any significant difference on any of the variables between them\(^\text{15}\), and they are shown in Table 6-5. As these results show, we found no significant differences between the two tutorial groups for any of the variables. Therefore, no movement of students between tutorials was required to balance any such differences.

Pre-subject under versus post-graduate comparison

We also compared the groups of post-graduate and under-graduate participants to evaluate if there were any significant statistical differences for all the variables and this is shown in Table 6-6. We found that, as expected, the post-graduate participants were older than the under-graduate participants were. The under-graduate participants were both more oriented towards the future and more positive about the past.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.174</td>
<td>0.673</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.442</td>
<td>0.678</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.350</td>
<td>0.742</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI_Total)</td>
<td>0.569</td>
<td>0.803</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.682</td>
<td>0.751</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.952</td>
<td>0.277</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td><strong>0.434</strong></td>
<td><strong>0.047</strong></td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td><strong>0.034</strong>(^*)</td>
<td><strong>0.026</strong></td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.498</td>
<td>0.143</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td><strong>0.000</strong>(^*)</td>
<td><strong>0.004</strong></td>
</tr>
</tbody>
</table>

Table 6-6 Students pre-subject under-graduate compared with post-graduate

\(^{15}\) In all cases, if Levene’s test was less than 0.05 then we used the values for t and significance calculated for not normally distributed. In these cases the Levene’s test value has an * beside it in the tables.
6.4 Teaching

6.4.1 Teaching resources design and creation

We began the design of the teaching resources by developing a more detailed description of the two capabilities, and then we defined a teaching approach for those capabilities that was congruent with the structure of the subject. Finally, we developed detailed material for teaching the capabilities. We describe these activities below.

There were two major groups of students in the subject. These two groups were:

1. Under-graduates. These are software engineering bachelor’s degree students, in their fourth year of study. The first two years of this degree involve standard subjects within the university, the third year is an external industry internship, with the fourth year being a combination of a major industry-based capstone project, and masters level elective software engineering subjects (RMIT University 2007d).

2. Post-graduates. These are students enrolled in one of a number of coursework masters degrees (RMIT University 2006), comprising international full-time students, often also working part-time; and local part-time students, working full-time and studying part-time.

The resources we developed were designed to be suitable for both of these groups of students.

More detailed capability description development

Developing a more detailed definition of the targeted capabilities was required to design relevant teaching materials. For this design the Approach Avoidance Style (AAS) is described as “active searching for a variety of alternative solutions and reviewing of previous problem-solving efforts” (Güçray 2003). The Future (ZTPI-F) is described as “present behavior is dominated by a striving for future goals and rewards. … these items suggest an orientation away from focusing on immediate benefits and toward calculating future gains and costs” (Zimbardo & Boyd 1999).
Teaching design and approach

The selected capabilities were taught through problem-based learning (PBL) tutorials (Biggs 2003). PBL was selected because its defining characteristics are (Savin-Baden & Major 2004):

- learning is driven through open-ended problems,
- students work in small collaborative groups,
- a focus on facilitating learning rather than teaching.

Accordingly, the problems presented did not have fixed answers or single solutions, all the activities were group based, and the tutors did not ‘lecture’ instead they facilitated discussion and activities.

We developed two streams of tutorials, one focussed on AAS, the other on ZTPI-F. Each stream has three tutorials, delivered in weeks four, five, and eight of the twelve teaching weeks of the subject. The first two and half of both streams of tutorials covers material specific to the focus area. In the second half of the third tutorial, the students explained and gave examples of the concepts covered in their stream to the students from the other stream. Both tutorial streams included material on personal reflection to encourage deeper student learning (Bain 2004; Biggs 2003). The gap between the first two tutorials and the third tutorial was to allow the students time to use what had been covered in the tutorials as part of their subject assignments, if they chose.

The tutorials were placed within the context of an existing structure of the systems architecture subject and this structure dictated the timing of the tutorials to some extent. For example, focusing on improving students capabilities relating to their future orientation (ZTPI-F) was not appropriate until the implications of future requirements on systems architectures had been covered in the lecture material. This overall design, being material presented in lectures, with associated Problem Based Learning tutorials has been shown to be effective for similar post-graduate subjects (Linge & Parsons 2006).

The research material being supplementary to the existing subject content and objectives dictated the use of tutorials and displacement of lecture material was not
Teaching IT Architect capabilities permitted. Regardless of whether the students participated in the research or not they chose and attended the tutorial streams.

**Detailed teaching material**

*AAS*

Heppner describes Approach Avoidance Style (*AAS*) as the “general tendency of individuals to approach or avoid problem-solving activities” (1988) and “…actively seeking alternatives…” (Heppner & Petersen 1982). From these descriptions of the *AAS*, we focussed the teaching material on the generation of solution alternatives for problems and reviewing the outcomes of the solution attempts. The development of the *AAS* focussed material was also informed by Newell and Simon’s problem solving approach (1972) and also by D’Zurilla & Goldfreid’s (1971) definition of problem solving. They define problem solving as “a behavioral process, whether overt or cognitive in nature, which (a) makes available a variety of potentially effective response alternatives for dealing with the problematic situation and (b) increases the probability of selecting the most effective response from among those various alternatives.”

The first tutorial presented two alternative models for problem solving with the exercises based on the Melbourne 2006 Commonwealth Games, which were underway at the same time as the subject. The first approach was based on Newell & Simon, while the second was based on the Theory of Inventive Problem Solving (TRIZ) (Altshuller, Altov & Shulyak 1996). The associated exercises contrasted the TRIZ approach with Newell and Simon’s approach.

The second tutorial focused on the development of alternative solutions for problems. Two alternative-generation approaches were taught: De Bono’s Six Hat Thinking (2000) and brainstorming (Osborn 1963). The exercises focussed on issues reported in the newspapers relating to the 2006 Commonwealth Games.

The final tutorial had two sections. The first section explored approaches for evaluating possible solutions for problems and focussed on evaluation criteria and alternative evaluation mechanisms (Newell & Simon 1972). In the second section of this tutorial, both the tutorial groups merged. Each group explained the *AAS* and
ZTPI-F objectives and teaching material, depending on which tutorial stream that they had been in. Then all students were placed in mixed groups from both streams and performed additional Commonwealth Games exercises to underline the learning.

**ZTPI-F**

Matching the description of the Zimbardo & Boyd, the ZTPI-F tutorial material focussed on strategic thinking approaches, scenarios and on deepening the students understanding of delays between the initial development or presentation of ideas or proposals and their actual implementation.

The first tutorial aimed to increase students’ awareness of long-term timeframes using material from The Long Now Foundation (2005). Their project to build a clock for a ten thousand years lifespan was the major example for the exercises. The students were asked to consider the issues involved in building such a clock and how ten thousand years compared with many other time spans in history.

For the second tutorial, the teaching material included alternative models of strategic thinking methods for developing and evaluating strategies. Such alternative models of thinking such as “creative abrasion” and similar approaches as discussed in Leonard & Straus (1997) were explained and then explored with exercises also relating to the original planning in the 1990s for the 2006 Melbourne Commonwealth Games.

The first section of the third tutorial focused on scenarios during which the students learnt about such approaches primarily using material from Schwartz (1996) and then explored the use of scenarios using examples again related to the Commonwealth Games. The second half of the tutorial was the same as for the AAS tutorial stream. To reinforce the long-term focus, ZTPI-F tutorials included different quizzes about the dates of common inventions and the elapsed time before they became successful or popular. Details of the tutorials learning objectives and problems are presented in Appendix K.
Teaching IT Architect capabilities

Teaching feedback
Feedback regarding the research during semester was positive from students, tutors, and lecturer. One of the tutors said, “The overall feedback was extremely positive. Many students remarked that having approaches to problem solving being described to them helped them understand how they could tackle problems which arise in this (and other) subjects. Being able to discuss the concepts using a topical problem (such as the Commonwealth Games) was also very useful. It provided a sense of immediacy and context without which they may have struggled to develop the same level of understanding.” Supporting this one student when asked by a tutor said, “we get told to be creative in developing solutions but really have no understanding of how to do it.”

In informal discussions with the researcher, the students’ comments were positive about the material, teaching, and overall intention and approach of the tutorials for the capabilities. They expressed the view that the material was useful and helped them understand both problem solving and thinking about the future. Comments included “I didn’t realise how little I knew about problem solving”, and “I can see how I can use scenarios in my work.”

On reflecting on the feedback, the students found the topic interesting and relevant.

6.5 Post-subject survey administration and processing
The tutorials were held during weeks four, five, and eight of the subject. In week eleven, we asked the students who had participated in the initial survey to complete the survey again. Both the two scales used in the survey, PSI and ZTPI, had previously proven good test/re-test reliability.

We processed all missing values and outliers in the same manner as the prior survey processing, including the pre-subject survey responses and again the responses were normally distributed as reported in Table 6-7, Table 6-8 and Table 6-9. Again, # is used to indicate if the ratio of the skew to skewness standard error is greater than two. This indicates the data is not normally distributed. This was only true for age data, which we did not use for any comparison therefore this did not affect our analysis.
There were 27 students allocated across both tutorials and there was one participant for whom we could not determine his tutorial, making the total number of participants 28, 80% of the initial survey participants. The reason for the reduction in numbers of participants is unknown; however, one student who had responded to the initial survey had withdrawn from the subject, while others had reduced their attendance at tutorials and lectures.

In the following sub-sections, results for various analyses are presented. These are discussed in Section 6.5.5.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>All</th>
<th>Mean</th>
<th>SD</th>
<th>Skew (Std error 0.45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td></td>
<td>24.81</td>
<td>8.59</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td></td>
<td>43.36</td>
<td>10.19</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td></td>
<td>14.78</td>
<td>4.61</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td></td>
<td>82.85</td>
<td>19.88</td>
<td>0.20</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td></td>
<td>2.84</td>
<td>0.43</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td></td>
<td>3.13</td>
<td>0.48</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td></td>
<td>3.66</td>
<td>0.53</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td></td>
<td>3.40</td>
<td>0.52</td>
<td>-0.33</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td></td>
<td>2.24</td>
<td>0.49</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>Age range</td>
<td></td>
<td>2.57</td>
<td>0.92</td>
<td>1.88#</td>
</tr>
</tbody>
</table>

Table 6-7 Student post-subject analysis (part 1)
## Table 6-8 Student post-subject analysis (part 2)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Tutorial 1</th>
<th></th>
<th></th>
<th>Tutorial 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skew</td>
<td>Mean</td>
<td>SD</td>
<td>Skew</td>
</tr>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td>Problem Solving Confidence (PSC)</td>
<td>24.11</td>
<td>8.49</td>
<td>0.33</td>
<td>26.5</td>
<td>9.15</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>41.63</td>
<td>10.85</td>
<td>0.59</td>
<td>47.13</td>
<td>7.62</td>
<td>-0.71</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>14.05</td>
<td>4.74</td>
<td>0.26</td>
<td>16.50</td>
<td>4.04</td>
<td>-0.73</td>
</tr>
<tr>
<td><strong>Overall (PSI Total)</strong></td>
<td></td>
<td>79.79</td>
<td>20.45</td>
<td>0.57</td>
<td>90.13</td>
<td>17.49</td>
<td>-0.77</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective Inventory</strong></td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.87</td>
<td>0.45</td>
<td>0.21</td>
<td>2.77</td>
<td>0.40</td>
<td>-0.18</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.07</td>
<td>0.39</td>
<td>-0.02</td>
<td>3.27</td>
<td>0.63</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.79</td>
<td>0.50</td>
<td>-0.30</td>
<td>3.35</td>
<td>0.47</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.44</td>
<td>0.56</td>
<td>-0.59</td>
<td>3.31</td>
<td>0.43</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.13</td>
<td>0.38</td>
<td>0.29</td>
<td>2.50</td>
<td>0.67</td>
<td>-0.41</td>
</tr>
<tr>
<td><strong>Age range</strong></td>
<td></td>
<td>N/A</td>
<td>2.63</td>
<td>1.01</td>
<td>1.22#</td>
<td>0.52</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Teaching IT Architect capabilities
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Ugrad</th>
<th>Mean</th>
<th>SD</th>
<th>Skew</th>
<th>Std Error</th>
<th>Pgrad</th>
<th>Mean</th>
<th>SD</th>
<th>Skew</th>
<th>Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td></td>
<td>24.14</td>
<td>8.10</td>
<td>0.36</td>
<td>0.60</td>
<td></td>
<td>24.17</td>
<td>9.75</td>
<td>0.43</td>
<td>0.64</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
<td>44.71</td>
<td>10.05</td>
<td>0.58</td>
<td>0.60</td>
<td></td>
<td></td>
<td>41.75</td>
<td>10.96</td>
<td>-0.09</td>
<td>0.64</td>
</tr>
<tr>
<td>Avoidance Style (AAS)</td>
<td></td>
<td></td>
<td>15.57</td>
<td>4.59</td>
<td>0.23</td>
<td>0.60</td>
<td></td>
<td>13.58</td>
<td>4.69</td>
<td>-0.13</td>
<td>0.64</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall (PSI Total)</td>
<td></td>
<td>85.43</td>
<td>19.91</td>
<td>0.30</td>
<td>0.60</td>
<td></td>
<td></td>
<td>79.50</td>
<td>21.04</td>
<td>0.24</td>
<td>0.64</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.76</td>
<td>0.49</td>
<td>0.59</td>
<td>0.62</td>
<td></td>
<td></td>
<td>2.94</td>
<td>0.37</td>
<td>-0.28</td>
<td>0.66</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td></td>
<td>3.21</td>
<td>0.55</td>
<td>0.07</td>
<td>0.58</td>
<td></td>
<td></td>
<td>3.04</td>
<td>0.41</td>
<td>-0.25</td>
<td>0.64</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td></td>
<td>3.72</td>
<td>0.61</td>
<td>0.45</td>
<td>0.60</td>
<td></td>
<td></td>
<td>3.57</td>
<td>0.44</td>
<td>-0.68</td>
<td>0.66</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td></td>
<td>3.49</td>
<td>0.51</td>
<td>-0.68</td>
<td>0.58</td>
<td></td>
<td></td>
<td>3.29</td>
<td>0.56</td>
<td>0.10</td>
<td>0.64</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td></td>
<td>2.16</td>
<td>0.48</td>
<td>-0.09</td>
<td>0.60</td>
<td></td>
<td></td>
<td>2.29</td>
<td>0.52</td>
<td>1.22</td>
<td>0.64</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td>2.00</td>
<td>None</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td>3.25</td>
<td>1.06</td>
<td>-0.04</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Table 6-9 Student post-subject analysis (part 3)
6.5.1 Post-subject norms analysis

Again, we compared the participants’ responses to the same norms as we used for the pre-subject analysis and all the prior comparisons within our research. The results of this analysis are shown in Table 6-10.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Means</th>
<th>t-test significance</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>24.81</td>
<td>0.340</td>
<td>23.21</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>43.36</td>
<td>0.593</td>
<td>44.32</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>14.78</td>
<td>0.469</td>
<td>15.43</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.84</td>
<td>0.120</td>
<td>2.98</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.13</td>
<td><strong>0.002</strong></td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.66</td>
<td>0.078</td>
<td>3.47</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.40</td>
<td><strong>0.004</strong></td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.24</td>
<td>0.197</td>
<td>2.37</td>
</tr>
</tbody>
</table>

Table 6-10 Student post-subject norm analysis

These results show that there were no differences considered statistically significant between the norms for the PSI variable results. This is different from the pre-subject responses where the value for AAS was considered statistically significantly different from the norm population. These results are discussed in the final section of this chapter.

For the ZTPI responses, these results show that the students at the completion of the subject were considered statistically significantly different from the prior norm groups for the variables PH and PP. That is, the post-subject students were more focused on present pleasures and were more positive about the past than the norm groups. The result for the PP variables is similar to those in the pre-subject analysis. For the other variables, there are differences:

- Before the teaching the students were less Past Negative (ZTPI-PN) than the norm population, now they are similar to that population,
The post-subject responses are no longer significantly different from the Future \((ZTPI-F)\) norm, that is, they no longer have a longer term view, and

- The participants are no longer less Present Fatalistic \((ZTPI-PF)\) than the norm population. That is, they do not feel more in control than the normative group.

These results would match our expectation that as the end of the semester approaches students are only focussed on that event and examinations.

### 6.5.2 Pre-subject and post-subject comparison

We compared the pre-subject and post-subject responses in two stages. In the first stage, we compared all participants to the pre-subject survey with all participants of the post-subject survey. For the second comparison, we compared only the students who completed both surveys.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.203</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.278</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.808</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>0.204</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective</strong></td>
<td><strong>Inventory</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.474</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.171</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.497</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.586</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.555</td>
</tr>
</tbody>
</table>

Table 6-11 Comparison of all responses pre-subject and post-subject

For the first comparison, there were no differences considered statistically significant. The results are shown in Table 6-11. This is discussed in the Section 6.5.5.

For the second comparison, there were two differences considered statistically significant as shown in Table 6-12 and discussed in Section 6.5.5.
Table 6-12 Comparison of matched responses pre and post-subject

### 6.5.3 Post-subject tutorial group comparison

We then compared the two tutorial groups using t-tests to investigate if there were any differences considered statistically significant for any of the variables. These analysis results are in Table 6-13.

The only variable considered statistically significant different from the survey results before and after the subject for the different tutorials was \( ZTPI-F \). That is, the tutorial group that had material focused on \( AAS \), not \( ZTPI-F \), had a more long-term perspective towards the future at the end of the subject compared to the future perspective focussed tutorial. We comment on this result in Section 6.5.5.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.933</td>
<td>0.519</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.256</td>
<td>0.207</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.392</td>
<td>0.214</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.326</td>
<td>0.224</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.686</td>
<td>0.632</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.024*</td>
<td>0.411</td>
</tr>
<tr>
<td></td>
<td><strong>Future (ZTPI-F)</strong></td>
<td><strong>0.864</strong></td>
<td><strong>0.040</strong></td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.346</td>
<td>0.529</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.056</td>
<td>0.082</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.149</td>
<td>0.624</td>
</tr>
</tbody>
</table>

Table 6-13 Students post-subject tutorial one compared with tutorial two

6.5.4 Post-subject under-graduate and post-graduate comparison

We compared post-graduate and under-graduates pre and post-subject using t-tests. This analysis showed that the age of the students was the only variable considered statistically different and the analysis results are in Appendix M.

Factorial ANOVA Analysis

We also performed factorial ANOVA analysis to investigate if there was any interaction between a tutorial group and post-graduate or under-graduate status. This is the appropriate form of a General Linear Model (GLM) to use when investigating interaction effects between two variables (Moore & McCabe 2003). Again, our use of SPSS meant that any unbalanced respondent data sets did not affect the calculations. We found no interaction considered statistically significant and the analysis is in Appendix N.
6.5.5 Pre-subject and post-subject comparison

Our results have indicated that the teaching design, within a post-graduate subject, can influence the variables we were measuring. There were changes in the pre and post-subject comparison to the normative group results, and although there was no significant difference in the targeted capabilities (AAS and ZTPI-F), one other problem solving variable that was not the direct focus of the research, Problem Solving Confidence, was significantly different between the start and end of the semester. We discuss possible reasons for these counter-intuitive or unexpected findings in four categories below.

External environment

From student discussion and conversations, external time pressure on the participants was identified as an important influence on the lack of impact of the capability tutorials. For under-graduates the major external pressure was other subjects and assignments, including a major capstone project, while for post-graduates the effort of working while studying may lead to expedient decision-making and short-term behaviours. For both groups of students, there is constant pressure at the end of semester of associated assignments, final assessments and examinations. This may lead to a stronger focus on short-term actions, choosing the single most expedient solution and not evaluating the possible results, all of which lead to low levels for AAS and ZTPI-F. Another possible environmental aspect is that AAS and ZTPI-F related attitudes and behaviour could be influenced by other events outside the university or by other causes that are not obvious to us.

Individual attributes

At the commencement of the subject, the participants were already significantly different from the norms for the variables under study. Therefore, it may have been very difficult to improve further this capability for this cohort of participants. A previous study (Thomas 1998) reported working with students who were lower than the respective norms for the PSI that showed improvement through teaching, however, the participants in that research were students with learning disabilities. One other possible reason for our findings is research by Ericsson (2002), who found
that becoming an expert requires at least ten years of deliberate practice. A single university subject cannot provide this.

**Measures**

Another possible explanation of the findings is that the period between intervention and measurement is too short to observe any effects. The participants may need additional time for reflection, practice and interpretation as we were not measuring simple skills but rather complex capabilities (Dreyfus & Dreyfus 1980; Schön 1995). Thus, we may not see any effects from the teaching until there is a longer delay after the material has been delivered. In addition, it is possible that any differences are only evident after the students had used the techniques we taught a number of times in practice before there is a measurable difference. It is also possible that what we are measuring may not be actually teachable but is a manifestation of some innate personality trait and the instruments are only indirect indicators of the capability.

**Educational**

There are several possible educational reasons for our findings. The change in PSC shows that it is possible to influence some of the student’s problem solving behaviours, in fact, the reduction in PSC suggests that the students are now less confident as they have an increased understanding of the complexity of problem solving through the tutorial material. The students’ written comments in the subject feedback supported this conclusion.

It is possible that there was insufficient time spent learning and reinforcing the concepts underpinning the AAS and ZTP1-F in only three tutorials. Also, the structure, content, and delivery of the material may not have been relevant or focussed enough to affect the study variables. Finally, the capability may have already been determined by prior education, culture or by life experiences and we could not easily affect it through any later educational intervention.

**6.6 One-year later administration and processing**

We re-administered the survey to the post-subject participants in February 2007, twelve months after the initial survey and nine months after the subject was completed. The intention of this was to investigate if there were any influences
Teaching IT Architect capabilities
evident over a longer term with the students and the IT Architect capabilities we were measuring. We used the same survey as we used for pre and post-subject surveys. The only difference was that we distributed the survey by email and the responses were completed and returned using email. Again, the participants had the opportunity of receiving one of two $75 book vouchers for participating.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Skewness (Standard error is 0.56)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>19.31</td>
<td>6.32</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>35.36</td>
<td>5.83</td>
<td>-0.38</td>
</tr>
<tr>
<td></td>
<td>Avoidance Style (AAS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>13.13</td>
<td>4.86</td>
<td>-0.37</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>65.64</td>
<td>11.22</td>
<td>-0.90</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.54</td>
<td>0.79</td>
<td>0.11</td>
</tr>
<tr>
<td>Inventory</td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.08</td>
<td>0.61</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.60</td>
<td>0.84</td>
<td>-0.36</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.64</td>
<td>0.58</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>1.84</td>
<td>0.54</td>
<td>0.04</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td>2.56</td>
<td>1.03</td>
<td>1.48#</td>
</tr>
</tbody>
</table>

**Table 6-14 Students one-year later responses overall**

There were sixteen participants, 46% of the pre-subject participants, and 57% of the post-subject participants. There were no missing values in the responses. We calculated outliers through SPSS using the same techniques as the prior surveys and removed them. The remaining responses were normally distributed and the mean and standard deviations for the different tutorials, all students, and under-graduate and post-graduate are reported in Table 6-14, Table 6-15 and Table 6-16.
Information Technology Architect Capabilities

Again, # is used to indicate if the ratio of the skew to skewness standard error is greater than two. This indicates the data is not normally distributed. This was only true for age data, which we did not use for any subsequent comparison; therefore this did not affect our analysis.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Tutorial 1</th>
<th></th>
<th></th>
<th>Tutorial 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skew</td>
<td>Mean</td>
<td>SD</td>
<td>Skew</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>19.33</td>
<td>5.83</td>
<td>0.50</td>
<td>19.29</td>
<td>7.38</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>35.75</td>
<td>4.46</td>
<td>0.43</td>
<td>34.83</td>
<td>7.73</td>
<td>-0.48</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>12.78</td>
<td>5.12</td>
<td>-0.26</td>
<td>13.57</td>
<td>4.86</td>
<td>-0.65</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>66.25</td>
<td>9.50</td>
<td>-0.26</td>
<td>64.83</td>
<td>14.13</td>
<td>-1.24</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.46</td>
<td>0.82</td>
<td>0.24</td>
<td>2.64</td>
<td>0.81</td>
<td>0.00</td>
</tr>
<tr>
<td>Inventory</td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.05</td>
<td>0.47</td>
<td>0.14</td>
<td>3.11</td>
<td>0.81</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.43</td>
<td>1.02</td>
<td>0.10</td>
<td>3.82</td>
<td>0.53</td>
<td>-0.60</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.51</td>
<td>0.46</td>
<td>0.86</td>
<td>3.79</td>
<td>0.71</td>
<td>-0.90</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>1.85</td>
<td>0.60</td>
<td>0.35</td>
<td>1.84</td>
<td>0.50</td>
<td>0.66</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td>2.44</td>
<td>0.88</td>
<td>1.62#</td>
<td>2.71</td>
<td>1.25</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Table 6-15 Students one-year later responses by tutorial
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Ugrad</th>
<th>Pgrad</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean, SD, Skew, Skew std error</td>
<td>Ugrad</td>
<td>Pgrad</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>18.83, 5.44, -0.31, 0.64</td>
<td>20.75, 9.36, 1.33, 1.01</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>34.82, 5.95, -0.38, 0.66</td>
<td>37.33, 6.03, -0.49, 1.23</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>13.75, 4.50, -0.36, 0.64</td>
<td>11.25, 6.13, -0.7, 1.014</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>66.27, 12.13, -1.13, 0.66</td>
<td>68.33, 8.51, 1.49, 1.23</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.69, 0.77, 0.15, 0.64</td>
<td>2.08, 0.78, 0.01, 1.014</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.19, 0.62, 0.71, 0.64</td>
<td>2.73, 0.51, 1.42, 1.01</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.60, 0.86, -0.41, 0.64</td>
<td>3.60, 0.90, -0.38, 1.01</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.80, 0.52, 0.29, 0.66</td>
<td>3.22, 0.61, -0.49, 1.01</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>1.85, 0.59, 0.13, 0.66</td>
<td>1.83, 0.43, -1.38, 1.01</td>
</tr>
<tr>
<td>Age range</td>
<td>N/A</td>
<td>2.00, 0.00, 0.00, 0.00</td>
<td>4.25, 0.5, 2.00, 1.01</td>
</tr>
</tbody>
</table>

Table 6-16 Students one-year later responses by original enrolment status
Summary of all responses

In Table 6-17, the numbers of responses of each type are summarised. The totals will not match for two reasons. For some responses, we could not determine which tutorial the student was in, for others we could not determine whether they were under-graduate or post-graduate.

<table>
<thead>
<tr>
<th></th>
<th>Post-graduate</th>
<th>Under-graduate</th>
<th>AAS tutorial</th>
<th>ZTP-F tutorial</th>
<th>Total responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-subject</td>
<td>10</td>
<td>23</td>
<td>22</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>Post-subject</td>
<td>10</td>
<td>18</td>
<td>19</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>One-year later</td>
<td>4</td>
<td>11</td>
<td>9</td>
<td>6</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 6-17 Summary of all responses

6.6.1 Post-subject norms analysis

Again, we compared the participants’ responses to the same norms as we used for the pre-subject analysis and all the prior comparison within our research. The results of this analysis are in Table 6-18.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Mean</th>
<th>t-test significance</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>19.31</td>
<td>0.040</td>
<td>23.21</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>35.36</td>
<td>0.000</td>
<td>44.32</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>13.13</td>
<td>0.063</td>
<td>15.43</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.54</td>
<td>0.050</td>
<td>2.98</td>
</tr>
<tr>
<td>Inventory</td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.08</td>
<td>0.066</td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.60</td>
<td>0.723</td>
<td>3.47</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.64</td>
<td>0.614</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>1.84</td>
<td>0.002</td>
<td>2.37</td>
</tr>
</tbody>
</table>

Table 6-18 Student one-year later norm analysis
Teaching IT Architect capabilities

These results show that there were two differences considered statistically significant between the norms for the PSI variable results. Both the participants’ PSC and AAS were higher than the normative group responses. This is different from the pre-subject responses where only the value for AAS was considered statistically significantly different from the norm population. This is discussed in the final section of this chapter.

For the ZTPI responses, these results show that for the responses from the students one-year later than the start of the subject only the ZTPI-PF was considered significantly different from the norm groups. That is, one-year later the students felt more in control about the present than the normative group.

The comparison between all three survey responses for this stage is shown in Table 6-19.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Pre-subject</th>
<th>Post-subject</th>
<th>One-year later</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>None</td>
<td>None</td>
<td>Stronger</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>Stronger</td>
<td>None</td>
<td>Stronger</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>Less</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>None</td>
<td>More</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>More</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>Less</td>
<td>Less</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>Less</td>
<td>Less</td>
<td>Less</td>
</tr>
</tbody>
</table>

Table 6-19 Pre-subject, post-subject, one-year later norms comparison

The student participants were more confident problem solvers (PSC), compared to the norms, one-year after the initial survey than either at the start or end of the subject. The students say they were more likely to approach problems and generate
alternatives (AAS) at the commencement of the subject, than at the end of the subject, however one-year later this difference from the normative group was again evident. While the reason is unknown it could be that the teaching made the participants more aware of problem solving but one-year later they were again less aware. There was no difference for the three different survey administrations in the comparison for Personal Control (PC) as compared to the normative groups.

There were several differences for the ZTPI compared to the norms across the three different survey administrations. At the commencement of the subject the participants were less negative about the past (ZTPI-PN) than the normative groups, whereas they were similar at the end of the subject and again one-year later. This may be due to the pressures and difficulties of the subject and the other university related circumstances. Initially and one-year later the participant group was not considered statistically significantly any more or less hedonistic (ZTPI-PH) than from the normative group however, at the end of the subject was more hedonistic than the normative group. The initial participant group was more oriented towards the future (ZTPI-F) than the normative group, but neither of the subsequent groups was considered statistically significantly different from the normative responses. In addition, the pre-subject and post-subject participants were less negative about the past (ZTPI-PP) than the normative group, whereas the participants one-year later were not considered statistically different from the normative group. The final ZTPI variable, ZTPI-PF evaluates the participant’s fatalism with regard to the present, also described as the participant’s feeling of control or otherwise over current and future circumstances. For this variable, the pre-subject and one-year later participants were less fatalistic than the normative group whereas the post-subject were not considered statistically different from the normative group. One explanation may be that the external and internal pressure of assignments and other assessment close to the end of the subject meant that the participants felt they had limited control.

**6.6.2 One-year later tutorial group comparison**

We then compared the two different tutorial groups using t-tests to investigate if there were any differences considered statistically significant for any of the variables. The results of the analysis are shown in Table 6-20. As this table shows, there was no
Teaching IT Architect capabilities

difference considered statistically significant between the two tutorial groups for any of the variables we were measuring one-year later.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence $(PSC)$</td>
<td>0.993</td>
<td>0.989</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style $(AAS)$</td>
<td>0.143</td>
<td>0.784</td>
</tr>
<tr>
<td></td>
<td>Personal Control $(PC)$</td>
<td>0.915</td>
<td>0.758</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>0.483</td>
<td>0.826</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative $(ZTPI-PN)$</td>
<td>0.629</td>
<td>0.655</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic $(ZTPI-PH)$</td>
<td>0.316</td>
<td>0.848</td>
</tr>
<tr>
<td></td>
<td>Future $(ZTPI-F)$</td>
<td>0.035*</td>
<td>0.334</td>
</tr>
<tr>
<td></td>
<td>Past-Positive $(ZTPI-PP)$</td>
<td>0.648</td>
<td>0.374</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic $(ZTPI-PF)$</td>
<td>0.514</td>
<td>0.984</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.245</td>
<td>0.620</td>
</tr>
</tbody>
</table>

Table 6-20 One-year later tutorial comparison

6.6.3 One-year later under and post-graduate comparison

There were only four post-graduate responses received therefore analysis would not be statistically valid.

6.6.4 Pre-subject and one-year later comparison

We compared the pre-subject and one-year later responses in two stages. For the first, we compared all participants to the pre-subject survey with all participants of the one-year later survey. For the second comparison, we compared only the participants who completed both surveys. For both comparisons, we used paired t-tests.

For the first comparison, there was only one difference considered statistically significant, for the overall PSI value, and the results are in Table 6-21 and discussed in the next major section.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.700</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.110</td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.089</td>
<td>0.274</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.151</td>
<td>0.024</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.183</td>
<td>0.328</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.340</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.001*</td>
<td>0.518</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.504</td>
<td>0.288</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.594</td>
<td>0.084</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.207</td>
<td>0.688</td>
</tr>
</tbody>
</table>

Table 6-21 Comparison pre-subject and one-year later - all responses

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.985</td>
<td>0.448</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.233</td>
<td>0.172</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.025*</td>
<td>0.466</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.430</td>
<td>0.114</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.457</td>
<td>0.865</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.754</td>
<td>0.648</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.044*</td>
<td>0.489</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.423</td>
<td>0.676</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.548</td>
<td>0.243</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.300</td>
<td>0.706</td>
</tr>
</tbody>
</table>

Table 6-22 Comparison pre-subject and one-year later - matched responses

This difference indicates that the group that responded one-year later reported themselves as overall more effective problem solvers than the group that responded to the initial, pre-subject, survey.
Teaching IT Architect capabilities

For the second comparison, there were no differences considered statistically significant. The results are in Table 6-22 and discussed in the final section of this chapter.

### 6.6.5 Post-subject and one-year later comparison

We then compared the post-subject and one-year later responses in two stages. For the first, we compared all participants to the post-subject survey with all participants of the one-year later survey. For the second comparison, we compared only the participants who completed both surveys. All comparisons were paired t-tests.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene’s test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.093</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.034*</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.647</td>
<td>0.272</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td><strong>0.028</strong>*</td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.021*</td>
<td>0.177</td>
</tr>
<tr>
<td>Inventory</td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.284</td>
<td>0.748</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.008*</td>
<td>0.804</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.689</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td><strong>0.689</strong></td>
<td><strong>0.020</strong></td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.666</td>
<td>0.976</td>
</tr>
</tbody>
</table>

**Table 6-23 Comparison post-subject and one-year later - all responses**

For the first comparison, there were three differences considered statistically significant, for the AAS, PSITotal, and ZTPI-PF value, and the results are in Table 6-23 and discussed in the final section of this chapter.

For the second comparison, there was one difference considered statistically significant and the results are in Table 6-24 and discussed in the next major section. One student completed the pre-subject survey and the one-year later survey but not the post-subject survey, so we removed their results from this comparison.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Levene's test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>0.445</td>
<td>0.196</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>0.063</td>
<td>0.076</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>0.895</td>
<td>0.503</td>
</tr>
<tr>
<td></td>
<td>Overall (PSITotal)</td>
<td>0.069</td>
<td>0.044</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>0.022*</td>
<td>0.316</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.810</td>
<td>0.837</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>0.005*</td>
<td>0.736</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.818</td>
<td>0.278</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.232</td>
<td>0.070</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.753</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 6-24 Comparison post-subject and one-year later - matched responses

Again, the results are discussed in the final section of this chapter.

6.6.6 Only matched participants norms comparison

We also compared only the fifteen participants who participated in each survey to the same norms as the overall groups and the summary is in Table 6-25.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Variable</th>
<th>Pre-subject</th>
<th>Post-subject</th>
<th>One-year later</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>None</td>
<td>None</td>
<td>Stronger</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>Stronger</td>
<td>None</td>
<td>Stronger</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>Less</td>
<td>None(*)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>None(*)</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>More</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>None(*)</td>
<td>Less</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>Less</td>
<td>None</td>
<td>Less</td>
</tr>
</tbody>
</table>

Table 6-25 Common students: pre-subject, post-subject, one-year later norms comparison
Teaching IT Architect capabilities

For the matched student responses there were two that were different from the complete group norms comparison and are both marked in Table 6-25 with an asterisk. The matched student set has no differences from the norms for ZTPI-PH regardless of whether pre-subject, post-subject or one-year later. The other difference is that the matched participants pre-subject are the same as the norms responses for being positive about the past.

The comparison against the norms for only the matched student responses are shown graphically in Figure 6-1 and Figure 6-2.

Figure 6-1 Matched responses PSI norms comparison

Figure 6-2 Matched responses ZTPI norms comparison
6.6.7 One-year later and both pre-subject and post-subject comparison

The responses for the one-year later survey showed a change in the comparison with the normative groups. The one-year later responses were more confident in their problem solving, compared to the norms, than any of the other survey participant groups. The comparison for the ZTPI variables also shows that the one-year later participants feel more in control. The other changes and differences relative to the normative groups varied between administrations and did not show a clear tendency. The comparison to the normative group responses of the one-year later responses showed that they were more similar to their pre-subject responses normative group comparison.

One reason for this difference could be that several of the one-year later participants had graduated and this may have affected these comparisons, while another possibility is that the participants had just completed their summer studies break during which many of them were employed and this may have resulted in an increase in variables such as \( PSC \). Alternatively, the teaching intervention had made no long-term impact on the capabilities.

In comparing all the responses the one-year later survey with the pre-subject participants the only difference considered statistically significant was that the one-year later participants reported themselves as overall more effective problem solvers. When comparing only the matched responses between one-year later and pre-subject there were no significant differences in any of these factors.

The comparison between the one-year later survey and the post-subject differences for all respondents had three differences considered statistically significant. The one-year later respondents reported themselves as higher on the \( AAS \) factor and overall \( PSI \). That is, they considered themselves better problem solvers and generated more alternatives to problems than immediately after the subject. They were also significantly higher on the \( ZTPI-PF \) factor and as such, report themselves as being more fatalistic less in control in the present than at the end of the subject. For
Teaching IT Architect capabilities

matched respondents the only difference was that the one-year later results showed they reported themselves as being better problem solvers than post-subject.

Reasons for these differences are unknown, although possibilities include long-term improvement from the teaching, time away from the university environment, impact of other studies during the year, and simply further experience.

6.7 Power analysis for different student responses

We performed post hoc power analysis for each comparison we performed. As we described in Section 5.4.4, this was to determine the likelihood of false negatives. These analyses were again performed using the tool GPower (Erdfelder et al. 1996; Faul et al. 2007). Following Cohen (1988, 1992), for all calculations a medium effect size (d) of 0.5 was used, the analyses were independent t-tests on means, \( \alpha \) of 0.05 were used, and all distributions were two-tailed. The numbers in each population were similarly distributed and as such do not violate the requirements for the power calculation.

There were two groups of comparisons performed. The first group was all respondents for each survey administration compared with all respondents for each other survey administration. The three comparisons of this type, the number of participants in each comparison group, and the resultant power are all shown in Table 6-26 Student unmatched responses power analysis summary. These values show that for the each comparison there is a more than 50\% chance that with additional respondents we may have found additional variables with differences considered statistically significant. That is, due to the number of respondents, there may be other significant differences between the groups being compared that we did not determine (Cohen 1988, 1992; Kitchenham & Pfleeger 2002a).

<table>
<thead>
<tr>
<th>Comparison</th>
<th>N1</th>
<th>N2</th>
<th>1- ( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-subject versus post-subject (unmatched)</td>
<td>35</td>
<td>28</td>
<td>0.4925</td>
</tr>
<tr>
<td>Pre-subject versus one-year later (unmatched)</td>
<td>35</td>
<td>16</td>
<td>0.3688</td>
</tr>
<tr>
<td>Post-subject versus one-year later (unmatched)</td>
<td>28</td>
<td>16</td>
<td>0.3444</td>
</tr>
</tbody>
</table>

*Table 6-26 Student unmatched responses power analysis summary*
The second group of comparisons were between the matched respondents. The first of these was for the pre-subject and post-subject respondents, and the second for the participants who responded to all of the pre-subject, post-subject and on-year later survey administrations. Each of these two comparisons were also performed using GPower, with a medium effect size (d) of 0.5 was used, the analyses were matched t-tests on means, α of 0.05 were used, and all distributions were two-tailed. The resultant power is shown in Table 6-27 Student matched responses power analysis summary and these results show that there was a more than 35% chance that with additional respondents we may have found additional variables with differences considered statistically significant.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>N</th>
<th>1- β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-subject versus post-subject (matched)</td>
<td>28</td>
<td>0.6040</td>
</tr>
<tr>
<td>All passes (matched) (unmatched)</td>
<td>16</td>
<td>0.7227</td>
</tr>
</tbody>
</table>

Table 6-27 Student matched responses power analysis summary

All this analysis was post hoc, as we did not know what the actual response rate from all the students would be at any point during the research. In addition, we surveyed all members of the populations.

6.8 Discussion

The summary of this research stage is discussed in three sections. The first section is some conclusions from this stage; the second section describes some limitations of this stage, while the final section re-visits Chapter Four and Chapter Five and comments in the light of this chapter’s findings.

6.8.1 Implications

A first approach to enhancing two critical capabilities for IT Architects for students studying Systems Architecture was not successful in producing a measurable positive difference in those capabilities. Including targeted teaching of distinguishing IT Architect capabilities within a relevant subject would appear to be an effective manner in which to develop the capabilities. We have shown that this might not be the case. Alternatively, if this is an appropriate approach, any evidence of change in the capabilities may not be measurable. This result is useful for academia and industry in designing alternative approaches for developing these capabilities and
Teaching IT Architect capabilities

opens up a new research area into designing, developing and evaluating educational approaches, and increases our knowledge relating to the acquisition of some capabilities of highly-skilled IT Architect.

Overall, this stage of the research has shown that the approach of teaching focussed material within a single university subject may not be optimal for enhancing some capabilities of highly-skilled IT Architects. In addition, external pressures may inhibit the immediate application of learning of the capabilities for many students. However, it has shown that it is possible to modify student’s perceptions of problem solving through such an approach, which is an important educational result as it indicates that a different teaching approach or similar change may be more successful within the same constraints.

6.8.2 Limitations

There are several limitations in this stage of our research. Only using a single type of educational intervention in this chapter is a major limitation. A different type of intervention, such as including the material within the lectures rather than the tutorials or using IT Architect examples in the teaching may affect the results. The research design for this stage was constrained by ethical considerations, and alternative designs that could not be considered such as the use of control groups or directly connecting the targeted capabilities to assessment may result in different findings from this stage.

No information as to the cultural background of any of the participants was collected or analysed. Other researchers (Hofstede 2001; Trompenaars & Hampden-Turner 2000) have shown that attitude to time, amongst other things, varies by culture and as such that could affect our results. There also was no gender analysis of the participants as the proportion of females was too small for a meaningful sample; again, this could influence the result. In addition, the available data on norms for all variables may have limited applicability for this research. The norms for Zimbardo’s Time Perspective Inventory are developed from American college students, who could be significantly different from our participants. The norms for the PSI are for married Canadian males of different professions within a single study; again, their characteristics may be different from our research participants.
We also had different groups of participants for each of the survey administrations and we had no information as to any of the participant’s attendance at tutorials because RMIT University does not collect this data. In addition, we collected no information about external influences, other than some informal comments, and the scope and time for such influences to influence the participants could have been significant, in particular for the one-year later survey.

In addition, there could have been interaction between the different survey questions. We could have used factor analysis and similar techniques to investigate this. However, we chose not to change the survey questions to maximise repeatability between our research stages and with other studies using those instruments.

Finally, the results for the power calculations and resultant Type II error show that we may have been unable to determine some significant differences due to the lack of respondents for the one-year later survey. Additional respondents may have enabled us to have found additional differences.

6.8.3 Revisit interviews

We re-examined the interviews from the first stage of our research to investigate whether interviewee’s comments were consistent with our results. Their comments support the findings from this stage. Many interviewees identified as critical the need for actual experience, not just education. Some comments that support this from different interviewees are “I just think that experience is worth so much more than qualifications”, “you don’t appreciate that you have learnt it until you’ve got something to contrast it with”, and “experience is the number one driver.” Therefore, not being able to impact some of the previously identified highly-valued capabilities within a university subject would not be unexpected by the interviewees.

Nevertheless, the results in this chapter indicate that the material covered in the subjects relating to problem solving and future orientation did affect the student’s perception and knowledge of those topics. This additional knowledge of capabilities critical for IT Architects could be expected to be of value for students when they are undertaking the role of IT Architect. This was supported by comments from the interviewees described in Chapter Four who stated that education had value for IT
Teaching IT Architect capabilities

Architects with statements such as “good from a background point of view”, and “established my credibility.”

### 6.9 Summary

Within this chapter we have taken the two distinguishing capabilities of IT Architects identified in Chapter Five and included targeted teaching intervention into a post-graduate software engineering subject. We also measured the student’s results for those capabilities with the same instruments as used in Chapter Five. These measurements were done at the start of the subject, at the end of the subject, and then one year later. The results from these three survey administrations were analysed and compared and we found that external pressures overrode any differences in the capabilities they may have been as a result of the teaching intervention.

The next and final chapter of the thesis describes overall conclusions, some limitations of the research, and suggests some areas for further exploration and consideration.
Chapter 7. Conclusions and future work

This final chapter discusses the findings and contribution of each stage of our research. As we have described in Chapters One and Two, the architecture of an Information Technology (IT) system is important for achieving its functional and non-functional requirements. People performing the role of IT Architect design this architecture. Whilst there has been research into characteristics of people in some IT roles, there has been only very limited investigation of IT Architects and similar roles. As these roles are critical, it is highly likely that more highly-skilled IT Architects within industry will support the implementation of improved systems for businesses. Understanding the key characteristics of highly-skilled IT Architects, investigating which capabilities distinguish them from less-skilled IT Architects, and exploring the improvement of such capabilities through education supports the identification and development of more highly-skilled IT Architects. Accordingly, we defined relevant research questions and research methods to explore those questions and undertook the three stages of our research described within this thesis.

In the first stage, described in Chapter Four, we interviewed highly-skilled IT Architects and from these interviews determined characteristics for the IT Architect role. We found that these characteristics were of three types, experience related, personality traits, and capabilities, and that there were characteristics that distinguished the highly-skilled IT Architects. In the second stage, Chapter Five, we surveyed IT Architects and IT Project Managers of differing skill levels and found two statistically significant differentiating capabilities for the highly-skilled IT
Information Technology Architect Capabilities

Architects. We found that there were two capabilities that distinguished highly-skilled IT Architects, being their problem solving approach and their long-term attitude towards time. In the final stage, documented in Chapter Six, we taught material related to those capabilities in a post-graduate subject and measured the changes using the same instruments as in the second stage. We found that we could impact the relevant capabilities for the students, but external pressures outweighed any improvements we could make.

In this chapter, the findings and contributions for each research stage are discussed. We then outline the boundaries of our investigations, suggest future research areas and describe the contributions of this research.

7.1 **IT Architect characteristics findings and contribution**

Through the interviews and subsequent analysis we identified three types of characteristics that are required for highly-skilled IT Architects (Frampton et al. 2005). The first type was personality traits such as creativity, passion, open-mindedness and resilience. The second type was background, including all aspects and stages of the software development lifecycle, prior technical expertise and over ten years of experience within IT. The third characteristic type was capabilities. We identified eight capabilities important for highly-skilled IT Architects. These were analysis, business knowledge, communication, conceptualisation, middle-ground, problem solving, situational politics, and visionary.

7.2 **Highly-skilled IT Architect distinguishing capabilities findings and contribution**

We investigated this research question through a survey built upon four, previously-validated questionnaire instruments. In the survey we investigated four capabilities analysis, conceptualisation, problem solving and visionary. This was done, using four existing, corresponding, psychological measures: the Cognitive Style Inventory (CSI), the Vividness of Visual Imagery Questionnaire (VVIQ), the Problem Solving Inventory (PSI), and Zimbardo’s Time Perspective Inventory (ZTPI). None of these instruments have previously been reported as having been used for investigation of capabilities or characteristics for IT roles.
Conclusions and future work

We used these instruments for three comparisons:

(1) between less skilled and highly-skilled IT Architects,
(2) between IT Architects and Project Managers, and
(3) between highly-skilled IT Architects and Projects Managers compared with less skilled IT Architects and Project Managers.

For the first comparison (Frampton et al. 2006a) we found three statistically distinguishing capabilities of highly-skilled IT Architects where certification was the indication of skill level. These are that the highly-skilled IT Architects:

(1) are more oriented towards the future,
(2) perceive themselves as approaching problems rather than avoiding them.
(3) perceive themselves as being excellent problem solvers.

None of these differences have been reported for IT Architects in prior research.

Using the same instruments in the second comparison between IT Architects and Project Managers we found four differences considered statistically significant. The Project Managers perceive themselves as:

1. More oriented towards the future, and
2. More positive about the past.

Thirdly, the Project Managers are older than the IT Architects, and, fourthly they have more years of experience in IT. No prior research has compared IT Architects and Project Managers.

In the third comparison, again using the same instruments, we compared the highly-skilled IT Architects and Project Managers with the less skilled IT Architects and Project Managers. In this comparison, we found four differences. The highly-skilled IT Architect and Project Managers, as a group, perceive themselves as:

1. More intuitive, and

They were also older and had longer experience in the IT industry than the less-skilled IT Architects and Project Managers. Again, no prior research has compared less-skilled IT Architects and Project Managers with those that are highly-skilled.
7.3 *Experiences teaching IT Architect capabilities*

A first approach to enhancing two of the eight capabilities important for highly-skilled IT Architects for students in a Systems Architecture subject did not show a measurable positive difference in those capabilities (Frampton et al. 2006b). We did find differences considered statistically significant in student responses when they completed the survey instruments at the start and end of the subject, and then one-year later. However, we did not find any such differences for the two capabilities being targeted, Approach Avoidance Style (*AAS*) within the Problem Solving Inventory (*PSI*), and Future Orientation (*ZTPIF*) within Zimbardo’s Time Perspective Inventory (*ZTPI*). Whilst inclusion of targeted teaching within a strongly related subject would appear to be an appropriate manner in which to develop the capabilities, we have found this to be only partially effective or that any evidence of change in the capabilities may not be measurable within the time frames we surveyed the students.

Through addressing these three research questions we have identified characteristics of highly-skilled IT Architects, determined two capabilities that distinguish less-skilled IT Architects from highly-skilled IT Architects, and investigated teaching those distinguishing capabilities within a post-graduate subject.

7.4 *Boundaries of this research*

There are five major boundaries of research scope of this thesis. The first of these is that all the IT Architects involved in our research were already practicing and skilled; none were novices or beginning IT Architects.

The second scope boundary is that we did not examine intelligence or related concepts such as General Mental Ability (*GMA*). While this might be relevant as a differentiator for IT Architects, as we are investigating capabilities that we can affect through educational activities, because “test score is a better predictor of job performance than any other single measure” (Herrnstein & Murray 1996) it is not the subject of our research. Another characteristic which might distinguish highly-skilled IT Architects is emotional intelligence (*EQ*) (Goleman 2005; Salovey & Mayer 1994; Salovey & Sluyter 1997). However, to date no reliable measure has been found, as
Conclusions and future work

Davies et al. (1998) say “little remains of emotional intelligence that is unique and psychometrically sound”, therefore we have not investigated EQ.

A third area we did not investigate was the capabilities of IT Architects within teams or larger units. Individual aspects contribute to team and larger organisational group aspects therefore an understanding of those is critical before looking at larger people groups and structures. Hence, we focussed on individual capabilities of IT Architects.

Long-term capability development was the fourth major area outside our research scope. While investigating how IT Architect capabilities are developed is important, without understanding which capabilities should be researched such research is of limited value. Accordingly, we focussed on the highly-valued and distinguishing capabilities at the time of the research, which can be used as a focus for later research into the development of those capabilities.

The fifth scope boundary of our research was that it covered Australia and New Zealand for the IT Architects, and Melbourne, Australia based students for the teaching stage. While there may be differences in IT Architect capabilities depending on culture, an initial understanding such as we have developed within a single environment allows later research to more effectively compare and contrast any results.

7.5 Suggestions for future work

There are many areas of future investigation suggested by our research results. We describe them in this section.

Background and experience

Our investigation into the preferred background or experience for highly-skilled IT Architects was based only on interview analysis. Further and more detailed investigation into required education, work experience, including the detailed analysis of the number and content of prior roles and jobs of highly-skilled IT Architects, would be valuable for identifying and developing future highly-skilled IT Architects. One aspect of this could be exploring the impact of skills transferability between roles
and employers (Lee 2005) on the effectiveness of highly-skilled and less skilled IT Architects.

**Capabilities not investigated**

There were four capabilities that we identified that we did not investigate through the survey instruments. Each of these, business knowledge, communication, middle-ground, situational politics would be appropriate for further investigation. The use of other frameworks or taxonomies to investigate these could be appropriate, for example for more detailed analysis of business knowledge a suitable approach could be through analysis and comparison using a taxonomy such as that of Bassellier & Benbasat (2004).

**Personality traits**

From the interviews, we identified distinguishing personality traits for highly-skilled IT Architects. Investigating whether there was any difference from a quantitative perspective using a standard personality instrument, for example NEO (Costa Jr & McCrae 1992) or an alternative instrument (Hendriks, Hofstee & Raad 1999; Hendriks, Perugini, Angleitner, Ostendorf, Johnson, De Fruyt, Hrebickova, Kreitler, Muramaki, Bratko, Conner, Nagy, Rodriguez-Fornells & Ruisel 2003) would be of value. Similarly, investigating IT Architects’ Myers-Briggs profiles (Myers et al. 1998; Smith 1988) has been suggested as important by industry (Handler 2005) and supported by academia (Witt & Burke 2002) and would be valuable. Exploring what IT Architects regard as critical for their careers, such as career anchors (Schein 1978; Sumner & Yager 2004; Sumner, Yager & Franke 2005) would also be valuable in increasing knowledge relating to highly-skilled IT Architects.

**Samples selection**

Repeating the interviews and subsequent analysis with a wider range of IT Architects including some from software package suppliers would be useful to extend the results from this stage of our research. In addition, repeating the survey with different companies that have mechanisms for differentiating highly-skilled and less skilled IT Architects and then comparing the results with ours would provide additional insight into the capabilities of IT Architects and allow comparison on other grounds such as organisation culture and geographic location. The Open Group’s certification for IT
Conclusions and future work

Architects (Cozzi 2003b; Open Group 2005) may provide an appropriate survey population and a larger sample size, especially for females.

Organisational and industrial
We have investigated individual IT Architects. The capabilities required for highly-skilled IT Architects may not be the same for different organisation structures or when IT Architects are working in teams or other organisation units. Therefore, investigation of the capabilities and characteristics within different organisations structures and units would be valuable. Another area of useful investigation would be, investigating what are the required capabilities for highly-skilled IT Architects, at different points in the Software Development Life Cycle, or when working in different types of projects or industries.

Cultural and gender related
Culture (Hofstede 2001; Trompenaars & Hampden-Turner 2000) affects people’s attitudes towards time, the gathering of experience and others factors we have shown to be relevant for highly-skilled IT Architects. Hunter and Beck (1996) have found that there were differences in cultural perceptions of what is an ‘excellent’ systems analyst and Leidner (2006) has called for additional cultural research within Information Systems. Accordingly, future research investigating differences in characteristics required for highly-skilled IT Architects from a cultural perspective would be valuable. Similarly, research exploring any differences from a gender perspective would be useful. Recent research investigating gender typing of critical attributes for IT consulting (Joshi & Kuhn 2007) has shown a gender bias in critical attributes. Extending that research for IT Architects would be useful for further understanding about the role and the people who perform it.

Trends in the IT Architect profession
Another area for research would be the understanding and analysis of the impact of the increasing push towards professionalism (Hughes & Thompson 2007) and certification (Adelman 2001; Open Group 2006b; SCIA 2002) of IT Architects and related roles on IT Architect characteristics. For example, will these pressures change or limit IT Architect capabilities?
Education and training
Future research investigating different approaches in the teaching and facilitated learning of IT Architect capabilities would be valuable. Such approaches could include:

- more extensive material, including different and more IT specific examples or industry case studies,
- including the material throughout a complete degree, rather than in a single subject,
- delivering the material in a different manner, such as off-site or within lectures, or without the same time pressures, and
- including assessment components for the capabilities.

Related to university education of IT Architects would be investigating the learning and acquisition of capabilities and other required characteristics in industry.

Theoretical model and comparative analysis
An important area for future research related to our work is the development, testing, and refinement of a theoretical model for IT Architect characteristics including how they might be acquired and developed and how they impact the types and quality of architectures that are constructed. In addition, comparing research into highly-skilled IT Architects with similar research into other fields such as Systems Engineering would be valuable. As we described in Chapter Two, systems engineering researchers, most notably Frank (2002, 2006b) are investigating this topic and whilst we have commenced joint exploration (Frank, Frampton & Di Carlo 2007) there are significant opportunities for broader collaboration.

7.6 Overall research contributions
Each stage of our research produced contributions of value to both academia and industry as described in Section 7.1 and in this section we summarise the overall contribution of our research.

In relation to academia, there are three particular contributions from this research. The first is that we provide additional information about IT Architect education. We provide both information about important characteristics of IT Architects and also
Conclusions and future work

report on initial teaching of some distinguishing capabilities of those highly-skilled IT Architects. This will enable more effective education of students who will become IT Architects through alternative educational designs, and enhance existing curricula and subject material for the role. This contribution will support academia in providing enhanced educational options and additional relevant education and thus support industry in obtaining more highly-skilled IT Architects.

Second, we extend existing knowledge of IT Architects and other IT roles, which will support the enhancement of existing theory relating to IT Roles and facilitate the development of new knowledge specifically for the IT Architect role. These results can be used to build theory that is based on empirical, statistically significant and validated results and strengthens the bridge between academia and industry.

Thirdly our results suggest many areas of future research into the characteristics of different IT roles as well as additional investigation of IT Architects. Future research will increase the knowledge base regarding the IT Architect role and support industry in more effectively recruiting, developing, and retaining highly-skilled IT Architects.

In relation to industry, our results provide valuable information for the selection, development, and education of highly-skilled IT Architects. First, in Stage 1, we identified perceptions of some key characteristics of highly-skilled IT Architects. These results provide valuable information for industry as to what career paths and training are required to develop junior IT Architects and to support further development of people already established in the role to maximise their potential. In Stage 2, using existing survey instruments for this role for the first time, we identified how highly-skilled IT Architects differ from both those who are less skilled and Project Managers. In this way, we provide specific information about distinguishing capabilities of highly-skilled IT Architects and our use of established surveys provides a basis for the derivation of an instrument for use in IT Architect selection and development. This contribution will directly support industry in obtaining more highly-skilled IT Architects.

In conclusion, our research has addressed a significant gap in the existing knowledge of IT personnel and it has extended knowledge relating to IT Architects and provided
a range of findings that directly support academia and industry to enhance the capabilities of people performing the role of IT Architect thereby improving the quality of the IT systems they architect.
Appendices

Appendix A. Interview guide

This guide briefly describes the suggested interview process and questions for the experienced IT Architect interviews that are described in Chapter Four. The interview guide includes both the suggested questions and some of the associated logistics and interview management.

Pre-interview

Initial contact – telephone

Follow-up letter confirming date, time, and location, and including some background to the research and interview.

Day before interview

Logistics

- Tapes & tape recorders
- Consent form copies
- Definition sheet copies

Interview Introduction – 5 minutes

Welcome

Introduce myself; thank them for agreeing to this interview.
Purpose of interview

Research background
The purpose of this research is to increase our understanding of some of the capabilities that characterise IT Architects, investigate what distinguishes IT Architects from other specialised IT professionals, and determine how these capabilities can be improved within an educational environment. To do this an understanding of what successful IT Architects perceive as the key capabilities for IT Architects is essential.

Why is this worth doing?
Carriere et al. (1999) state that, “architecture is increasingly being viewed as a key artifact in realizing an organization’s technical and business goals.” Therefore, the people responsible for creating these architectures are also important to organisations. This research will provide industry with a clearer description of the distinguishing capabilities of IT Architects. This will allow organisations themselves to more effectively select and develop IT Architects and thereby improve the resultant architectures that are developed.

For educational institutions, such as RMIT University, a better understanding of the distinguishing characteristics of IT Architects, and how some of these may be improved, will enable improved teaching of IT Architects and a clearer focus on the capabilities to be fostered within students and will inform subject content and curriculum development.

In addition, the research area of IT Architects is very sparsely covered. This research will provide insight into this area and be a basis for further IT Architect related research.

This interview
In this interview, I plan to ask you for:

1. Some background information on your role, responsibilities, and experience,
2. What capabilities you think are required for IT Architects, and
3. What you look for if hiring, training, and/or selecting IT Architects.

With your consent, I am taping the interview for later transcription & analysis.
Context & planned usage of interview information

- Confidentiality & privacy
  - Other than your name and your current role & responsibilities, and a summary of your experience, no personal information is being collected in this research. This information will be stored in a secure manner, made anonymous for purposes of analysis & collation, and will not be disclosed or reported on in any manner that enables identification of the interviews.

- Consent form
  - Could you please read, and if it is acceptable, sign the consent form for this interview.

- Tape-recording
  - Thank you, here is the tape recorder.\(^{16}\)

Definitions & descriptions\(^{17}\)

**IT Architect**

“The IT Architect defines – architects – solutions to client business problems through the reasoned application of information technology. Those solutions are manifested as architectures and can include systems, applications and process components. They may also involve the application and integration of a broad variety of products, technologies and services, various systems and applications architectures, and diverse hardware and software components.” (Cozzi 2003b)

**Capability**

“Combination of attributes, qualities, skills and knowledge that enables a person to perform to a high standard in a given context and role” (Scott 1999a)

---

\(^{16}\) The tape recorder will only be turned on at this point. Also remember to keep the tape recorder away from any paper and other noises.

\(^{17}\) If required for interview.
Background – 10 minutes

Experience

Suggested questions
1. Could you please give a summary of your career so far?
2. What do you think have been the highlights related to IT Architecting?
3. How long have you been an IT Architect?

Personal

Suggested Questions
1. Age?
2. Qualifications?

Role & responsibilities

Suggested Questions
1. Could you please briefly explain what your current role is?
2. Within that role, what are you responsible for?
3. Why do you do this role?
   a. Upsides?
   b. Down-sides?

Question area: What do you think makes you good at being an IT Architect? – 20 minutes

- Sub-question: What capabilities do you think make you good at being an IT Architect?
- Sub-question: In relation to being an IT Architect, what are your strengths & weaknesses?
- Sub-question: What capabilities do you think make other IT Architects good at being an IT Architect?

Any examples?
Question area: What capabilities do you look for when hiring or training new IT Architects? – 15 minutes

- Sub-question: Which of these capabilities are the most important?
- Sub-question: Which of these capabilities are the least important?
- Sub-question: What might have you strongly recommend against them?

Any examples?

Closing – 5 minutes
Anything else you would like to say?

What are your outside interests? Hobbies?

After this turn off tape recorder.

Who else would you suggest I interview?
- How could I contact them?
- Can I use your name?

What happens next?
The interviewed will be transcribed; I will send you a copy of the transcription so you can confirm that it is OK. The identifying information will be removed from the transcription and the transcription will be analysed for capabilities etc and combined with the results of similar analysis from other interview transcriptions. This will then be the basis for a candidate set of IT Architect capabilities that will be further researched with surveys.
More information?

Ethics related
Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.

Project related
For anything relating to this research in general, please contact me, Keith Frampton.

Thank you!

Immediately after interview

Logistics
- Label tapes
- Check tapes

Day after interview
- Thank you letter with copy of signed consent form
- Transcription organise
- Load memory stick recordings onto PC
- Update logs etc
- Review notes and make any immediate additions & comments

After transcription
- Send copy to interviewee, if wanted
Appendices

**Appendix B. Material sent to interviewees**

This appendix includes the three documents that were sent to the interviewees prior to the interview. The first document is the plain language statement for the research, the second is the informed consent form, while the third are definitions of IT Architect and capability as background to the interview.

**Plain Language Statement**

**Invitation to Participate in a Research Project**

**Project Information Statement**

**Project Title:** Identifying and improving capabilities of IT architects

**Principal Investigator:** Keith Frampton, Ph D student

**Phone:** xxxxx xxx xxx

**Table: Supervisor Details**

<table>
<thead>
<tr>
<th>Supervisors</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr James Thom, Senior Lecturer, School of Computer Science &amp; Information technology, RMIT University</td>
<td>(03) xxxxx-xxxx</td>
<td><a href="mailto:xxx@xxx.edu.au">xxx@xxx.edu.au</a></td>
</tr>
<tr>
<td>Dr Jennie Carroll, Senior Lecturer, Department of Information Systems, The University of Melbourne</td>
<td>(03) xxxxx-xxxx</td>
<td><a href="mailto:xxx@xxx.edu.au">xxx@xxx.edu.au</a></td>
</tr>
</tbody>
</table>

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or ‘plain English’. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.
Who is involved in this research project? Why is it being conducted?

The investigators are Keith Frampton, James Thom, and Jennie Carroll, and the project is part of Keith Frampton’s Doctor of Philosophy (PhD) studies. This project has the approval of the RMIT University Human Research Ethics Committee.

Why have you been approached?

You have been recommended by colleagues as a skilled and successful IT architect, located in Melbourne, with extensive experience across a range of projects. These recommending colleagues were either personally known by the investigators, or were referred by other senior IT people personally known by the investigators.

What is the project about? What are the questions being addressed?

The purpose of this project is to increase our understanding of some of the capabilities that characterise skilled IT architects. In particular, the purpose of this activity is to address the question “What capabilities are important for the role of IT architect?”

If I agree to participate, what will I be required to do?

If you agree to participate you will be interviewed. The interview will have three sections. In the first section of the interview we will ask some personal information such as years of experience and educational background. In the second section you will be asked what capabilities do you think make you effective as an IT architect, and in the third section you will be asked what capabilities you are looking for if your are selecting or training IT architects.

What are the risks associated with participation?
Appendices

There are no risks associated with your participation outside your normal day-to-day work activities.

**What are the benefits associated with participation?**

There are no immediate benefits to your participation in this study. However, if you would like, we will send a summary of findings and conclusions to you on completion of the project.

**What will happen to the information I provide?**

All information is confidential, and participation is entirely voluntary. We will be audiotaping the interview and taking notes. The audiotapes of the interviews will be transcribed, however, before this is done, any identifying information relating to the person being interviewed will be removed. The audiotape transcriptions and interview notes will only be analysed by the three investigators.

Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission.

**What are my rights as a participant?**

Your rights as a participant are:

- The right to withdraw your participation at any time, without prejudice,
- The right to have any unprocessed data withdrawn and destroyed, provided it can be reliably identified,
- The right to have any questions answered at any time.

By participating in the interview, we assume you have given consent to using this information for our research. We plan to publish the analysis of the interviews in a PhD thesis and in research papers that may be published in journals and at conferences. At no stage in any of these publications will any of the interviewees be
identified by name or organisation. All data will be kept confidential and will be destroyed a minimum of 5 years after the planned completion of the PhD in 2010.

**Who should I contact if I have questions?**

Any further information you require may be obtained by contacting any of the investigators, details above.

If you are happy to participate in this project, please sign the attached form.

Thank you very much for your time.

Keith Frampton  
Principal Investigator  
BSc

Dr James Thom  
Investigator  
BSc(Hons), MSc, PhD (Melbourne)

Dr Jennie Carroll  
Investigator  
BEC, DipEd, Grad Dip Comp, M Comp, PhD

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.
Appendices

Informed Consent Form

RMIT HUMAN RESEARCH ETHICS COMMITTEE

Prescribed Consent Form For Persons Participating In Research Projects Involving Interviews, Questionnaires or Disclosure of Personal Information

PORTFOLIO OF Science, Engineering and Technology
SCHOOL OF Computer Science and Information Technology

Name of participant:

Project Title: Identifying and improving capabilities of IT architects

Name(s) of investigators:
Keith Frampton

Phone: Xxxx

xxx

1. I have received a statement explaining the interviews involved in this project.

2. I consent to participate in the above project, the particulars of which - including details of the interviews - have been explained to me.

3. I authorise the investigator or his or her assistant to interview me.

4. I acknowledge that:

   (a) Having read Plain Language Statement, I agree to the general purpose, methods and demands of the study.

   (b) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.

   (c) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.
(d) The privacy of the information I provide will be safeguarded. However should information of a private nature need to be disclosed for moral, clinical or legal reasons, I will be given an opportunity to negotiate the terms of this disclosure.

(e) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided. Any information, which will identify me, will not be used.

Participant’s Consent

Name: ___________________________ Date: ___________________________

(Participant)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.
Appendices

*Definitions used in the research interview*

**Definitions & descriptions**

1. **IT architect**
   “The IT Architect defines – architects – solutions to client business problems through the reasoned application of information technology. Those solutions are manifested as architectures and can include systems, applications and process components. They may also involve the application and integration of a broad variety of products, technologies and services, various systems and applications architectures, and diverse hardware and software components.” (Cozzi 2003a)

2. **Capability**
   “Combination of attributes, qualities, skills and knowledge that enables a person to perform to a high standard in a given context and role” (Scott 1999b)
Appendix C. Preconceptions and expected findings

The purpose of this appendix is to describe the preconceptions, expectations, biases, etc that I have with regard to the capabilities of good IT architects.

I expect that all good IT architects are familiar with the traps described in my draft document "traps for (young) architects ", which is included after this initial list.

List of preconceptions

Amongst the capabilities that I expect good IT architects to have are:

- abstraction
- conceptualisation
- problem solving
- communication, including written and verbal
- the ability to lead small teams
- a broad understanding of many skill areas of information technology, including project management, all areas of the software development life cycle, product evaluation and selection, etc
- Passion and determination
- negotiation
- being a chameleon, that they are able to take different roles at different times in different projects
- curiosity
- big picture
- skilled at identifying what is critical
- self reflective
- planning
- experience
- seeing the next question, including business requirements and drivers, and planning for the same
- being tolerant of ambiguity
- good at work at an abstract level
Appendices

- visionary
- Evangelical
- Scenario style thinking – for example, “what if …”
- Only want to lead small teams but want to influence large, is this related to I in MBTI?

**Traps for (young) Architects**

This document is a collection and explanation of some common things that inexperienced architects do or do not do that cause themselves problems. However, please be very aware that often these traps are not just for inexperienced but also for architects with extensive experience, skills, and prior successful projects.

**Content seduction**

Content seduction – in other words the architect is ‘seduced’ by the attractiveness of some aspect of the content of the architecture problem space. That is, the situation is that an architect may become too interested in one part of the problem:

1. Either a specific subset of the technology that may be being considered for the solution, or
2. One particular area of the problem domain, such as a security, or one functional requirement.

The trap is that the architect will not consider other areas of technology or the problem domain in sufficient depth to produce an architecture that appropriately satisfies all the stakeholders and meets all the functional & non-functional requirements.

**Delay, delay!**

Delay all decisions as long as possible, this allows more complete requirements to be determined and better understandings of the potential problems to be gained before decisions are made.

Make as many decisions as possible based on facts, do not rush! Allow the requirements to develop as long as possible and then make sustainable decisions.
The trap is that the requirements are less complete than they could be and/or a quick decision is wanted but the right decision is needed.

**Art of assumptions**
Use of assumptions is critical to architecting. Assumptions can be used to (temporarily) put boundaries on scope thereby allowing additional focus on just the area being studied by eliminating the other areas for the time being. Assumptions can also be used to explore alternatives and error/failure situations during the architecting phase. Assumptions **MUST** be documented and included in any architecture document.
They are useful to manage scope, work on areas while others are unclear, and clarify requirements. Understand that you do not and can not know everything.

There are two traps. They are:

1. Not being clear, and/or not communicating, what assumptions you have made, or are operating under, thereby potentially making architectural decisions on incorrect foundations, and
2. By not using assumptions to segment problems attempting to solve the entire architectural problem at once, often leading to “paralysis by analysis”.

**Unbalanced metrics**
Ensure where you use metrics that the effort in collecting the metrics matches their value; also ensure metrics are spread appropriately across all requirements.

The trap is that either metrics are of limited and/or no value, or even distracting, unless the cost/benefit of collecting/using a particular metric or a set of metrics is not of sufficient value.

**Dolphining**
Software architecting requires the ability to operate at multiple levels and to be able to transition from one level to another. In addition, changing levels during the various activities of architecting can assist the architecture team in developing the most appropriate architecture.
Appendices

Explore/analyse/develop your architecture at different levels, detailed where required, high level where appropriate, are able to move between levels of abstraction.

The trap is that if the architecting is only performed at a single level potential areas of problem will not have been sufficiently explored or sufficient levels of abstraction will not have been considered.

**Early closure**

Do not be too quick to decide on the architecture/solution, ensure as many alternatives as possible have been explored.

The trap is that only a limited set of possible architectures and/or solutions may have been considered and the most appropriate may therefore not have been considered.

E³

Otherwise known as elephants, earthquakes & eclipses. It is very rare in Australia for there to be a charging herd of elephants, an earthquake, and an eclipse all at once where most IT systems are deployed & used. Do not architect/design/code for every single, possible thing that might happen, particularly need to be careful you do not over cater for things that might go wrong. Determine the actual likelihood of things occurring, either by analysis or by collection of prior data, then make trade-off decisions accordingly.

The trap is the solution may be over architected and/or over designed and more complex/expensive than required to best satisfy the clients requirements.

**Solution fixation (a.k.a. chisels)**

Often caused by a purchased solution or the architects previous project experience. When a single solution, from a prior system/vendor/etc, is the answer, regardless of the real requirements, ensure that the real requirements/differences are considered. This often manifests itself as “this is the answer, now what is the problem?”

The trap is that viable alternative solutions may not be explored or considered.
Too much certainty
Behavioural trap! Architecting is often ambiguous, if your language/behaviour is too certain then you may not be architecting appropriately! Be comfortable with uncertainty.

The trap is that insufficient attention may be given to alternative approaches, solutions and requirements. In addition, people may not volunteer information if you seem too certain.

Back of the envelope
Often doing a rough calculation can provide information as to the viability or feasibility of a possible architectural approach. For example, $500 per machine for a hardware upgrade is not significant, unless the organisation has 7000 machines, so the cost of the hardware alone, let alone people to install the upgrades, is $3,500,000(!), before any value has been received by the purchasing organisation.

The trap is exploring alternatives in too much detail where a little estimation or rough calculation would have demonstrated the viability or otherwise very early in the project.

Lego
This relates to the use of modelling tools. Most modelling tools do not support the architecting process very well. For example, UML is low level and does not capture/document assumptions/design decisions/alternatives considered very well. Tools such as Lego & Duplo can actually be used for high-level conceptual models. Advantages of such non-technical tools include:

1. Easily accessible for non-technical people
2. Removes technical people from technical details and encourages them to consider conceptual issues rather than physical configuration. For example, it is very hard to look at a bright orange 2x2 block that represents a workstation and be fixated on the amount of memory that the specific workstation has.
3. Are interesting enough that other people want to participate or know about any project using such tools.
Appendices

Use appropriate models; non-technical models like Lego are often useful early in a project, particularly for non-technical stakeholders.

There two traps. These are:

1. Use of technically oriented models may alienate some stakeholders and hinder effective communication with the stakeholders.
2. The converse is that use of inexact modelling tools may allow for unnecessary ambiguity in the architecture and obscure critical decision areas.

Who’s the client?
Software projects often have many clients and the client’s involvement & interest changes at different points during the projects lifecycle. It is critical during any phase/stage of a software engineering project to be very clear who is the primary client for any/all activities being undertaken and any deliverables being produced. Asking the question ‘who’s the client?’ assists in ensuring you are actually addressing the correct client needs and in the most appropriate manner for that client.

Each activity/stage in architecting has different clients/stakeholder focus. Ensure that regardless of what you are doing you are clear who the client is, and what they actually are after.

The trap is you do not actually satisfy the real client!

Danish Question
The trap comes from a financial project that was investigating the use of some Danish software within the Australian market. The project team had spent many, many hours, days, and weeks, speaking with the developers, reviewing detailed technical questions & answers, and seeing demonstrations of the software. Just before a final decision & recommendation was made for a multi-million dollar project one of the project team asked the developers for a set of manuals. The response was “sure, can you read Danish?” None of the manuals, comments, and supporting documents was in English and no one had ever asked!

The trap is by not asking questions critical information may not be volunteered or uncovered and the architecture and associated decisions are impacted as a result.
Dead Moose
It is not unknown that there is a fundamental problem or unsatisfiable requirement associated with the system being architected and that no one is acknowledging the problem. (One reason for this is the person who is the champion is very powerful or is the sponsor of the project or the unworkable approach.) Such issues need to be appropriately raised.

The trap is the problems with the proposed solution may not be evident to other members of the team until significant amounts of time & money have been expended.

Fashion
If it is new, it must be better. For example WAP.

The trap is potentially using something that is very high risk and/or ignoring a perfectly reasonable solution that might be less ‘fashionable’.

Not Invented Here (NIH)
The trap is not learning from the past or other similar solutions.

The method/process is the answer
The trap is following the method and no paying attention to the actual problem and/or requirements.

There is no relevant/appropriate method/process
The trap is “anarchy”, incompatibility and miscommunication.

Five Nines
The traps are:
1. Unreasonable expectations may be set, either in peoples minds, or in formal SLA, and
2. An inappropriate or unaffordable architecture for the problem and/or organisation may be created.
Appendices

**Appendix D. Coding categories and descriptions**

This appendix is the list of the categories and their descriptions used in the analysis of the interviews with skilled IT Architects.

**Behaviours**

**Strong willed/persistent/determined**
Inclined to persist; having staying qualities; tenacious of position or purpose.

**Middle-ground**
Able to stand between IT & the business, or between other organisation or political units, even if it means being a “queue of one”.

**(Self-)Confident**
Showing poise and confidence in your own worth.

**Enthusiastic**
Having or showing great excitement and interest.

**Resilient**
Able to recovering readily from adversity, depression, or the like

**Passionate**
Characterised by passion; expressing passion; ardent in feeling or desire; vehement; warm; as, a passionate friendship.

**Curious**
Eager to investigate and learn or learn more (sometimes about others' concerns).

**Self-reflective**
The ability to consider aspects of your own performance, attitudes and behaviours in order to change or enhance future outcomes. (HILP 2002)

**Myers-Briggs Type Indicator**
MBTI or Myers-Briggs Type Indicator (MBTI).

**Taking long view**
Looks past the immediate time horizon for the system/problem being considered and considers implications of such thinking. This also includes consideration of implications if system/program/application is viable/used for longer than projected time frame.

**Visionary**
Information Technology Architect Capabilities

A person who possesses the ability to imagine how an organisation, system, industry, etc. will develop in the future and to plan in a suitable way.

**Entrepreneurial**
An entrepreneur is a person who habitually creates and innovates to build something of recognized value around perceived opportunities.(Thomson & Bolton 2000)

**Evangelical (on demand)**
Marked by ardent or zealous enthusiasm for a cause. Able to do this when required.

**Skills**
Professional aptitude and "know-how" needed to perform a job or business process. Skills are clearly identifiable and observable. They increase through job experience, performance support and learning.

**Technical**
Skills that are directly related to information technology and its related disciplines.

**Detailed technical domain knowledge**
Currently or previously very skilled in one (or more) technical domain, often acknowledge as expert in that area both inside and outside current organisation.

**Full SDLC**
Knowledge and experience with all aspects of the Software Development LifeCycle (SDLC), from requirements to maintenance & decommissioning of programs/applications/systems.

**Credibility**
One or more areas of expertise (often in past)

**Generalist**
Has more than superficial knowledge about many different interests, in particular of approaches, techniques, and technologies & products.

**Non-technical (professional)**

**Communication**
The activity of conveying information

- Oral – through speech or audio recordings
- Presentation – through presentation of information & ideas, either formal or informal
- Visual – through use of diagrams & pictures
Appendices

- Written – through documents

Ability to see/understand from multiple viewpoints
This is being able to view/understand a problem/solution/proposal from multiple viewpoints, being aware of the differences from those viewpoints.

Negotiation
Negotiation is the process whereby interested parties resolve disputes, agree upon courses of action, bargain for individual or collective advantage, and/or attempt to craft outcomes which serve their mutual interests

Facilitation
“A facilitator is someone who uses knowledge of group processes to formulate and deliver the needed structure for meeting interactions to be effective. The facilitator focuses on effective processes (meeting dynamics) allowing the participants to focus on the content and substance of their work together.” (IAF 2002)

Identifying what is critical
This is the ability to consider issues from a range of perspectives, to understand them and to draw upon appropriate concepts and values in arriving at a critical assessment of them. (HILP 2002)

Analysis
Ability to break material down into its component parts to see interrelationships/hierarchy of ideas.(Bloom 1956)

Planning
A formalised attitude (and process) that involves selecting a rational course of collective action to achieve a future state of affairs. It includes assessing the present state, setting goals, gathering and analysing information, evaluating information, developing budgets, making decisions, and acting.

Cultural awareness/change
Having knowledge or cognizance of different cultures and implications of such differences. This is not only difference between various social cultures but also organisation cultures.

Background/experience

Education
Education record, primarily formal education, but significant informal also included.

Experience
Roles and/or projects undertaken since leaving school, often expressed in terms of employers.

**Motivations**

The driving forces within that cause an individual to act in order to achieve a specific goal.

**Values**

These are the beliefs of a person or social group in which they have an emotional investment (either for or against something).

**Pragmatic**

Guided by practical experience and observation rather than theory, proposes approaches solutions that are viable and are likely to be reasonable. No ivory towers.

**Power-related**

What forms of power are important to the person? According to (Handy 1993), there are six types. These are:

- Physical power i.e. superior force
- Resource power - inc control of rewards
- Position power, thru role or position in the org
- Expert power, thru acknowledged expertise
- Personal power, charisma, popularity etc
- Negative power inc power to stop things happening

**Capabilities**

A capability is defined as the:

“Combination of attributes, qualities, skills and knowledge that enables a person to perform to a high standard in a given context and role.” (Scott 1999a)

**Abstraction**

This is the act or process of leaving out of consideration one or more properties of a complex object so as to attend to others. Thus, when the mind considers the form of a tree by itself, or the colour of the leaves as separate from their size or figure, the act is called abstraction.
Appendices

**Conceptualisation**
This is inventing or contriving an idea or explanation and formulating it mentally.

**Big picture thinking**
Being able to take a macro view of the entire area, not just the specific minutiae of the problem/domain at hand.

**Scenario style thinking**
This is the using scenarios for exploration & understanding, as well as to gather information. A scenario is a technical term usually used to describe an image of the future deliberately crafted for planning or foresight purposes. It should be rooted in identifiable trends or emerging issues data, which are extrapolated, and organized using an explicit theory of social change. It should describe how changes created the particular future present out of the past, and offer a vivid, provocative, accessible picture of how the future present differs from today. Scenarios are often evaluated in terms of plausibility and probability; they should contain both opportunities and threats – they are statements of possible future outcomes.

**Being tolerant of ambiguity**
Being able to be tolerant with the state of things being doubtful or indistinct in meaning or capable of being understood in more than one way.

**Seeing the next question**
Looking for what is the next hurdle/barrier/objections/problem/opportunity when consider the current situation and possible solutions/alternatives.

**Problem solving**
The creative application of various rules, procedures, techniques, or principles to solve complex problems where there is no single correct answer. A method involving clear definition of the problem confronted, formation of hypothetical solutions, and tests of the hypotheses, until evidence warrants acceptance of a hypothesis.

**Creative**
Being able to think outside the box, also, having unusual ideas and innovative thoughts, and to be able to put things together in new and imaginative ways.

**Flexibility**
The extent to which and the rate at which adjustments to changed circumstances are possible.

**Multiple roles**
Able to take multiple roles, depending on the situation and what is needed.
Open-minded
Ready to entertain new ideas.

Management/leadership
Leadership is the art of creating an environment and influencing people to willingly follow a chosen direction. It requires a clear vision and guides followers along a path that realises the vision. Leadership directly affects the opinions and attitudes of people, leading to changes in individual's behaviour then group behaviour. Leadership helps individuals and groups accept uncertainty, because they have confidence that the leader will provide solutions to any problems that may arise.
Whereas, management is the administration of a business concern or public undertaking, management includes the actions of planning, organising, directing, coordinating, controlling and evaluating the use of people, money, materials and facilities to accomplish missions and tasks.

Small team leading
Prefers to lead teams of fifteen or less, rather than large organisations and/or project teams.

Mentoring
Mentoring is an educational process where the mentor serves as a role model, trusted counsellor or teacher who provides opportunities for professional development, growth and support to less experienced individuals in career planning or employment settings. Individuals receive information, encouragement and advice as they plan their careers.

Business related
Understanding of the purposes, objectives, strategies of the business, and the implications of this information.

Identify IT opportunities
Being able to identify opportunities that IT could provide to the business.
Appendices

Appendix E. Transcript extracts and coding examples

The appendix is in two sections. The first section includes unedited extracts from two of the interviews. The purpose is to illustrate the nature of the questions and the responses that were used during the first stage of the research. While the second section includes samples from two different interviews and the associated coding produced from NVivo.

Interview Transcript Examples

Transcript Extract One

Keith: So, what…what do think are the things that are necessary to be good at that job?

Response: Communication skills…um…maybe a good level of experience in various industries where you’ve been client facing so you’ve crossed that part of software development life cycle where you’re seeing the problems that might ask for this, it doesn’t get done, it comes back, it doesn’t happen so you can see the breakdown in the …methodologies that are being applied and you’ve worked in other areas where you’ve got a methodology that does work and you can go sit back and think well I can see this happen in this scenario so you could say forth sight based on experience…um…I don’t know of a lot of formal education as far as what IT Architects do and things like that.

Keith: A working definition of IT Architect that I am using is here…but that doesn’t mean that that is correct? (cough)

Response: Yeah, that’s one, that’s probably a bit closer to what you’re speaking about when you are describing consultant rightly or wrongly, it isn’t just the technology this could be all of services and what are the kind of business problems and speaks about the processes as well not just the technical infrastructure, rightly or wrongly but that’s just the nature of what I’m working on.

Keith: So what’s your strengths when you’re doing that?
Response: When I’m doing…?

Keith: Consulting role.

Response: Certainly I think its my communication skills. Good at talking to people. Perhaps too much in a casual way, but conversation that’s not too much focused on work, but …um… I think coming to a weakness. I think I’m very good…

Keith: That was the next question.

Response: Maybe we’ll work on the weakness then come to the strength.

Keith: Sure

Response: I find often when I’m engaging a client to identify their needs and stuff I get the needs at a higher level, but because potentially my lack of domain knowledge in that area I need to go away and assimilate that knowledge. So if I were doing it, you know, this is the one bang interview this is the only opportunity you’ve got to identify these client’s requirements, I don’t think I would be very good at all, because often I need to sit there and really think, and that’s a lot more difficult to do in a one on one interview type situation. If I can then do the questions that I can come up with and think about on the spot go away think about that start analysing it they always lead to lots more questions, and I think the scenario where you only have the one bang this is your only opportunity; 1: its doomed to failure, but 2: it is unrealistic.

Keith: I’m sorry I’m not planning to interview you again. (Laugh)

Response: (Laugh)… I’m unstructured.

Keith: That’s fine mate. No, no that’s fine. So is that the, …for you…

Response: For me I think it’s a weakness that I need to go away and think a lot more. Necessarily I tend to be an analytical type personality so I like to try and think through thinks…talk through scenarios and things usually when I think I have got everything I can think of I’ll take that away and analyse it at the end and then invariably you have to go back and keep reiterating. You do have to find a level where you cut that off and say well OK we’re going to start progressing. It doesn’t
mean you can't go back if you want, but you need to start progressing the solution…um…The area of weakness often I feel that I don't get enough out of that initial contact, that may be a lack of formal analytical skills…um…So strength, probably my enthusiasm to solve the problem. My general nature is to try and help people.

**Transcript Extract Two**

**Keith:** So, if you're gonna hire somebody, so is this somebody who isn't necessarily yet successful in the role…

**Response:** Yep

**Keith:** …What would you be looking for?

**Response:** Well, I…

**Keith:** What are your indicators?

**Response:** …Um, obviously, you know, some good, technical background and understanding, um, but I think the ability to, to think beyond the square, to, you know, to, to, um, to understand that, um, you know, the world is bigger than an IT solution, to, um, I, I, I think just, just people who have got the ability to, to, to think about options and alternatives and the implications around those, um, and be practical and pragmatic in terms of what is needed um, um, what and need to know, you know, educational background and so forth, um, experience and, and, and its hard to, to, ah, to get that out of an interview because, ah, but, but, you know, just, just to, um, sit down and talk to people in terms of what they see as important about IT Architecture, um, you, you can usually see, what, what, what drives them, um, and a lot of them and a lot of them are very technically-oriented and that’s fine, um, I think, um, ah, that the ones that’ve been successful have, probably come from the opposite direction, probably more from a, um, not necessarily IT technician’s as such, but, people who have got a, a broader, um, experience, or, or educational background.
Keith: In terms of experience, what would you be looking for?

Response: In hiring somebody?

Keith: Yeah

Response: (Sigh), well, I mean, that obviously depends on the circumstances at the time, but if you’re looking just generally at a, hiring an IT Architect, um, experience, in terms of, being, being through and seeing a number of different, um, issues and problems within different organisations and so forth and experiencing, formulating, um, architectural frameworks, um, implement, implementing them, or seeing them partway through their, their, their natural, um, progress, and, um, being able to communicate effectively and, you know, and relate well at, at most levels of, of an organisation, um, but yeah, what we’re looking for consulting architects, and, rather than, yeah, in-house architect within an organisation…

Keith: I’ll comment about that later, cos I can give you a number of people who are in-house

Response: Yep, so, so that, so that, you know, there’s probably a different role

Keith: What would turn you off, in an interview? What’s the one thing they would do?

Response: (Sigh), I suppose start talking of, right down the depths of detail, um, I mean, I must say, whenever, I’ve recruited IT Architects in a number of different lives, you know, I’ve, I’ve recruited, I’ve, sorry, I’ve interviewed them for one reason and got somebody else to interview them from a, a technical, technology point of view

Keith: I seem to remember having role (laughs)

Response: Yep (laughs)
Appendices

**Keith:** I can think of a couple in that category (laughs)

**Response:** And, and, and yeah, you’ve gotta recognise your weaknesses But yeah, that’s to verify the, have you got the basic um, skill and experience, to, to, to, to do that fundamental architectural type work, um, but yeah, I spose, I’d put more value, in terms of the, the relationship, um, the business acumen type of, of skills, and, and, that’s assuming that they’ve got the, the fundamental technology skills there already. But, um, yeah, um, don’t know whether I can say any more about that

**Keith:** No, that’s fair enough, cos, I don’t have much else to ask anyway.

**Response:** (Laughs)

**Keith:** No, no, no, it, cos that gives me the flavour I’m aware of some of the things that you’ve done and as you said, you’ve been hiring and you’ve been working with them, so, it’s an interesting tape, um…

**Response:** Yeah, I think, um, IT Architects have obviously gotta be good at strategy as well, um, so, um, you know, you have to kind of understand, what of the options are available to you, strategically and how that would, you know, support that business specific business issues, understand problem, um, so that kind of analytical skill, that abil, ability to, to identify various alternatives, alternative approaches and analyse the implications of, of going down one path against another, and once again, articulate clearly to the business, but, yeah…

**Keith:** Anything else you’d like to…

**Response:** Just walk on water, you know
Transcript extracts and coding examples

Interview A

Response: Um ... (cough) at a high level which they don't see me at ... they will actually I think cross that over into helping define solutions ... but ... from the model they have because they respond to tenders ... excuse me ... because they are responding to tenders ... um ... they already get ready made requirements, documents and stuff ... um ... while they are allowed to ask a lot more questions, they generally don't cos the questions that get asked will get distributed to all the other competitors, so they tend to take what is in the tender document and work with that, yet to me, that is a restricted way of working but a necessary evil for their business ... um ... for me a consultant is probably a combination of the business analyst and the IT architect where they're working with a client and what is more of a consulting role, not interested in who's doing the other work but interesting in researching the client to find out actually what are their needs, wants and requirements are and defining some structure around that, say well, anyone that comes in and does this work needs to structure it this way to fit in with your policies and necessary to fit in with your current infrastructure or they need to supply a solution that is replacing those things that are necessary but that comes down to the client.

Keith: So, what ... what do think are the things that are necessary to be good at that job?

Response: Communication skills ... um ... maybe a good level of experience in various industries where you've been client facing so you've crossed that part of software development life cycle where you're seeing the problems that might ask for this, it doesn't get done, it comes back, it doesn't happen so you can see the breakdown in the methodologies that are being applied and you've worked in other areas where you've got a methodology that does work and you can go sit back and think well I can see this happen in this scenario so you could say forthright based on experience ... um ... I don't know of a lot of formal education as far as what IT architects do and things like that.

Keith: A working definition of (inaudible) that I am using is (inaudible) ... but that doesn't mean that that is correct' (cough)

Response: Yeah, that's one, that's probably a bit closer to what you're speaking about when you are describing consultant rightly or wrongly, it isn't just the technology this could be all of services and what are the kind of business problems and speaks about the processes as well not just the technical infrastructure, rightly or wrongly but that's just the nature of what I'm working on.


Interview B

Keith: That's fair enough.

Response: No, I wouldn't classify Scott as an architect.

Keith: Interesting, OK.


Keith: Interesting OK.

Response: Scott hasn't got as much depth. Um, he's a good guy, he certainly has um a lot of the concepts and things but I don't think he has the depth um of understanding in the broader IT marketplace that we need and that and I think all good organisations need that, they need you need to have people who know and understand our current architecture and our current systems and processes but we also need people who are able to market scan and understand what's happening in other parts of the industry and how those could impact or change our current um systems and applications that we use and I don't think Scott's quite as broad as that.

Keith: So um talking about architects then um what do you think makes all the capabilities ??? IT ???

Response: Vision um and so some of the things I've just mentioned are fairly important, I think they need to have a detailed understanding of how our systems and processes interact or interact today, probably not always um to the depth that you would anticipate because uh they don't have to be able to write you know Cobol, or they don't have to write in C, or they don't have to write in VB, they just have to understand how the, how those systems interact with one another and what are the key factors within those systems that will help to drive change or will impinge on the ability for flexibility or connectivity between systems. And processes so it doesn't, I'm not, I don't think architects have to be original coders or programmers or whatever they say, um they don't have to be ah in fact if you were to classify me as an IT architect it's a classic example where I've never been one um while I've been trained on some of those things I don't use them in anger ah but I understand enough to, to reach of them to be able to identify how they all link together. So um understanding um the current, how all the current systems interact with one another understanding the limitations of those systems and applications and um understanding how they're used by the company um because applying them is very different to the reality of what they may,
Appendix F.  Plain language statement and professional survey

The appendix is the plain language statement and the IBM IT Architect and Project Manager survey for second stage of the research. For the survey, each instrument only has the instructions and an example question. Page breaks and other minor formatting have also been removed.
**Plain Language Statement**

**Invitation to Participate in a Research Project**

**Project Information Statement**

**Project Title:** Identifying and improving capabilities of IT architects

**Principal Investigator:** Keith Frampton, Ph D student  
**Phone:** 0407 518 323

**Supervisors:**
- Dr James Thom, Senior Lecturer, School of Computer Science & Information Technology, RMIT University  
- Dr Jennie Carroll, Senior Lecturer, Department of Information Systems, The University of Melbourne

**Phone:**
- (03) xxx-xxxx  
- (03) xxxx-xxxx

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or ‘plain English’. Please read this sheet carefully and make sure that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

**Who is involved in this research project? Why is it being conducted?**
The investigators are Keith Frampton, James Thom, and Jennie Carroll, and the project is part of Keith Frampton’s Doctor of Philosophy (PhD) studies. This project has the approval of the RMIT University Human Research Ethics Committee.

**Why have I been approached?**

You are a member of either the IT Architect or Project Manager profession within IBM Australia and New Zealand.

**What is the project about? What are the questions being addressed?**

The purpose of this project is to increase our understanding of some of the capabilities that characterise IT Architects and differentiate them from Project Managers. In particular, the purpose of this activity is to address the question “*What capabilities are important for the role of IT architect?*” (We expect that there will be between 50 and 100 respondents to the questionnaire.)

**If I agree to participate, what will I be required to do?**

If you agree to participate you will be asked to complete a questionnaire. The questionnaire should take less than 30 minutes to complete. The questionnaire will ask a series of questions related to different capabilities that may be important in the role of IT Architect or Project Manager.

**What are the risks associated with participation?**

There are no expected risks associated with your participation outside your normal day-to-day work activities.

**What are the benefits associated with participation?**

There are no immediate benefits to your participation in this study.

**What will happen to the information I provide?**

All information is anonymous. The completed questionnaires will be first sent to Bruce Crossman, Technical Strategy Program Manager, in IBM, and he will remove all identifying information before sending the data to the investigators. Please note that participation is entirely voluntary.

Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission.

Because of the nature of data collection, we are not obtaining written informed consent from you. Instead, we will assume that you have given consent by your completion and return of the questionnaire.
Appendices

**What are my rights as a participant?**

Your rights as a participant are:

- The right to withdraw your participation at any time, without prejudice,
- The right to have any unprocessed data withdrawn and destroyed, provided it can be reliably identified,
- The right to have any of your questions answered at any time.

By completing and returning the questionnaire, we assume you have given consent to using this information for our research. We plan to publish the analysis of the questionnaires in a PhD thesis and in research papers that may be published in journals and at conferences. At no stage in any of these publications will any of the respondents be identified by name. All data will be kept confidential and will be destroyed a minimum of 5 years after the planned completion of the PhD in 2010.

**Who should I contact if I have questions?**

Any further information you require may be obtained by contacting any of the investigators, details above.

Keith Frampton  
Principal Investigator  
BSc

Dr James Thom  
Investigator  
BSc(Hons), MSc, PhD

Dr Jennie Carroll  
Investigator  
BEd, DipEd, Grad Dip Comp, M Comp, PhD

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745.
Professional Survey

Introduction

First, thank you for reading this before completing this questionnaire!

This questionnaire has five sections. The first four sections are related to possible capabilities that might be important for IT Architects and Project Managers when undertaking those roles. The fifth section requests some personal information, which will be kept confidential and anonymous. This personal information is important because it will be used for analysing if the number and professions of the respondents are representative, and for differentiating the response of the IT Architects and Project Managers.

Each section has a different format and requires different responses. Except for the personal data, there are no correct or preferred responses for ANY of the questions. The questionnaire can either be completed electronically or on paper.

Anonymity
All information is anonymous. The completed questionnaires will be first sent to IBM Contact, Technical Strategy Program Manager, in IBM, and he will remove all identifying information before sending the data to the investigators.

Confidentiality
No identification of any person completing this questionnaire will be published; only statistical analysis of the responses will be undertaken. Also, IBM and RMIT University have signed a joint non-disclosure agreement covering the overall project and IBM will review any documents and reports prior to publication.

Key dates
Please return this questionnaire by 12th September 2005 to IBM Contact.

Participation Incentive
Please complete and return this questionnaire to be in the draw for one of two A$75 book vouchers.

Section 1
Appendices

People differ in the way they think. Below are 38 statements designed to identify your own approach. If you believe that a statement is true about you, answer T. If you believe that it is false about you, answer F. If you are uncertain whether it is true or false, answer using ?. This is not a test of your ability, and there are no right or wrong answers. Simply choose the one response which comes closest to your own opinion. Work quickly, giving your first reaction in each case, and make sure that you respond to every statement.

Indicate your answer by overtyping the appropriate oval opposite the statement with an ‘X’:

<table>
<thead>
<tr>
<th>T</th>
<th>True</th>
<th>?</th>
<th>Uncertain</th>
<th>F</th>
<th>False</th>
</tr>
</thead>
</table>

Example: The kind of work I like best is that which requires a logical, step-by-step approach.

Section 2

Directions: People respond to personal problems in different ways. The statements on this inventory deal with how people react to personal difficulties and problems in their day-to-day life. The term “problems” refers to personal problems that everyone experiences at times, such as depression, inability to get along with friends, choosing a vocation, or deciding whether to get a divorce. Please respond to the items as honestly as possible so as to most accurately portray how you handle such personal problems. Your responses should reflect what you actually do to solve problems, not how you think you should solve them. When you read an item, ask yourself: “Do I ever behave this way?” Please answer every item.

Read each statement and indicate the extent to which you agree or disagree with that statement, using the scale provided. Mark your responses by entering an ‘x’ in the column to the right of the statement corresponding to the number.

1. Strongly Agree
2. Moderately Agree
3. Slightly Agree
4. Slightly Disagree
5. Moderately Disagree
6. Strongly Disagree
Example. When a solution to a problem has failed, I do not examine why it didn’t work.

Section 3
The aim of this test is to determine the vividness of your imagery. The items of the test will bring certain images to your mind. You are to rate the vividness of each image by reference to the accompanying rating scale, which is shown below. For example, if your imagery is "vague and dim" you give it a rating of 4. Record your answer in the brackets provided after each item. Just put the appropriate number after each item. Before you rate the vividness of any images, please familiarise yourself with the different categories on the rating scale. Throughout the test, refer to the rating scale when judging the vividness of each image.

Please do not refer back to check on other items you have done. Try to do each item separately and independent of how your may have done other items.

The image aroused by an item of this test may be:

- Perfectly clear and as vivid as normal vision rating 1
- Clear and reasonably vivid rating 2
- Moderately clear and vivid rating 3
- Vague and dim rating 4
- No image at all, you only "know" that you are thinking of the object rating 5

An example of an item on the test would be one which asked you to consider an image which comes to your mind's eye of a red apple. If your visual image was moderately clear and vivid you would check the rating scale and type three in the brackets as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example5. A red apple</td>
<td>( 3 )</td>
</tr>
</tbody>
</table>

Section 4
Appendices

**Directions:** People respond to time in different ways. Please read each item, and as honestly as you can, please answer the following question for each item: “How characteristic or true is this of you?” Please answer every item.

Mark your responses by entering an ‘x’ in the column to the right of the statement corresponding to the number.

1. Very characteristic
2. Characteristic
3. Neutral
4. Uncharacteristic
5. Very uncharacteristic

---

**Example. Happy memories of good times spring readily to mind.**

---

**Section 5 - PERSONAL INFORMATION**

<table>
<thead>
<tr>
<th>&lt; 30</th>
<th>30-39</th>
<th>40-49</th>
<th>&gt; 49</th>
</tr>
</thead>
<tbody>
<tr>
<td>How old are you please?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How long have you been employed by IBM or IBM GSA? _____ years
How long have you been in the IT Industry? _____ years
What is your IBM profession (IT Architect /Project Manager)?
_____________________
Are you certified (yes or no)? ________

**Key dates**

Again, please return this completed questionnaire by 12th September 2005 to IBM Contact to go in the draw for one of two A$75 book vouchers.

Thank you!
**Appendix G. Overall response characteristics**

Within the tables below # indicates that the ratio of the absolute value of skewness to skewness standard error is greater than two, and that the data is not normally distributed. However, as there were more than fifteen respondents within each group t-test are still appropriate to use for comparison (Moore & McCabe 2003).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertified IT Architects</th>
<th>Certified IT Architects</th>
<th>All IT Architects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skewness (Standard error is 0.32)</td>
</tr>
<tr>
<td>Cognitive Style Index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSI</td>
<td>41.85</td>
<td>10.30</td>
<td>0.04</td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>23.29</td>
<td>7.44</td>
<td>0.48</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>40.22</td>
<td>9.61</td>
<td>0.18</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>14.12</td>
<td>4.60</td>
<td>0.14</td>
</tr>
<tr>
<td>Overall (PSI Total)</td>
<td>78.02</td>
<td>19.28</td>
<td>0.02</td>
</tr>
<tr>
<td>Vividness of Visualisation Questionnaire</td>
<td>VVIQ</td>
<td>36.97</td>
<td>12.04</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.65</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.20</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.51</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.46</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.41</td>
<td>0.55</td>
</tr>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years in IT</td>
<td>19.88</td>
<td>7.36</td>
<td>0.46</td>
</tr>
<tr>
<td>Age Range</td>
<td>2.84</td>
<td>0.79</td>
<td>-0.18</td>
</tr>
</tbody>
</table>

G-1 Overall characteristics for IT Architects
## Appendices

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertified Project Managers</th>
<th>Certified Project Managers</th>
<th>All Project Managers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skewness (Standard error is 0.46)</td>
</tr>
<tr>
<td>Cognitive Style Index</td>
<td>CSI</td>
<td>43.20</td>
<td>12.04</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td>Problem Solving Confidence (PSC)</td>
<td>21.59</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>Approach Avoidance Style (AAS)</td>
<td>40.60</td>
<td>9.24</td>
</tr>
<tr>
<td></td>
<td>Personal Control (PC)</td>
<td>15.09</td>
<td>3.97</td>
</tr>
<tr>
<td></td>
<td>Overall (PSI Total)</td>
<td>76.88</td>
<td>13.61</td>
</tr>
<tr>
<td>Vividness of Visualisation Questionnaire</td>
<td>VVIQ</td>
<td>33.78</td>
<td>9.31</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td>Past Negative (ZTPI-PN)</td>
<td>2.69</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.17</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Future (ZTPI-F)</td>
<td>3.71</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.69</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.27</td>
<td>0.47</td>
</tr>
<tr>
<td>Demographic</td>
<td>Years in IT</td>
<td>21.00</td>
<td>7.21</td>
</tr>
<tr>
<td></td>
<td>Age range</td>
<td>3.00</td>
<td>0.83</td>
</tr>
</tbody>
</table>

### G- 2 Overall characteristics for Project Managers
### Information Technology Architect Capabilities

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Uncertified Respondents</th>
<th>All Certified Respondents</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Skewness (Standard error is 0.27)</td>
</tr>
<tr>
<td>Cognitive Style Index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSI</td>
<td>42.43</td>
<td>10.89</td>
<td>-0.5</td>
</tr>
<tr>
<td>Problem Solving Inventory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>22.82</td>
<td>6.59</td>
<td>0.59#</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>40.49</td>
<td>9.37</td>
<td>0.00</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>14.49</td>
<td>4.34</td>
<td>0.03</td>
</tr>
<tr>
<td>Overall (PSI Total)</td>
<td>77.91</td>
<td>17.30</td>
<td>0.03</td>
</tr>
<tr>
<td>Vividness of Visualisation Questionnaire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VVIQ</td>
<td>36.44</td>
<td>12.07</td>
<td>0.78#</td>
</tr>
<tr>
<td>Zimbardo’s Time Perspective Inventory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>2.68</td>
<td>0.60</td>
<td>-0.18</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.19</td>
<td>0.50</td>
<td>0.27</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>3.57</td>
<td>0.39</td>
<td>-0.12</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.54</td>
<td>0.55</td>
<td>-0.40</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.36</td>
<td>0.52</td>
<td>0.43</td>
</tr>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years in IT</td>
<td>20.37</td>
<td>7.263</td>
<td>0.44</td>
</tr>
<tr>
<td>Age Range</td>
<td>2.90</td>
<td>0.80</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

G- 3 Overall characteristics for all respondents
Appendices

**Appendix H. Survey factorial ANOVA detailed results**

All factorial ANOVA analyses were performed to investigate if there was any interaction between the respondent’s certification status and profession. All other factors were used as the dependent variable in the analyses reported in this appendix. (Please note that these are copied from SPSS and reflect SPSS fonts and formatting.)

The R-Squared values are all less than 10%, therefore, over 90% of the variable results cannot be explained by any interactions between the variables of certification and profession (Moore & McCabe 2003). In addition, we used R-Squared rather than Adjusted R-Squared for this comparison as we were using the complete population of IT Architects rather than a sample (Moore & McCabe 2003).

### Dependent variable: CSI

**Tests of Between-Subjects Effects**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1394.930(b)</td>
<td>3</td>
<td>464.977</td>
<td>3.431</td>
<td>.018</td>
<td>10.294</td>
<td>.764</td>
</tr>
<tr>
<td>Intercept</td>
<td>242587.796</td>
<td>1</td>
<td>242587.796</td>
<td>1790.174</td>
<td>.000</td>
<td>1790.174</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>34.560</td>
<td>1</td>
<td>34.560</td>
<td>.255</td>
<td>.614</td>
<td>.255</td>
<td>.079</td>
</tr>
<tr>
<td>Cert</td>
<td>811.802</td>
<td>1</td>
<td>811.802</td>
<td>5.991</td>
<td>.015</td>
<td>5.991</td>
<td>.682</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>166.597</td>
<td>1</td>
<td>166.597</td>
<td>1.229</td>
<td>.269</td>
<td>1.229</td>
<td>.197</td>
</tr>
<tr>
<td>Error</td>
<td>23578.868</td>
<td>174</td>
<td>135.511</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>310254.000</td>
<td>178</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>24973.798</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .056 (Adjusted R Squared = .040)

### Dependent variable: PSI-PSC

**Tests of Between-Subjects Effects**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>286.683(b)</td>
<td>3</td>
<td>95.561</td>
<td>2.466</td>
<td>.064</td>
<td>7.397</td>
<td>.605</td>
</tr>
<tr>
<td>Intercept</td>
<td>66854.623</td>
<td>1</td>
<td>66854.623</td>
<td>1725.014</td>
<td>.000</td>
<td>1725.014</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>26.039</td>
<td>1</td>
<td>26.039</td>
<td>.672</td>
<td>.414</td>
<td>.672</td>
<td>.129</td>
</tr>
<tr>
<td>Cert</td>
<td>145.816</td>
<td>1</td>
<td>145.816</td>
<td>3.762</td>
<td>.054</td>
<td>3.762</td>
<td>.488</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>35.203</td>
<td>1</td>
<td>35.203</td>
<td>.908</td>
<td>.342</td>
<td>.908</td>
<td>.158</td>
</tr>
<tr>
<td>Error</td>
<td>6588.518</td>
<td>170</td>
<td>38.756</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>88949.000</td>
<td>174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>6875.201</td>
<td>173</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .042 (Adjusted R Squared = .025)

### Dependent variable: PSI-AS

225
### Information Technology Architect Capabilities

**Tests of Between-Subjects Effects**

**Dependent Variable: PSI-AAS**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>606.315 (b)</td>
<td>3</td>
<td>202.105</td>
<td>2.239</td>
<td>.085</td>
<td>6.717</td>
<td>.559</td>
</tr>
<tr>
<td>Intercept</td>
<td>219331.740</td>
<td>1</td>
<td>219331.740</td>
<td>2430.023</td>
<td>.000</td>
<td>2430.023</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>247.792</td>
<td>1</td>
<td>247.792</td>
<td>2.745</td>
<td>.099</td>
<td>2.745</td>
<td>.378</td>
</tr>
<tr>
<td>Cert</td>
<td>440.117</td>
<td>1</td>
<td>440.117</td>
<td>4.876</td>
<td>.029</td>
<td>4.876</td>
<td>.593</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>205.386</td>
<td>1</td>
<td>205.386</td>
<td>2.276</td>
<td>.133</td>
<td>2.276</td>
<td>.323</td>
</tr>
<tr>
<td>Error</td>
<td>15524.571</td>
<td>172</td>
<td>90.259</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>289630.000</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>16130.886</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  
b  R Squared = .038 (Adjusted R Squared = .021)

**Dependent variable: PSI-PC**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>75.919 (b)</td>
<td>3</td>
<td>25.308</td>
<td>1.301</td>
<td>.276</td>
<td>3.902</td>
<td>.343</td>
</tr>
<tr>
<td>Intercept</td>
<td>28839.726</td>
<td>1</td>
<td>28839.726</td>
<td>1482.230</td>
<td>.000</td>
<td>1482.230</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>28.803</td>
<td>1</td>
<td>28.803</td>
<td>1.480</td>
<td>.225</td>
<td>1.480</td>
<td>.227</td>
</tr>
<tr>
<td>Cert</td>
<td>66.851</td>
<td>1</td>
<td>66.851</td>
<td>3.436</td>
<td>.065</td>
<td>3.436</td>
<td>.454</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.119</td>
<td>1</td>
<td>.119</td>
<td>.006</td>
<td>.938</td>
<td>.006</td>
<td>.051</td>
</tr>
<tr>
<td>Error</td>
<td>3366.058</td>
<td>173</td>
<td>19.457</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>38190.000</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>3441.977</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  
b  R Squared = .022 (Adjusted R Squared = .005)

**Dependent variable: PSI-Total**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1734.832 (b)</td>
<td>3</td>
<td>578.277</td>
<td>2.069</td>
<td>.106</td>
<td>6.208</td>
<td>.523</td>
</tr>
<tr>
<td>Intercept</td>
<td>80645.061</td>
<td>1</td>
<td>80645.061</td>
<td>2885.832</td>
<td>.000</td>
<td>2885.832</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>304.456</td>
<td>1</td>
<td>304.456</td>
<td>1.089</td>
<td>.296</td>
<td>1.089</td>
<td>.180</td>
</tr>
<tr>
<td>Cert</td>
<td>1318.574</td>
<td>1</td>
<td>1318.574</td>
<td>4.718</td>
<td>.031</td>
<td>4.718</td>
<td>.579</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>680.355</td>
<td>1</td>
<td>680.355</td>
<td>2.435</td>
<td>.121</td>
<td>2.435</td>
<td>.342</td>
</tr>
<tr>
<td>Error</td>
<td>47766.448</td>
<td>171</td>
<td>279.453</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1052887.000</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>49521.280</td>
<td>174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  
b  R Squared = .035 (Adjusted R Squared = .018)

**Dependent variable: VVIQ**

226
Appendices

**Tests of Between-Subjects Effects**

### Dependent Variable: VVIQ

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>532.172(b)</td>
<td>3</td>
<td>177.391</td>
<td>1.357</td>
<td>.258</td>
<td>4.071</td>
<td>.357</td>
</tr>
<tr>
<td>Intercept</td>
<td>201498.729</td>
<td>1</td>
<td>201498.729</td>
<td>1541.336</td>
<td>.000</td>
<td>1541.336</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>166.232</td>
<td>1</td>
<td>166.232</td>
<td>1.272</td>
<td>.261</td>
<td>1.272</td>
<td>.202</td>
</tr>
<tr>
<td>Cert</td>
<td>251.759</td>
<td>1</td>
<td>251.759</td>
<td>1.926</td>
<td>.167</td>
<td>1.926</td>
<td>.281</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>150.610</td>
<td>1</td>
<td>150.610</td>
<td>1.152</td>
<td>.285</td>
<td>1.152</td>
<td>.187</td>
</tr>
<tr>
<td>Error</td>
<td>22354.822</td>
<td>171</td>
<td>130.730</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>268119.000</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>22886.994</td>
<td>174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a* Computed using alpha = .05  
*b* R Squared = .023 (Adjusted R Squared = .006)

### Dependent variable: ZTPI-PN

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.248(b)</td>
<td>3</td>
<td>.416</td>
<td>1.202</td>
<td>.310</td>
<td>3.607</td>
<td>.319</td>
</tr>
<tr>
<td>Intercept</td>
<td>1036.427</td>
<td>1</td>
<td>1036.427</td>
<td>2995.561</td>
<td>.000</td>
<td>2995.561</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>.893</td>
<td>1</td>
<td>.893</td>
<td>2.582</td>
<td>.110</td>
<td>2.582</td>
<td>.359</td>
</tr>
<tr>
<td>Cert</td>
<td>.271</td>
<td>1</td>
<td>.271</td>
<td>.782</td>
<td>.378</td>
<td>.782</td>
<td>.142</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.526</td>
<td>1</td>
<td>.526</td>
<td>1.521</td>
<td>.219</td>
<td>1.521</td>
<td>.232</td>
</tr>
<tr>
<td>Error</td>
<td>60.202</td>
<td>174</td>
<td>.346</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1324.740</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>61.450</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a* Computed using alpha = .05  
*b* R Squared = .020 (Adjusted R Squared = .003)

### Dependent Variable: ZTPI-PH

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.932(b)</td>
<td>3</td>
<td>.311</td>
<td>1.236</td>
<td>.298</td>
<td>3.708</td>
<td>.327</td>
</tr>
<tr>
<td>Intercept</td>
<td>1580.109</td>
<td>1</td>
<td>1580.109</td>
<td>6283.949</td>
<td>.000</td>
<td>6283.949</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>.002</td>
<td>1</td>
<td>.002</td>
<td>.008</td>
<td>.929</td>
<td>.008</td>
<td>.051</td>
</tr>
<tr>
<td>Cert</td>
<td>.690</td>
<td>1</td>
<td>.690</td>
<td>2.743</td>
<td>.099</td>
<td>2.743</td>
<td>.377</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.040</td>
<td>1</td>
<td>.040</td>
<td>.158</td>
<td>.692</td>
<td>.158</td>
<td>.068</td>
</tr>
<tr>
<td>Error</td>
<td>43.753</td>
<td>174</td>
<td>.251</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1928.929</td>
<td>178</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>44.685</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a* Computed using alpha = .05  
*b* R Squared = .021 (Adjusted R Squared = .004)

### Dependent variable: ZTPI-F
### Information Technology Architect Capabilities

#### Tests of Between-Subjects Effects

**Dependent Variable: ZTPIF**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.853(b)</td>
<td>3</td>
<td>.618</td>
<td>3.858</td>
<td>.011</td>
<td>11.575</td>
<td>.816</td>
</tr>
<tr>
<td>Intercept</td>
<td>1987.035</td>
<td>1</td>
<td>1987.035</td>
<td>12415.613</td>
<td>.000</td>
<td>12415.613</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>.234</td>
<td>1</td>
<td>.234</td>
<td>1.465</td>
<td>.228</td>
<td>1.465</td>
<td>.225</td>
</tr>
<tr>
<td>Cert</td>
<td>.582</td>
<td>1</td>
<td>.582</td>
<td>3.638</td>
<td>.056</td>
<td>3.638</td>
<td>.475</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.589</td>
<td>1</td>
<td>.589</td>
<td>3.682</td>
<td>.057</td>
<td>3.682</td>
<td>.479</td>
</tr>
<tr>
<td>Error</td>
<td>27.527</td>
<td>172</td>
<td>.160</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2362.811</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>29.380</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  

b  R Squared = .063 (Adjusted R Squared = .047)

**Dependent variable: ZTPI-PP**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.538(b)</td>
<td>3</td>
<td>.513</td>
<td>1.829</td>
<td>.144</td>
<td>5.488</td>
<td>.469</td>
</tr>
<tr>
<td>Intercept</td>
<td>1859.824</td>
<td>1</td>
<td>1859.824</td>
<td>6636.262</td>
<td>.000</td>
<td>6636.262</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>1.349</td>
<td>1</td>
<td>1.349</td>
<td>4.812</td>
<td>.030</td>
<td>4.812</td>
<td>.588</td>
</tr>
<tr>
<td>Cert</td>
<td>.117</td>
<td>1</td>
<td>.117</td>
<td>.417</td>
<td>.520</td>
<td>.417</td>
<td>.968</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.065</td>
<td>1</td>
<td>.065</td>
<td>.231</td>
<td>.631</td>
<td>.231</td>
<td>.077</td>
</tr>
<tr>
<td>Error</td>
<td>48.484</td>
<td>173</td>
<td>.280</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2271.877</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>50.021</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  

b  R Squared = .031 (Adjusted R Squared = .014)

**Dependent variable: ZTPI-PF**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.969(b)</td>
<td>3</td>
<td>.323</td>
<td>1.235</td>
<td>.299</td>
<td>3.705</td>
<td>.327</td>
</tr>
<tr>
<td>Intercept</td>
<td>777.677</td>
<td>1</td>
<td>777.677</td>
<td>2973.632</td>
<td>.000</td>
<td>2973.632</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>.107</td>
<td>1</td>
<td>.107</td>
<td>.408</td>
<td>.524</td>
<td>.408</td>
<td>.097</td>
</tr>
<tr>
<td>Cert</td>
<td>.330</td>
<td>1</td>
<td>.330</td>
<td>1.260</td>
<td>.263</td>
<td>1.260</td>
<td>.201</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.308</td>
<td>1</td>
<td>.308</td>
<td>1.177</td>
<td>.279</td>
<td>1.177</td>
<td>.190</td>
</tr>
<tr>
<td>Error</td>
<td>44.982</td>
<td>172</td>
<td>.262</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>986.111</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>45.951</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  

b  R Squared = .021 (Adjusted R Squared = .004)

**Dependent Variable: Age**
### Tests of Between-Subjects Effects

**Dependent Variable: Age**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>8.281 (b)</td>
<td>3</td>
<td>2.760</td>
<td>4.835</td>
<td>.003</td>
<td>14.504</td>
<td>.900</td>
</tr>
<tr>
<td>Intercept</td>
<td>1372.993</td>
<td>1</td>
<td>1372.993</td>
<td>2404.818</td>
<td>.000</td>
<td>2404.818</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>1.710</td>
<td>1</td>
<td>1.710</td>
<td>2.996</td>
<td>.065</td>
<td>2.996</td>
<td>.406</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>.216</td>
<td>1</td>
<td>.216</td>
<td>.378</td>
<td>.539</td>
<td>.378</td>
<td>.094</td>
</tr>
<tr>
<td>Error</td>
<td>94.204</td>
<td>165</td>
<td>.571</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1721.000</td>
<td>169</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>102.485</td>
<td>168</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* a Computed using alpha = .05
* b R Squared = .081 (Adjusted R Squared = .064)

**Dependent variable: Years in IT**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>465.947 (b)</td>
<td>3</td>
<td>155.318</td>
<td>3.043</td>
<td>.030</td>
<td>9.129</td>
<td>.707</td>
</tr>
<tr>
<td>Intercept</td>
<td>70554.305</td>
<td>1</td>
<td>70554.305</td>
<td>1382.279</td>
<td>.000</td>
<td>1382.279</td>
<td>1.000</td>
</tr>
<tr>
<td>Profess</td>
<td>52.363</td>
<td>1</td>
<td>52.363</td>
<td>1.026</td>
<td>.313</td>
<td>1.026</td>
<td>.172</td>
</tr>
<tr>
<td>Cert</td>
<td>250.101</td>
<td>1</td>
<td>250.101</td>
<td>4.900</td>
<td>.028</td>
<td>4.900</td>
<td>.595</td>
</tr>
<tr>
<td>Profess * Cert</td>
<td>1.826</td>
<td>1</td>
<td>1.826</td>
<td>.036</td>
<td>.850</td>
<td>.036</td>
<td>.054</td>
</tr>
<tr>
<td>Error</td>
<td>8630.268</td>
<td>173</td>
<td>51.042</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>93562.000</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>9296.215</td>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* a Computed using alpha = .05
* b R Squared = .050 (Adjusted R Squared = .034)
Appendix I. Material for student participants

This appendix contains the material that was provided to potential student participants in Stage Three of the research. There were two document provided, a plain language statement of the research, and an informed consent form for their participation.

Plain Language Statement

Invitation to Participate in a Research Project

Project Information Statement

**Project Title:** Identifying and improving capabilities of IT architects

**Principal Investigator:** Keith Frampton, Ph D student  
**Phone:** xxxx xxx xxx

<table>
<thead>
<tr>
<th>Supervisors:</th>
<th>Phone:</th>
<th>Email:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr James Thom, Associate Professor, School of Computer Science &amp; Information Technology, RMIT University</td>
<td>(03) xxx-xxxx</td>
<td><a href="mailto:xx@xxx.edu.au">xx@xxx.edu.au</a></td>
</tr>
<tr>
<td>Dr Jennie Carroll, Senior Lecturer, Business Information Systems, University of Sydney</td>
<td>(02) xxx-xxxx</td>
<td><a href="mailto:xx@xxx.edu.au">xx@xxx.edu.au</a></td>
</tr>
</tbody>
</table>

Computer Science and Information Technology

Building 10, Level 10  
124 La Trobe Street  
Melbourne VIC 3000  
Australia

GPO Box 2467V  
Melbourne VIC 3001  
Australia

Tel. +61 3 9925 2348  
Fax +61 3 9962 1617

[www.rmit.edu.au](http://www.rmit.edu.au)
You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and make sure that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

**Who is involved in this research project? Why is it being conducted?**

The investigators are Keith Frampton, James Thom, and Jennie Carroll, and the project is part of Keith Frampton’s Doctor of Philosophy (PhD) studies. This project has the approval of the RMIT University Human Research Ethics Committee. Please note, that while James Thom is an Associate Professor he has any involvement in teaching of the lectures or tutorials, no involvement in marking of assessment, and no day to day interaction, contact or supervision of the students. Also neither RMIT investigator has any responsibility for direct selection, enrolment, or advising of the students in the course.

**Why have I been approached?**

You were a student of Systems Architecture, either ISYS1088 or ISYS1089, at RMIT University in semester 1 2006.

**What is the project about? What are the questions being addressed?**

The purpose of this project is to determine if we can improve some capabilities of IT architects through educational activities. In particular, the purpose of this activity is to address the question “Are some student capabilities related to the role of IT architects improved by systems architecture education?”

**If I agree to participate, what will I be required to do?**
If you agree to participate you will be asked to complete a questionnaire at the start of the course and again at the end of the course. The questionnaire should take less than 15 minutes to complete. The questionnaire will ask a series of questions related to different capabilities that have been identified as in the role of IT Architect.

You will also be asked to select one of two streams of tutorials focused on IT architect capabilities. Part of the tutorials will include exchange of information to ensure all students have the opportunity to learn about the different IT architect capabilities. These tutorials will be run as part of the course, regardless of this research, and material from them may be assessed. This assessment has nothing to do with the research; it is just part of normal course assessment of tutorial material.

**What are the risks associated with participation?**

There are no expected risks associated with your participation outside your normal day-to-day activities.

**What are the benefits associated with participation?**

There are no immediate benefits to your participation in this study.

**What will happen to the information I provide?**

The information will be analysed using SPSS and the questionnaires will only be accessed by the investigators. The questionnaire results will have **NO** relationship to marks or assessment results. Please note that participation is entirely voluntary.

Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission.

**What are my rights as a participant?**

Your rights as a participant are:

- The right to withdraw your participation at any time, without prejudice,
Appendices

- The right to have any unprocessed data withdrawn and destroyed, provided it can be reliably identified,
- The right to have any of your questions answered at any time.

We plan to publish the analysis of the questionnaires in a PhD thesis and in research papers that may be published in journals and presented at conferences. At no stage in any of these publications will any of the respondents be identified by name. All data will be kept confidential and will be destroyed a minimum of 5 years after the planned completion of the PhD by 2010.

Who should I contact if I have questions?

Any further information you require may be obtained by contacting any of the investigators, details above.

Keith Frampton  Dr James Thom  Dr Jennie Carroll
Principal Investigator  Investigator  Investigator
BSc  BSc(Hons), MSc, PhD  BEc, DipEd, Grad Dip

Any complaints about your participation in this project may be directed to the Secretary, RMIT Human Research Ethics Committee, University Secretariat, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 1745. Details of the complaints procedure are available from the above address.
Information Technology Architect Capabilities

Informed consent form

Prescribed Consent Form For Persons Participating In Research Projects Involving Interviews, Questionnaires or Disclosure of Personal Information

Portfolio
School of Science, Engineering & Technology

Computer Science & Information technology

Name of participant: 

Project Title: Identifying and improving capabilities of IT architects

Name(s) of investigators: (1) Keith Frampton Phone: Xxxx xxx xxx

(2) James Thom Phone: Xxxx xxxx

1. I have received a statement explaining the interview/questionnaire involved in this project.

2. I consent to participate in the above project, the particulars of which - including details of the interviews or questionnaires - have been explained to me.

3. I authorise the investigator or his or her assistant to interview me or administer a questionnaire.

4. I acknowledge that:

(f) Having read Plain Language Statement, I agree to the general purpose, methods and demands of the study.

(g) I have been informed that I am free to withdraw from the project at any time and to withdraw any unprocessed data previously supplied.

(h) The project is for the purpose of research and/or teaching. It may not be of direct benefit to me.

(i) The privacy of the personal information I provide will be safeguarded and only disclosed where I have consented to the disclosure or as required by law.

(j) The security of the research data is assured during and after completion of the study. The data collected during the study may be published, and a report of the project outcomes will be provided to the School of Computer Science & Information Technology, and on Keith Frampton's webpage. Any information which will identify me will not be used.

Participant's Consent

234
Appendices

Participant: _______________________________ Date: ________________

(Signature)

Witness: _______________________________ Date: ________________

(Signature)

Participants should be given a photocopy of this consent form after it has been signed.

Any complaints about your participation in this project may be directed to the Executive Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 2251.

Details of the complaints procedure are available from the above address.
Appendix J. Rejected teaching design alternatives

There were several alternative designs considered which we rejected for several reasons. These designs and the reasons for rejection were:

1. Perform the experiment with the same subjects with the same structure but over two different offerings, for example, in 2006, then in 2007. This was rejected as there were too many potential points of variation between the two offerings. These included different student groups, different teaching staff, and changes in the other material in the subject to reflect updating in the material and other changes.

2. Use the same subjects with a different structure but over two different offerings, for example, in 2006, then in 2007. Possible changes in the structure could have been only focus on one capability in the first offering and then focus on the second capability in the second offering, and then compare the differences between years as well as across each subject offering. Again, this was rejected as there were too many potential points of variation between the two offerings. These included different student groups, different teaching staff, and changes in the other material in the subject to reflect updating in the material and other changes.

3. For the experiment, teach all students the same material in tutorials. We rejected this alternative, as it would provide no differences in material in the tutorials, the only differences would be the different tutors. This would not have examined both capabilities and we therefore rejected this design.

4. Alternatively, only cover the capability material in one tutorial of the subject, with the other tutorial group studying material related to the subject but not directly related to the capabilities. We rejected this alternative, as it does not provide equitable access to the material for all students in the subject.

5. An alternative design could have been to compare between different universities offering relevant subjects with targeted capabilities material included in the teaching. However, we rejected this, as there were too many potential differences and variables for comparison, including different subject structure and content, teaching, student knowledge and demographics, and any
Appendices

differences resulting from different assessment practices and even degree structures.

6. We also rejected performing the experiment outside a subject, as part of the objective was to investigate if targeting the capabilities within a university subject would be effective.

7. An alternative we considered was to connect explicitly the capabilities with some of the subject’s assessment. We rejected this on ethical grounds, because of the students perceiving a possible power relationship between responses to surveys and final assessment.
Appendix K. Summary of teaching objectives for tutorials

This appendix describes the tutorial structure used for teaching of the capabilities during a post-graduate Systems Architecture course. There were two streams of tutorials with three added tutorials with the capabilities material in each stream.

One stream focused on the Approach Avoidance Style of problem solving. This stream included material on generation of alternatives and evaluation of possible and actual outcomes. The other stream focussed on future orientation. This stream included activities on strategic thinking and scenario based planning.

Below are the outlines of the each tutorial stream.

Problem solving tutorials (Stream 1)

Tutorial A - Characteristics of problem solving

- Learning objectives
  - Understand two different models of problem solving
    - ‘Classical’ problem solving (Newell & Simon 1972)
  - Understand different problem solving styles & associated strengths & weaknesses
  - Understand your own personal problem solving style
  - Determine strategies for improving your own problem solving

- Activities:
  - The Commonwealth Games are bringing over 500 athletes and many thousands of spectators to Melbourne. (For all activities, be prepared to discuss with other students in tutorial.)
  - Activity one (after initial material presented)
    - What problem(s) has this caused or might cause?
    - Discuss in pairs, for 5 minutes
  - Activity two (after more material presented)
    - How big are the resulting problems?
Appendices

- Why do you say that?
  - Activity three (after additional material presented)
    - Assuming there have been problems, what has caused those problems?
    - Why do you say that?
  - Activity four (after additional material presented)
    - Assuming there have been problems, what might address the problems?
    - Why do you say that?
  - Activity five (again, after additional material presented)
    - Assuming you have developed some strategies to intervene, how would you measure if they were successful?
    - Why do you say that?
    - What new problems might have been caused by the interventions?

Tutorial B - Generation of alternatives

- Learning objectives
  - Understand what alternatives, in the context of problem solving, are
  - Understand and have practiced several approaches for generation of alternatives
    - For example, brainstorming, De Bono ‘6 hats (De Bono 2000), etc.
- Activities (all activity outcomes are shared with other students in tutorial)
  - Activity one
    - Brainstorming (after material presented) – How many different ways could you explain/illustrate systems architecture?
    - Discuss results of exercise in pairs for 2 minutes
  - Six hats exercises (all of these are still using Commonwealth Games as example/context)
    - Exercise 1
      - In your groups
        - 1 minute each of white hat thinking – no critique
Information Technology Architect Capabilities

- 1 minute in total of comments & discussion of process

- **Exercise 2**
  - In your groups
    - 1 minute each of **red** hat thinking – no critique
    - 1 minute in total of comments & discussion of process

- **Exercise 3**
  - In your groups
    - 1 minute each of **yellow** hat thinking – no critique
    - 1 minute in total of comments & discussion of process

- **Exercise 4**
  - In your groups
    - 1 minute each of **green** hat thinking for ways to improve the Games ‘experience’ – no critique
    - 1 minute in total of comments & discussion of process

- **Finalisation**
  - Discuss in groups for 2 minutes overall thoughts on the process

---

Tutorial C - Outcome review approaches

- **Learning objectives**
  - Understand objectives of post problem solving reviews
  - Understand and have practiced several approaches for reviewing problem solving outcomes
    - For example, formal post implementation reviews, peer reviews, etc.
    - Used material and concepts from (Newell & Simon 1972)
  - Incorporated knowledge from tutorials B & C into overall personal problem solving and relevance for systems architecture
Appendices

- Interchange key learning from this stream with students from other stream
  - Activities (all activity outcomes are shared with other students in tutorial)
    - Activity one (after evaluation examples & approaches introduced)
      - As part of the solution to control & reduce the time taken for athletes & other people to travel during the Commonwealth Games many of the main traffic routes has special lanes introduced just for official Games traffic
        - In pairs for 10 minutes evaluate how successful this was or wasn’t
    - Activity two
      - Facilitated (by tutors) group discussion of problem solving evaluation from activity one
      - Focus areas are:
        - Problems caused by solution
        - What problems in the area didn’t it address
        - Alternative solutions
        - How would you evaluate it worked?
  - Sharing of learning related
    - First stage
      - Identify 5 key things you have learnt
      - Note them down
      - Share with someone else
      - Revise notes
    - Second stage
      - Swap tutes (half from each group)
      - Explain 5 key things you learnt to someone in other tutorial
      - Have the other person write notes
      - Some of the students will then explain to the rest of the tutorial group

Future orientation tutorials (Stream 2)
Tutorial A - Awareness of timeframes

- Learning objectives
  - Understand some attitudes to time
    - Using material from many sources, including www.longnow.org
  - Understand your own personal time horizons
  - Understand, through examples, the actual timeframes of:
    - Technology
    - Business use of technology
  - Understand gap from idea to reality

- Activity
  - Activity one
    - In pairs, for 2 minutes, discuss:
      - How do you plan?
      - Why do you plan?
  - Activity two
    - Organise dates related to information technology
  - Activity three
    - If you were going to design a clock for 10,000 years, what would you need to think about?
    - Discuss for 5 minutes in groups of 3
  - Activity three (revisited)
    - Now, with more information, if you were going to design a clock for 10,000 years, what would you use?
    - Discuss for 5 minutes in groups of 3

Tutorial B - Techniques for ‘strategic’ thinking

- Learning objectives
  - Understood what is meant by ‘strategy’
  - Understood and have (briefly) used several techniques for ‘strategic’ thinking & associated frameworks

- Activity
Appendices

o Part one
  ▪ In the early 1990s Melbourne failed in a bid to host the Olympic Games in 1996. It is now 1992 and someone has a vision that Melbourne should host a different major sporting event.
  ▪ In pairs, use strategic thinking for 7 minutes to see how this might happen.

o Part two
  ▪ Even after your initial thoughts people still want to proceed with the idea of how Melbourne might host a major sporting event
  ▪ In the same pairs, for 6 minutes, do more strategic thinking about this and organise your thoughts according to the framework on the prior page

o Part three
  ▪ In pairs, discuss for 8 minutes, what are some areas that you might consider strategic thinking for in your own life
  ▪ Ensure you explicitly discuss the timeframes involved

Tutorial C – Scenarios

• Learning objectives
  o Understand what are scenarios, their key characteristics, and how they are useful
  o Understand steps in developing scenarios
  o Understood how scenarios are useful for systems architecture
  o Interchanged key learning from this stream with students from other stream

• Activities
  o Scenario related
    ▪ Development of two scenarios for a non-technical problem with multiple dimensions
• In your groups, for 10 minutes, develop two scenarios for Melbourne hosting a major sporting event in the future
  ▪ Further development of the scenario after initial scenario analysis ideas presented
    • For 6 minutes, in your groups, take one of your scenarios and develop it further, tell it like a story or news report after the event occurs!
  ○ Sharing of learning related
    ▪ First stage
      • Identify 5 key things you have learnt
      • Note them down
      • Share with someone else
      • Revise notes
    ▪ Second stage
      • Swap tutes (half from each group)
      • Explain 5 key things you learnt to someone in other tutorial
      • Have the other person write notes
      • Some of the students will then explain to the rest of the tutorial group
Appendices

Appendix L. Pre-subject matched respondents’ norm analysis

Norms analysis was also performed using the pre-subject values for the students that responded to both surveys, that is, this is the norms comparison pre-subject for students who also completed the post-subject survey. This norms analysis was conducted in the same manner as all others. That is, we used one-sample t-tests in SPSS and compared the respondents’ means with the norms for PSI and ZTPI factors described above.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>t-test significance</th>
<th>Norm value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>21.46</td>
<td>0.159</td>
<td>23.21</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>40.31</td>
<td>0.025</td>
<td>44.32</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>14.70</td>
<td>0.347</td>
<td>15.43</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective Inventory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>2.70</td>
<td>0.030</td>
<td>2.98</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>3.29</td>
<td>0.132</td>
<td>3.44</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>3.74</td>
<td>0.007</td>
<td>3.47</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td>3.45</td>
<td>0.012</td>
<td>3.71</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>2.08</td>
<td>0.015</td>
<td>2.37</td>
</tr>
</tbody>
</table>

L-1 Pre subject matched respondents’ norms analysis

There were no differences in which variables were significantly different from the norms for the complete group of pre-subject respondents or the just the students who responded to both surveys.
Appendix M.  Detailed post-subject analysis

This appendix contains details of additional post-subject survey analysis that was performed in the third stage of the research.

Under-graduates compared with post-graduates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levene's test significance</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Solving Inventory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem Solving Confidence (PSC)</td>
<td>0.464</td>
<td>0.783</td>
</tr>
<tr>
<td>Approach Avoidance Style (AAS)</td>
<td>0.443</td>
<td>0.479</td>
</tr>
<tr>
<td>Personal Control (PC)</td>
<td>0.910</td>
<td>0.287</td>
</tr>
<tr>
<td>Overall (PSITotal)</td>
<td>0.569</td>
<td>0.468</td>
</tr>
<tr>
<td><strong>Zimbardo’s Time Perspective Inventory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Negative (ZTPI-PN)</td>
<td>0.433</td>
<td>0.347</td>
</tr>
<tr>
<td>Present-Hedonistic (ZTPI-PH)</td>
<td>0.075</td>
<td>0.371</td>
</tr>
<tr>
<td>Future (ZTPI-F)</td>
<td>0.098</td>
<td>0.490</td>
</tr>
<tr>
<td>Past-Positive (ZTPI-PP)</td>
<td>0.701</td>
<td>0.336</td>
</tr>
<tr>
<td>Present-Fatalistic (ZTPI-PF)</td>
<td>0.856</td>
<td>0.493</td>
</tr>
<tr>
<td>Age</td>
<td>N/A</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

M- 1 Post-subject Under-graduates compared with post-graduates

This analysis shows, as would be expected, that the post-graduate students are older than the under-graduate students are. There were no other differences considered statistically significant for any variables.
Appendices

Appendix N.  
**Post-subject factorial ANOVA detailed results**

Factorial ANOVA analyses were performed to investigate if there was any interaction between the student’s tutorial and graduate status on the survey responses at the end of the subject. All other variables were used as the dependent variable for the analyses reported in this appendix. The R-Squared values are all less than 50%, therefore, over 1/2 of the variable results cannot be explained by the any interactions between the variables and tutorial and graduate status and therefore no significant interaction was found (Moore & McCabe 2003). (The tables reflect SPSS fonts and formatting as they are copied from that software package.)

**Dependent variable: PSI-PSC**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>683.250</td>
<td>3</td>
<td>227.750</td>
<td>4.099</td>
<td>.019</td>
<td>12.298</td>
<td>.774</td>
</tr>
<tr>
<td>Intercept</td>
<td>13270.564</td>
<td>1</td>
<td>13270.564</td>
<td>238.857</td>
<td>.000</td>
<td>238.857</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>61.483</td>
<td>1</td>
<td>61.483</td>
<td>1.107</td>
<td>.304</td>
<td>1.107</td>
<td>.172</td>
</tr>
<tr>
<td>Ugrad</td>
<td>99.208</td>
<td>1</td>
<td>99.208</td>
<td>1.786</td>
<td>.195</td>
<td>1.786</td>
<td>.248</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>653.706</td>
<td>1</td>
<td>653.706</td>
<td>11.766</td>
<td>.002</td>
<td>11.766</td>
<td>.906</td>
</tr>
<tr>
<td>Error</td>
<td>1222.289</td>
<td>22</td>
<td>55.559</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17758.000</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>1905.538</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{a Computed using alpha = .05} \]

\[ \text{b R Squared = .359 (Adjusted R Squared = .271)} \]

**Dependent variable: PSI-AAS**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>564.235</td>
<td>3</td>
<td>186.078</td>
<td>1.945</td>
<td>.152</td>
<td>5.834</td>
<td>.432</td>
</tr>
<tr>
<td>Intercept</td>
<td>40851.217</td>
<td>1</td>
<td>40851.217</td>
<td>422.403</td>
<td>.000</td>
<td>422.403</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>259.203</td>
<td>1</td>
<td>259.203</td>
<td>2.680</td>
<td>.116</td>
<td>2.680</td>
<td>.347</td>
</tr>
<tr>
<td>Ugrad</td>
<td>4.308</td>
<td>1</td>
<td>4.308</td>
<td>.045</td>
<td>.835</td>
<td>.045</td>
<td>.055</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>308.294</td>
<td>1</td>
<td>308.294</td>
<td>3.188</td>
<td>.088</td>
<td>3.188</td>
<td>.400</td>
</tr>
<tr>
<td>Error</td>
<td>2127.650</td>
<td>22</td>
<td>96.711</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>51543.000</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>2691.885</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{a Computed using alpha = .05} \]

\[ \text{b R Squared = .210 (Adjusted R Squared = .102)} \]
### Dependent variable: **PSI-PC**

**Dependent Variable: PC**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>81.818(b)</td>
<td>3</td>
<td>27.273</td>
<td>1.304</td>
<td>.298</td>
<td>3.912</td>
<td>.299</td>
</tr>
<tr>
<td>Intercept</td>
<td>4648.013</td>
<td>1</td>
<td>4648.013</td>
<td>222.264</td>
<td>.000</td>
<td>222.264</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>30.222</td>
<td>1</td>
<td>30.222</td>
<td>1.445</td>
<td>.242</td>
<td>1.445</td>
<td>.210</td>
</tr>
<tr>
<td>Ugrad</td>
<td>2.586</td>
<td>1</td>
<td>2.586</td>
<td>.124</td>
<td>.728</td>
<td>.124</td>
<td>.063</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>32.740</td>
<td>1</td>
<td>32.740</td>
<td>1.566</td>
<td>.224</td>
<td>1.566</td>
<td>.224</td>
</tr>
<tr>
<td>Error</td>
<td>460.067</td>
<td>22</td>
<td>20.912</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6125.000</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>541.885</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Computed using alpha = .05  
b R Squared = .151 (Adjusted R Squared = .035)

### Dependent variable: **PSI-Totai**

**Dependent Variable: PSI**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>3179.666(b)</td>
<td>3</td>
<td>1059.889</td>
<td>3.296</td>
<td>.039</td>
<td>9.889</td>
<td>.671</td>
</tr>
<tr>
<td>Intercept</td>
<td>148603.396</td>
<td>1</td>
<td>148603.396</td>
<td>462.162</td>
<td>.000</td>
<td>462.162</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>866.617</td>
<td>1</td>
<td>866.617</td>
<td>2.695</td>
<td>.115</td>
<td>2.695</td>
<td>.349</td>
</tr>
<tr>
<td>Ugrad</td>
<td>108.739</td>
<td>1</td>
<td>108.739</td>
<td>.338</td>
<td>.567</td>
<td>.338</td>
<td>.086</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>2386.114</td>
<td>1</td>
<td>2386.114</td>
<td>7.421</td>
<td>.012</td>
<td>7.421</td>
<td>.740</td>
</tr>
<tr>
<td>Error</td>
<td>7073.872</td>
<td>22</td>
<td>321.540</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>188042.000</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>10253.538</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Computed using alpha = .05  
b R Squared = .310 (Adjusted R Squared = .216)

### Dependent variable: **ZTPi-PN**

**Dependent Variable: ZTPi-PN**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.334(b)</td>
<td>3</td>
<td>.111</td>
<td>.532</td>
<td>.665</td>
<td>1.596</td>
<td>.139</td>
</tr>
<tr>
<td>Intercept</td>
<td>142.655</td>
<td>1</td>
<td>142.655</td>
<td>681.153</td>
<td>.000</td>
<td>681.153</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>.050</td>
<td>1</td>
<td>.050</td>
<td>.240</td>
<td>.629</td>
<td>.240</td>
<td>.075</td>
</tr>
<tr>
<td>Ugrad</td>
<td>.286</td>
<td>1</td>
<td>.286</td>
<td>1.367</td>
<td>.256</td>
<td>1.367</td>
<td>.200</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>.098</td>
<td>1</td>
<td>.098</td>
<td>.486</td>
<td>.502</td>
<td>.486</td>
<td>.100</td>
</tr>
<tr>
<td>Error</td>
<td>4.184</td>
<td>20</td>
<td>.209</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>198.320</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>4.518</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Computed using alpha = .05  
b R Squared = .074 (Adjusted R Squared = -.065)
## Appendices

### Dependent variable: ZTPI-PH

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.998(b)</td>
<td>3</td>
<td>.666</td>
<td>3.548</td>
<td>.030</td>
<td>10.643</td>
<td>.710</td>
</tr>
<tr>
<td>Intercept</td>
<td>209.863</td>
<td>1</td>
<td>209.863</td>
<td>1117.990</td>
<td>.000</td>
<td>1117.990</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>.055</td>
<td>1</td>
<td>.055</td>
<td>.295</td>
<td>.592</td>
<td>.295</td>
<td>.082</td>
</tr>
<tr>
<td>Ugrad</td>
<td>.819</td>
<td>1</td>
<td>.819</td>
<td>4.362</td>
<td>.048</td>
<td>4.362</td>
<td>.516</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>1.558</td>
<td>1</td>
<td>1.558</td>
<td>8.301</td>
<td>.008</td>
<td>8.301</td>
<td>.788</td>
</tr>
<tr>
<td>Error</td>
<td>4.317</td>
<td>23</td>
<td>.188</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>271.813</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>6.315</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .316 (Adjusted R Squared = .227)

### Dependent variable: ZTPI-F

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.626(b)</td>
<td>3</td>
<td>.542</td>
<td>2.153</td>
<td>.124</td>
<td>6.460</td>
<td>.470</td>
</tr>
<tr>
<td>Intercept</td>
<td>245.548</td>
<td>1</td>
<td>245.548</td>
<td>975.431</td>
<td>.000</td>
<td>975.431</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>1.466</td>
<td>1</td>
<td>1.466</td>
<td>5.822</td>
<td>.025</td>
<td>5.822</td>
<td>.634</td>
</tr>
<tr>
<td>Ugrad</td>
<td>.234</td>
<td>1</td>
<td>.234</td>
<td>.928</td>
<td>.346</td>
<td>.928</td>
<td>.151</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>.082</td>
<td>1</td>
<td>.082</td>
<td>.326</td>
<td>.574</td>
<td>.326</td>
<td>.085</td>
</tr>
<tr>
<td>Error</td>
<td>5.286</td>
<td>21</td>
<td>.252</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>340.396</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>6.913</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .235 (Adjusted R Squared = .126)

### Dependent variable: ZTPI-PP

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.605(b)</td>
<td>3</td>
<td>.202</td>
<td>.691</td>
<td>.567</td>
<td>2.073</td>
<td>.173</td>
</tr>
<tr>
<td>Intercept</td>
<td>239.381</td>
<td>1</td>
<td>239.381</td>
<td>820.513</td>
<td>.000</td>
<td>820.513</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>.233</td>
<td>1</td>
<td>.233</td>
<td>.797</td>
<td>.381</td>
<td>.797</td>
<td>.137</td>
</tr>
<tr>
<td>Ugrad</td>
<td>.458</td>
<td>1</td>
<td>.458</td>
<td>1.570</td>
<td>.223</td>
<td>1.570</td>
<td>.225</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>.164</td>
<td>1</td>
<td>.164</td>
<td>.562</td>
<td>.461</td>
<td>.562</td>
<td>.111</td>
</tr>
<tr>
<td>Error</td>
<td>6.710</td>
<td>23</td>
<td>.292</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>319.284</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>7.315</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .083 (Adjusted R Squared = -.037)
Dependent variable: ZTPI-PF

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1.357 (b)</td>
<td>3</td>
<td>.452</td>
<td>2.067</td>
<td>.134</td>
<td>6.200</td>
<td>.457</td>
</tr>
<tr>
<td>Intercept</td>
<td>108.522</td>
<td>1</td>
<td>108.522</td>
<td>495.777</td>
<td>.000</td>
<td>495.777</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>.712</td>
<td>1</td>
<td>.712</td>
<td>3.251</td>
<td>.065</td>
<td>3.251</td>
<td>.407</td>
</tr>
<tr>
<td>Ugrad</td>
<td>.517</td>
<td>1</td>
<td>.517</td>
<td>2.361</td>
<td>.139</td>
<td>2.361</td>
<td>.312</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>.670</td>
<td>1</td>
<td>.670</td>
<td>3.061</td>
<td>.094</td>
<td>3.061</td>
<td>.387</td>
</tr>
<tr>
<td>Error</td>
<td>4.816</td>
<td>22</td>
<td>.219</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>134.568</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>6.173</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .220 (Adjusted R Squared = .113)

Dependent variable: Age

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Noncent. Parameter</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>10.667 (b)</td>
<td>3</td>
<td>3.556</td>
<td>6.815</td>
<td>.002</td>
<td>20.444</td>
<td>.950</td>
</tr>
<tr>
<td>Intercept</td>
<td>143.433</td>
<td>1</td>
<td>143.433</td>
<td>274.913</td>
<td>.000</td>
<td>274.913</td>
<td>1.000</td>
</tr>
<tr>
<td>Tute</td>
<td>.149</td>
<td>1</td>
<td>.149</td>
<td>.286</td>
<td>.598</td>
<td>.286</td>
<td>.081</td>
</tr>
<tr>
<td>Ugrad</td>
<td>7.313</td>
<td>1</td>
<td>7.313</td>
<td>14.017</td>
<td>.001</td>
<td>14.017</td>
<td>.948</td>
</tr>
<tr>
<td>Tute * Ugrad</td>
<td>.149</td>
<td>1</td>
<td>.149</td>
<td>.286</td>
<td>.598</td>
<td>.286</td>
<td>.081</td>
</tr>
<tr>
<td>Error</td>
<td>12.000</td>
<td>23</td>
<td>.522</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>196.000</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>22.667</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05
b  R Squared = .471 (Adjusted R Squared = .402)
Appendices

Appendix O.  Acronyms used within thesis

This appendix is a list, in alphabetic order, of all the acronyms used within the thesis and the expansions of those acronyms.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Expansion of Acronym</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAS</td>
<td>Approach Avoidance Style (factor within Problem Solving Inventory)</td>
</tr>
<tr>
<td>ACER</td>
<td>Australian Council for Educational Research</td>
</tr>
<tr>
<td>ACIS</td>
<td>Australasian Conference on Information Systems</td>
</tr>
<tr>
<td>ACM</td>
<td>Association for Computing Machinery</td>
</tr>
<tr>
<td>ATIS</td>
<td>Alliance for Telecommunications Industry Solutions</td>
</tr>
<tr>
<td>BRM</td>
<td>Business Reference Model</td>
</tr>
<tr>
<td>CPR</td>
<td>Computer Personnel Research</td>
</tr>
<tr>
<td>CSI</td>
<td>Cognitive Style Inventory</td>
</tr>
<tr>
<td>DRM</td>
<td>Data Reference Model</td>
</tr>
<tr>
<td>FEA</td>
<td>Federal Enterprise Architecture</td>
</tr>
<tr>
<td>GEAO</td>
<td>Global Enterprise Architects Organisation</td>
</tr>
<tr>
<td>GLM</td>
<td>General Linear Model</td>
</tr>
<tr>
<td>GMA</td>
<td>General Mental Ability</td>
</tr>
<tr>
<td>GSA</td>
<td>Global Services Australia</td>
</tr>
<tr>
<td>HILP</td>
<td>Hertfordshire Integrated Learning Program</td>
</tr>
<tr>
<td>IAF</td>
<td>International Association of Facilitators</td>
</tr>
<tr>
<td>IASA</td>
<td>International Association of Software Architects</td>
</tr>
<tr>
<td>IBM</td>
<td>International Business Machines</td>
</tr>
<tr>
<td>ICT</td>
<td>Information Communication Technology</td>
</tr>
<tr>
<td>INCOSE</td>
<td>International Council On Systems Engineering</td>
</tr>
<tr>
<td>IQ</td>
<td>Intelligence Quotient</td>
</tr>
<tr>
<td>IS</td>
<td>Information Systems</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>LIDDAS</td>
<td>Local Interlending and Document Delivery Administration System</td>
</tr>
<tr>
<td>MBA</td>
<td>Master of Business Administration</td>
</tr>
<tr>
<td>MBTI</td>
<td>Myers Briggs Type Instrument</td>
</tr>
<tr>
<td>NWCET</td>
<td>National Workforce Center for Emerging Technologies</td>
</tr>
<tr>
<td>PBL</td>
<td>Problem Based Learning</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Control (factor within Problem Solving Inventory)</td>
</tr>
<tr>
<td>Pgrad</td>
<td>Post-graduate</td>
</tr>
<tr>
<td>POPS</td>
<td>Perception of Organizational Politics</td>
</tr>
<tr>
<td>PRM</td>
<td>Performance Reference Model</td>
</tr>
<tr>
<td>PSC</td>
<td>Problem Solving Confidence (factor within Problem Solving Inventory)</td>
</tr>
<tr>
<td>PSI</td>
<td>Problem Solving Inventory</td>
</tr>
<tr>
<td>PSITotal</td>
<td>Problem Solving Inventory Total of PSC, AAS, and PC</td>
</tr>
<tr>
<td>RMIT</td>
<td>Royal Melbourne Institute of Technology</td>
</tr>
<tr>
<td>SAP</td>
<td>Systems Applications and Products</td>
</tr>
<tr>
<td>SCIA</td>
<td>Society for the Certification of Information Architects</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SDLC</td>
<td>Software Development LifeCycle</td>
</tr>
<tr>
<td>SFIA</td>
<td>Skills Framework for the Information Age</td>
</tr>
<tr>
<td>SIG</td>
<td>Special Interest Group</td>
</tr>
<tr>
<td>SIGCPR</td>
<td>Special Interest Group Computer Personnel Research</td>
</tr>
<tr>
<td>SIGITE</td>
<td>Special Interest Group Information Technology Education</td>
</tr>
<tr>
<td>SLA</td>
<td>Service Level Agreement</td>
</tr>
<tr>
<td>SRM</td>
<td>Service Component Reference Model</td>
</tr>
<tr>
<td>TRIZ</td>
<td>Theory of Inventive Problem Solving (the initials are from the Russian name)</td>
</tr>
<tr>
<td>TRM</td>
<td>Technical Reference Model</td>
</tr>
<tr>
<td>Ugrad</td>
<td>Under-graduate</td>
</tr>
<tr>
<td>UKAIS</td>
<td>United Kingdom Academy for Information Systems</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
</tr>
<tr>
<td>VVIQ</td>
<td>Vividness of Visual Imagery Questionnaire</td>
</tr>
<tr>
<td>WAP</td>
<td>Wireless Application Protocol</td>
</tr>
<tr>
<td>WWISA</td>
<td>WorldWide Institute of Software Architects</td>
</tr>
<tr>
<td>ZTPI</td>
<td>Zimbardo’s Time Perspective Inventory</td>
</tr>
<tr>
<td>ZTPI-F</td>
<td>Zimbardo’s Time Perspective Inventory Future</td>
</tr>
<tr>
<td>ZTPI-PF</td>
<td>Zimbardo’s Time Perspective Inventory Present Fatalistic</td>
</tr>
<tr>
<td>ZTPI-PH</td>
<td>Zimbardo’s Time Perspective Inventory Present Hedonistic</td>
</tr>
<tr>
<td>ZTPI-PN</td>
<td>Zimbardo’s Time Perspective Inventory Past Negative</td>
</tr>
<tr>
<td>ZTPI-PP</td>
<td>Zimbardo’s Time Perspective Inventory Past Positive</td>
</tr>
</tbody>
</table>


Babbie, ER 2004, The practice of social research, 10th edn, Wadsworth, Belmont, CA, USA.

References


Information Technology Architect Capabilities


Berg, BL 2004, *Qualitative research methods for the social sciences*, 5th edn, Allyn and Bacon, Boston, MA, USA.


Boniwell, I 2005, 'Beyond Time Management: how the latest research on time perspective and perceived time use can assist clients with time-related concerns', *International Journal of Evidence Based Coaching and Mentoring*, vol. 3, no. 2, pp. 61-74.
References

Booth, P 2007, 'Technology experts in the boardroom', Information Age, February/March, pp. 52-54.


Information Technology Architect Capabilities


References


Information Technology Architect Capabilities


Couger, JD 1995, *Creativity & Innovation in Information Systems Organizations*, Boyd and Fraser Publishing Company, Danvers, MA, USA.


References


Information Technology Architect Capabilities


Dreyfus, HL & Dreyfus, S 1980, *A Five-Stage Model of the Mental Activities involved in Directed Skill Acquisition*, University of California, Berkeley, CA, USA.


Eriksen, T 2006, 'Survey of the use of systems architecture in the development of complex technical systems - Exemplified by the autonomous underwater vehicle Hugin', paper presented to Fifth European Systems Engineering Conference, Edinburgh, United Kingdom, 18-20th September.

Fairbanks, G 2003, 'Why can't they create architecture models like "Developer X"? an experience report', Proceedings of 25th International Conference on Software Engineering, Portland, OR, USA, 3-10th May, pp. 548-552.


References


Fink, L & Neumann, S 2007, 'Gaining Agility through IT Personnel Capabilities: The Mediating Role of IT Infrastructure Capabilities', *Journal of the Association for Information Systems*, vol. 8, no. 8, Article 2, pp. 440-462.

Fitz-Eng, J 1978, 'Who is the DP Professional?', *Datamation*, vol. 24, no. 9, pp. 125-128.


Frampton, K, Carroll, JM & Thom, JA 2005, 'What Capabilities Do IT Architects Say They Need?', *paper presented to 10th United Kingdom Academy for Information Systems (UKAIS)* Newcastle, United Kingdom, 22-24th March.


Frank, M 2006b, 'Knowledge, abilities, cognitive characteristics and behavioral competences of engineers with high capacity for engineering systems thinking (CEST)', *Systems Engineering*, vol. 9, no. 2, pp. 91-103.


References


Gold-Bernstein, B & Ruh, W 2004, Enterprise Integration: The Essential Guide to Integration Solutions, Addison Wesley Professional, Indianapolis, IN, USA.


Gore, M 2003, 'Thoughts on the information system architect role', paper presented to Information Technology: Coding and Computing [Computers and Communications], 2003, Las Vegas, NV, USA, 28-30th April, pp. 706-710.


References


Hellstrom, C & Hellstrom, T 2003, 'The Present is Less than the Future Mental experimentation and temporal exploration in design work', *Time & Society*, vol. 12, no. 2-3, pp. 263-279.


References


References


Jick, TD 1979, 'Mixing Qualitative and Quantitative Methods: Triangulation in Action', *Administrative Science Quarterly*, vol. 24, no. 4, pp. 602-611.


Joshi, KKD & Kuhn, KM 2007, 'What it takes to succeed in information technology consulting', *Information Technology & people*, vol. 20, no. 4, pp. 400-424.


Kelly, G 1991, *The psychology of personal constructs*, Routledge in association with the Centre for Personal Construct Psychology, New York, NY, USA.
References


Krippendorff, K 2004, Content Analysis: An Introduction to is Methodology, 2nd edn, Sage Publications, Thousand Oaks, CA, USA.


References


Likert, R 1932, 'A Technique for the Measurement of Attitudes', *Archives of Psychology*, vol. 22, pp. 5-55.

Lincoln, YS & Guba, EG 1985, *Naturalistic Inquiry*, Sage, New York, NY, USA.


Information Technology Architect Capabilities


Mann, HB & Whitney, DR 1947, 'On a Test of Whether One of Two Random Variables is Stochastically Larger Than the Other', *Annals of Mathematical Statistics*, vol. 18, pp. 50-60.

References


Information Technology Architect Capabilities


Mendenhall, W, Beaver, BM & Beaver, RJ 2003, Introduction to probability and statistics, 11th edn, Brooks/Cole-Thomson Learning, Pacific Grove, CA, USA.


Moore, S & Ward, M 1998, 'Machiavellianism and tolerance of ambiguity', *Psychological Reports*, vol. 82, no. 2, pp. 415-418.


References


Neuman, WL 2003, *Social research methods: qualitative and quantitative approaches*, 5th edn, Allyn and Bacon, Boston, MA, USA.


Niederman, FJ & Mandviwalla, M 2004, 'Introduction to Special Issue on The Evolution of IT (Computer) Personnel Research: More Theory, More Understanding,
More Questions', *The DATA BASE for Advances in Information Systems*, vol. 35, no. 3, pp. 6-8.


Nunamaker, JF, Couger, JD & Davis, GB 1982, 'Information systems curriculum recommendations for the 80s: undergraduate and graduate programs', *Communications of the ACM*, vol. 25, no. 11, pp. 781-805.


References


Parsons, RI 2005, 'Enterprise architects join the team', *Software, IEEE*, vol. 22, no. 5, pp. 16-17.


References


Salant, P & Dillman, DA 1995, How to conduct your own survey, Wiley, New York, NY, USA.
References


Scott, G 1999b, *Change matters : making a difference in education and training*, Allen & Unwin, St Leonards, N.S.W.


Shaw, M 2003, 'Writing good software engineering research papers', *Proceedings of 25th International Conference on Software Engineering (ICSE03)*. Portland, OR, USA, 3-10th May, pp. 726-736.

References


Smolander, K 2002b, 'Four metaphors of architecture in software organizations: finding out the meaning of architecture in practice', *Proceedings of International Symposium on Empirical Software Engineering (ISESE'02)*, Nara, Japan, 3-4th October, pp. 211-221.


Sonnentag, S 1995, 'Excellent software professionals: experience, work activities, and perception by peers', *Behavior & Information Technology*, vol. 14, no. 5, pp. 289-299.
References


Surakka, S 2007, 'What Subjects and Skills are Important for Software Developers?', *Communications of the ACM*, vol. 50, no. 1, pp. 73-78.
References


Tabachnick, BG & Fidell, LS 2001, Using multivariate statistics, 4 edn, Allyn and Bacon, Boston, MA, USA.


References


White, KB & Leifer, R 1986, 'Information Systems Development Success: Perspectives from Project Team Participants', *MIS Quarterly*.


References


Yin, RK 2003, Case study research: design and methods, 3rd edn, Sage Publications, Thousand Oaks, CA, USA.


Yourdan, E & Constantine, L 1975, Structured Design, 1st edn, Yourdan Press, New York, NY, USA.
Yun, GW & Trumbo, CW 2000, 'Comparative Response to a Survey Executed by Post, E-mail, & Web', *Journal of Computer-Mediated Communication*, vol. 6, no. 1.


