FACTORS AFFECTING
THE DEVELOPMENT OF
UNDERGRADUATE MEDICAL
STUDENTS’
CLINICAL REASONING ABILITY

Kirsty Jane Anderson

A thesis submitted in fulfilment of the requirements for a
Doctor of Philosophy in Medical Education

Medicine Learning and Teaching Unit
Faculty of Health Sciences
University of Adelaide

November 2006
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table of Contents</td>
<td>i</td>
</tr>
<tr>
<td>List of Figures</td>
<td>vii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>ix</td>
</tr>
<tr>
<td>Thesis Abstract</td>
<td>xi</td>
</tr>
<tr>
<td>Certification of Thesis Originality</td>
<td>xiii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>xv</td>
</tr>
</tbody>
</table>

## CHAPTER ONE – AN OVERVIEW OF THIS STUDY .................................. 1

1.1 THE BACKGROUND AND RATIONALE FOR THIS STUDY .......................... 1

1.2 THE PURPOSE OF THIS STUDY .................................................. 4

1.3 THE RESEARCH QUESTIONS ...................................................... 4

1.4 THE SIGNIFICANCE OF THIS STUDY ........................................... 5

1.5 AN OUTLINE OF THIS THESIS .................................................. 5

## CHAPTER TWO – THE LITERATURE REVIEW ....................................... 7

2.1 INTRODUCTION ............................................................................ 7

2.2 FROM NOVICE TO EXPERT CLINICAL PROBLEM SOLVING ....................... 7
  2.2.1 Background Research ...................................................... 7
  2.2.2 Knowledge and Clinical Problem Solving Expertise .................. 9
    2.2.2.1 *Biomedical Knowledge and Clinical Knowledge* .................. 10
    2.2.2.2 *Knowledge Organisation* ........................................... 12
    2.2.2.3 *Knowledge Schemes* ................................................. 15
  2.2.3 Section Summary .......................................................... 16

2.3 TYPES OF REASONING USED BY EXPERTS ..................................... 16
  2.3.1 Hypothetico-deductive Reasoning ....................................... 17
  2.3.2 Forward Reasoning .......................................................... 17
  2.3.3 Case-based Reasoning ...................................................... 18
  2.3.4 Scheme Inductive Reasoning .............................................. 18
  2.3.5 Section Summary .......................................................... 18

2.4 CLINICAL REASONING IN MEDICAL STUDENTS ................................ 19
  2.4.1 Section Summary .......................................................... 19

2.5 FACTORS AFFECTING THE DEVELOPMENT OF CLINICAL REASONING ........ 20
  2.5.1 Critical Thinking Ability ............................................... 21
    2.5.1.1 *The Definition of Critical Thinking* .............................. 21
4.3 INTRA- AND INTER-RATER RELIABILITY OF TACRR……….. 60
4.4 CHAPTER SUMMARY……………………………………. 61

CHAPTER FIVE – THE DEVELOPMENT OF AN INSTRUMENT TO MEASURE CRITICAL THINKING ABILITY…………………… 65
5.1 INTRODUCTION………………………………………………. 65
5.2 DESIGNING TACTT……………………………………………. 65
5.3 INSTRUMENT REVIEW AND DEVELOPMENT……………. 65
5.3.1 Peer Review…………………………………………………. 65
5.3.2 The Final Version of TACTT…………………………….. 70
5.4 TRIALLING TACTT…………………………………………… 76
5.5 USING ANOTHER TEST TO VALIDATE TACTT…………… 79
5.6 CHAPTER SUMMARY…………………………………….. 81

CHAPTER SIX – THE CASE STUDIES…………………………… 83
6.1 THE CASE STUDY SELECTION PROCESS………………….. 83
6.2 THE CASE STUDY DATA COLLECTION METHODS………… 85
6.2.1 Cases 1 – 4………………………………………………….. 86
6.2.2 Open-Ended, Semi-Structured Interviews………………. 89
6.3 THE ANALYSIS OF THE CASE STUDY DATA………………. 90
6.4 THE CASE STUDY PARTICIPANTS…………………………. 91
6.4.1 Alison……………………………………………………….. 92
6.4.2 Chris………………………………………………………… 102
6.4.3 Brianna……………………………………………………… 111
6.4.4 Frank…………………………………………………………. 118
6.4.5 Hannah……………………………………………………… 124
6.5 CHAPTER SUMMARY…………………………………… 132

CHAPTER SEVEN – THE COLLATED RESULTS…………………………. 135
7.1 INTRODUCTION………………………………………………. 135
7.2 THE DEVELOPMENT OF CLINICAL REASONING………… 135
7.2.1 Section Summary………………………………………… 140
7.3 FACTORS THAT IMPACT ON THE DEVELOPMENT OF
    CLINICAL REASONING……………………………………. 140
    7.3.1 Reflection Upon the Modelling of Clinical Reasoning…. 140
    7.3.1.1 The Course Structure and Assessment Practices………… 141
    7.3.1.2 PBL Tutorials and Clinical Skills Teaching Sessions…… 144
    7.3.1.3 Section Summary……………………………………… 148
7.3.2 Practising Clinical Reasoning ........................................................................ 148
  7.3.2.1 Independent Practice .............................................................................. 149
  7.3.2.2 PBL Tutorials .......................................................................................... 150
  7.3.2.3 Clinical Skills Teaching Sessions ............................................................... 153
  7.3.2.4 Examinations .......................................................................................... 154
  7.3.2.5 Section Summary ..................................................................................... 156

7.3.3 Critical Thinking and Clinical Reasoning Ability .................................... 156
  7.3.3.1 Statistical Correlations ........................................................................... 156
  7.3.3.2 Individual Study ...................................................................................... 157
  7.3.3.3 Tutors, Other Students and the Group ..................................................... 159
  7.3.3.4 Section Summary ..................................................................................... 161

7.3.4 Knowledge and Clinical Reasoning Ability ......................................... 162
  7.3.4.1 Statistical Correlations ........................................................................... 162
  7.3.4.2 Knowledge Level .................................................................................... 163
  7.3.4.3 Section Summary ..................................................................................... 167

7.3.5 Approach to Learning and Clinical Reasoning Ability ....................... 167
  7.3.5.1 Statistical Correlations ........................................................................... 168
  7.3.5.2 Integrating Knowledge .......................................................................... 169
  7.3.5.3 Applying Knowledge .............................................................................. 171
  7.3.5.4 Section Summary ..................................................................................... 173

7.4 CHAPTER SUMMARY .................................................................................. 173

CHAPTER EIGHT – DISCUSSION AND CONCLUSIONS ............................... 177

8.1 AN OVERVIEW OF THE CHAPTER .......................................................... 177

8.2 DISCUSSION OF EACH RESEARCH QUESTION ..................................... 177
  8.2.1 How Can Clinical Reasoning Ability Be Measured? ............................... 177
  8.2.2 How Do Students’ Clinical Reasoning Abilities Change As They Progress Through The Program? ............................................................... 178
  8.2.3 What Factors Influence The Development of Students’ Clinical Reasoning Ability? ............................................................... 179
  8.2.4 How Can Students’ Critical Thinking Ability Be Measured? .................. 179
  8.2.5 How Do Students’ Critical Thinking Abilities Influence Student Clinical Reasoning? ............................................................... 180
  8.2.6 How Do Students’ Knowledge Bases Influence Their Clinical Reasoning? ......................................................................................... 181
  8.2.7 How Do Students’ Approaches To Learning Influence Their Clinical Reasoning? ......................................................................................... 181

8.3 LIMITATIONS OF THIS STUDY .................................................................. 182

8.4 RECOMMENDATIONS FOR MEDICAL CURRICULUM DESIGN, TEACHING AND ASSESSMENT ......................................................... 183

8.5 RECOMMENDATIONS FOR FURTHER RESEARCH ................................. 185
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Case 1 Examination Paper</td>
<td>62</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Questions in the Original Version of TACTT</td>
<td>67</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Questions in the Final Version of TACTT</td>
<td>72</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Comparison of TACTT with UMAT: Bland- Altmann Plot</td>
<td>81</td>
</tr>
<tr>
<td>Figure 5</td>
<td>An Example Answer for Examination Questions for Case 1</td>
<td>88</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1  Critical Thinking Skills According to the American Philosophical Association Delphi Research Report…………… 22
Table 2  Approach to Learning Category according to R-SPQ-2F Score. 50
Table 3  Approaches Used to Provide Information For Each Research Question………………………………………………………. 51
Table 4  Timing and Methods of Data Collection In This Study……… 52
Table 5  The Initial Version of TACRR………………………………… 54
Table 6  Summary of the Development of TACRR…………………… 57
Table 7  Final Version of TACRR……………………………………… 58
Table 8  TACRR Scores for First Year Medical Student Examination Papers………………………………………………………….. 63
Table 9  Critical Thinking Skills Tested by Sections of TACTT and What Was Required in Order to Answer the Questions in These Sections............................................................................. 71
Table 10  Year 1 Cohort Average TACTT Percentage Scores for Critical Thinking Abilities……………………………………………………… 77
Table 11  Total TACTT Percentage Scores for First Year Student Cohorts………………………………………………………………… 78
Table 12  Critical Thinking: Skills tested by the UMAT and TACTT…… 79
Table 13  Student Groups Based on Critical Thinking Ability and Approach to Learning……………………………………………….. 83
Table 14  Student Groups According to TACRR Analyses of their 2004 Examination Papers…………………………………………………… 84
Table 15  Sources for the Case Studies………………………………… 85
Table 16  Summary of Cases 1 to 4……………………………………… 86
Table 17  Summary of Case Study Data………………………………… 93
Table 18  Case Study Students’ TACRR Scores for Examination Cases 1 to 4……………………………………………………………… 94
Table 19  Students’ Clinical Reasoning Ability Groups According to the Percentage Increase in Their TACRR Scores for the Case Analyses……………………………………………………….. 135
Table 20 Differences Between Case Analysis Groups’ Clinical Reasoning Groups I, II, and III’s Improvement in Clinical Reasoning……………………………………………………………….. 136

Table 21 Differences in TACRR Percentage Scores between Students of Varying Clinical Reasoning Ability…………………………………….. 137

Table 22 Differences in TACRR Section Percentage Scores between Students of Varying Clinical Reasoning Ability……………………………….. 138

Table 23 Correlations Between Students’ Critical Thinking Ability According to TACTT, UMAT and TER Scores and their Clinical Reasoning Ability According to TACRR Scores for Case Analyses …………………………………………………………… 157

Table 24 Correlations Between Students’ Knowledge Level According to TACRR Question 9, Examination A and Examination B Scores and their Clinical Reasoning Ability According to Sub-Total TACRR Scores for Case Analyses………………………….. 164

Table 25 Correlations Between 2004 Students’ Approach to Learning and their Clinical Reasoning Ability According to TACRR Scores for Case Analyses………………………………………………………… 168

Table 26 Correlations Between 2005 Students’ Approach to Learning And Clinical Reasoning Ability According to TACRR Scores for Case Analyses…………………………………………………………………………… 169

Table E1 TACCR 2………………………………………………………. 223
Table E2 TACCR 3………………………………………………………. 224
Table E3 TACCR 4………………………………………………………. 225
Table E4 TACCR 5………………………………………………………. 226
Table E5 TACCR 6………………………………………………………. 227
THESIS ABSTRACT

It is important for doctors to be clinically competent and this clinical competence is influenced by their clinical reasoning ability. Most research in this area has focussed on clinical reasoning ability measured in a problem-solving context. For this study, clinical reasoning is described as the process of working through a clinical problem which is distinct from a clinical problem solving approach that focuses more on the outcome of a correct diagnosis. Although the research literature into clinical problem solving and clinical reasoning is extensive, little is known about how undergraduate medical students develop their clinical reasoning ability. Evidence to support the validity of existing measures of undergraduate medical student clinical reasoning is limited. In order better to train medical students to become competent doctors, further investigation into the development of clinical reasoning and its measurement is necessary. Therefore, this study explored the development of medical students’ clinical reasoning ability as they progressed through the first two years of a student-directed undergraduate problem-based learning (PBL) program. The relationships between clinical reasoning, knowledge base, critical thinking ability and learning approach were also explored.

Instruments to measure clinical reasoning and critical thinking ability were developed, validated and used to collect data. This study used both qualitative and quantitative approaches to investigate the development of students’ clinical reasoning ability over the first two years of the undergraduate medical program, and the factors that may impact upon this process. 113 students participated in this two-year study and a subset sample (N = 5) was investigated intensively as part of the longitudinal qualitative research.

The clinical reasoning instrument had good internal consistency (Cronbach alpha coefficient 0.94 for N = 145), inter-rater reliability (r = 0.84, p <0.05), and intra-rater reliability (r = 0.81, p <0.01) when used with undergraduate medical students. When the instrument designed to measure critical thinking ability was tested with two consecutive first year medical student cohorts (N = 129, N = 104) and one first year science student cohort (N = 92), the Cronbach Alpha coefficient was 0.23, 0.45 and 0.67 respectively.
Students’ scores for clinical reasoning ability on the instrument designed as part of this research were consistent with the qualitative data reported in the case studies. The relationships between clinical reasoning, critical thinking ability, and approach to learning as measured through the instruments were unable to be defined. However, knowledge level and the ability to apply this knowledge did correlate with clinical reasoning ability. Five student-related factors extrapolated from the case study data that influenced the development of clinical reasoning were (1) reflecting upon the modeling of clinical reasoning, (2) practising clinical reasoning, (3) critical thinking about clinical reasoning, (4) acquiring knowledge for clinical reasoning and (5) the approach to learning for clinical reasoning.

This study explored students’ clinical reasoning development over only the first two years of medical school. Using the clinical reasoning instrument with students in later years of the medical program could validate this instrument further. The tool used to measure students’ critical thinking ability had some psychometric weaknesses and more work is needed to develop and validate a critical thinking instrument for the medical program context. This study has identified factors contributing to clinical reasoning ability development, but further investigation is necessary to explore how and to what extent factors identified in this study and other qualities impact on the development of reasoning, and the implications this has for medical training.
CERTIFICATION OF THE THESIS ORIGINALITY

This thesis includes no material that has been awarded a degree or diploma from any institution and, to the best of my knowledge, includes no material published or written by anyone else, except where due reference has been documented.

I give consent for this copy of my work, when put in the University Library, to be made available in all forms of media.

Signature: .....................................................  Date.......................  

Kirsty Anderson
ACKNOWLEDGEMENTS

This research was made possible by a Faculty of Health Sciences Divisional Scholarship. Many people have also been instrumental in helping me with this study. My supervisors’ input into this thesis has been significant, and their generosity with their expertise and commitment to seeing new people become involved in studies of medical education has been a wonderful introduction to the world of academic research. Dr Ray Peterson’s supportive nature and tireless enthusiasm for PhD supervision made him an exemplary principal supervisor. Dr Edward Cleary and Associate Professor Anne Tonkin have also been great mentors as co-supervisors of this research. Anne’s enthusiasm for medical education was the inspiration for commencing this PhD. Given Ted’s experience in medical education, discussions with him have consistently helped to shape my own thoughts on the subject.

The students who participated in this study deserve acknowledgement for their time and willingness to share their experiences, as this research could not have been conducted without them. Ms Catherine Leahy is acknowledged for her help with the statistical analysis of this study, and Ms Beverly Karaffa for her data entry and help with word processing and printing. Dr Marianne Balogh is acknowledged for the many hours she spent proofreading. Mr Jonathan Salmon and Mr Mark Bailye provided invaluable information technology support. Feedback was kindly given to help develop the measure of critical thinking designed as part of this study by Ms Helen Fraser, Dr Gerry Mullins, Mr Larry Nelson, Professor Deborah Turnbull, Dr Rosemary Wray Williams and Dr Ian Wilson. Ms Velta Vingelis helped to arrange testing of the critical thinking instrument with undergraduate science students. Feedback on the scoring of the measure of approach to learning was provided by Professor David Kember. Explanation and examples of Clinical Reasoning Problems were provided by Dr Michele Groves. Finally, I would like to acknowledge God for providing me with the opportunity to do this research and the support of family and friends, without whom this thesis would never have been completed.