Brain-Compatible Classroom: An Investigation into Malaysia’s Secondary School Science Teachers’ Pedagogical Beliefs and Practices

Submitted by
Wan Rosmini Hassan
B Applied Science Hons
Diploma of Education
MSc Management

A thesis submitted in total fulfilment of the requirements for the degree of Doctor of Philosophy

Faculty of Education

La Trobe University
Bundoora, Victoria, 3086
Australia

April 2013
Statement of Authorship

This thesis integrates the publications authored by me or with my supervisor during my candidature. Most of them, as included in the end of this page, are modified where appropriate to fit into the structure of the thesis. Other than that, except where reference is made in the text of the thesis, this thesis contains no materials published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma. No other person’s work has been used without due acknowledgement in the main text of this thesis. This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution. All research procedures reported in the thesis were approved by the Human Research Ethics Committee, La Trobe University.

Wan Rosmini Hassan

Date: 5th April 2013

Publications integrated in the thesis

Dedication

I dedicate this thesis to my great father, Hassan Ibrahim, and my inspiring and lovely mother, Wan Kamariah Wan Abdullah, who has been a great listener and never stopped praying for my success.

My dedication also goes to my loving and a very supportive husband, Hamdan Khalid, who always stood beside me throughout the journey. To my lovely children, Syamel Hamdan, Luqman Hamdan and Irfan Hamdan, you gave me the strength—thank you for your patience.
Acknowledgments

This thesis would not have been possible without the guidance and help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, I offer my sincerest gratitude to my supervisor Professor Margaret Robertson, who has given her full support and steadfast encouragement. I will never forget her help, despite her being only newly appointed as my principal supervisor.

I am also heartily thankful to Dr Peta Heywood, who provided me with new, valuable insights into my study and patiently guided me until her day of retirement. My sense of gratitude is also extended to Dr Patricia McCann as my co-supervisor for her continuous moral support.

A special thank you is also extended to Professor Ramon Lewis, Professor Bernard Neville, Dr Tiina Moore, Dr Christine Brew, Dr Keith Simkin, Dr Dang Tan Tin, Dr Wan Ng, Dr Glyn Thomas, Dr. Intan Hashimah, Dr. Julianne East, Dr. Maree Arelette and Pam Delly. These people have been my inspiration as I hurdled all the obstacles in the completion of this research. In addition, I am indebted to many of my colleagues who stood beside me throughout the process and those who supported me in any respect during the completion of my study.

A sense of appreciation is also offered to my loving parents, husband and children, and last but not least, the one above all of us, the omnipresent God, for listening and answering my prayers and for giving me strength to plod on despite my constitution wanting to give up. Thank you so much, Dear Lord.
# Table of Contents

**Statement of Authorship** ......................................................................................................................... i
**Dedication** .................................................................................................................................................. ii
**Acknowledgments** ....................................................................................................................................... iii
**List of Abbreviations** ................................................................................................................................. viii
**List of Tables** .............................................................................................................................................. ix
**List of Figures** .............................................................................................................................................. x
**List of Appendices** ...................................................................................................................................... xi
**Abstract** ...................................................................................................................................................... xii

## Chapter 1 Introduction to the Thesis ........................................................................................................... 1
1.1 Introduction .................................................................................................................................................. 1
1.2 Education in Malaysia ............................................................................................................................... 1
1.3 Science Education in Malaysia .................................................................................................................. 5
1.4 Teaching and Learning Science in the Classroom .................................................................................... 8
1.5 Statement of the Problem ......................................................................................................................... 9
1.6 Research Objectives ................................................................................................................................. 13
1.7 Research Questions .................................................................................................................................. 13
1.8 Significance of the Study .......................................................................................................................... 14
1.9 Limitations of the Study ........................................................................................................................... 14
1.10 Context of the Study ............................................................................................................................... 16
1.11 Definition of Terms .................................................................................................................................. 17
1.12 Organisation of the Thesis ...................................................................................................................... 18
1.13 Summary .................................................................................................................................................. 19

## Chapter 2 Literature Review ....................................................................................................................... 21
2.1 Introduction .................................................................................................................................................. 21
2.2 Learning .................................................................................................................................................... 23
2.3 The Human Brain ...................................................................................................................................... 26
  2.3.1 Brain and mind .................................................................................................................................. 28
  2.3.2 The two sided-brain .......................................................................................................................... 29
  2.3.3 Brain characteristics and learning ....................................................................................................... 33
  2.3.4 Brain-based learning .......................................................................................................................... 39
  2.3.4.1 Relaxed alertness (optimal mind-state) .......................................................................................... 41
  2.3.4.2 Enriched experience ..................................................................................................................... 41
  2.3.4.3 Experience processing .................................................................................................................. 41
  2.3.5 Research related to the BCC .............................................................................................................. 44
  2.3.6 Summary ............................................................................................................................................ 49
2.4 Teacher Beliefs in Education ...................................................................................................................... 49
  2.4.1 Definition of teacher beliefs .............................................................................................................. 50
  2.4.2 Belief system ..................................................................................................................................... 52
  2.4.3 Link between belief and practice ...................................................................................................... 53
  2.4.4 Beliefs and practices in regards to brain-based education .................................................................. 56
  2.4.5 Summary ........................................................................................................................................... 59
2.5 Framework of the Study ............................................................................................................................ 59
2.6 Conclusion ................................................................................................................................................ 62
2.7 Summary .................................................................................................................................................. 62
List of Tables

Table 3.1 Relaxed Alertness (Optimal Mind-State) .......................................................... 82
Table 3.2 Enriched Experience ..................................................................................... 83
Table 3.3 Experience Processing .................................................................................. 84
Table 3.4 Elements and Sample Items from Brain-Compatible Classroom Beliefs ........ 85
Table 3.5 Types of Five-Point Response Format .......................................................... 87
Table 4.1 Schools and Respondents (Response Rate) ..................................................... 101
Table 4.2 Frequency of Age Group ............................................................................. 103
Table 4.3 Frequency of Gender .................................................................................. 104
Table 4.4 Frequency of Cultural Background ............................................................... 104
Table 4.5 Frequency of Highest Qualification .............................................................. 105
Table 4.6 Frequency of Teaching Experience .............................................................. 106
Table 4.7 Tests of Normality ...................................................................................... 108
Table 4.8 Kaiser-Meyer-Olkin and Bartlett’s Test of Sphericity .................................... 109
Table 4.9 Total Variance Explained ........................................................................... 110
Table 4.10 Comparison of Eigenvalues from Principal Component Analysis and Criterion Value from Parallel Analysis ................................................................. 111
Table 4.11 Pattern Matrix Table (Brain-Compatible Classroom Beliefs) ....................... 114
Table 4.12 Internal Consistency of the Brain-Compatible Classroom Beliefs Components (n = 153) ........................................................................................................ 116
Table 4.13 Internal Consistency for Brain-Compatible Classroom Beliefs and Brain-Compatible Classroom Practices (n = 153) ............................................................ 117
Table 4.14 Dimensions and Items in Brain-Compatible Classroom Beliefs ................... 119
Table 4.15 Components and Items in Brain-Compatible Classroom Practices ............. 120
Table 4.16 Descriptive Statistics of the Dimensions ..................................................... 122
Table 4.17 Pearson Product-Moment Correlation Test ................................................ 127
Table 4.18 Descriptive: Approaches to Encourage Student Learning (Brain-Compatible Classroom Beliefs) and Age ................................................................. 129
Table 4.19 Analysis of Variance: Approaches to Encourage Student Learning (Brain-Compatible Classroom Beliefs) and Age ......................................................... 130
Table 4.20 Post-Hoc Tests: Approaches to Encourage Student Learning (Brain-Compatible Classroom Beliefs) and Age. ................................................................. 131
Table 4.21 Descriptive: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Age ........................................................................................................ 132
Table 4.22 Analysis of Variance: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Age ........................................................................................................ 132
Table 4.23 Post-Hoc Tests: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Age ........................................................................................................ 133
Table 4.24 Group Statistics: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Teaching Experience ............................................................................. 134
Table 4.25 T-Test: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Teaching Experience .................................................................................. 134
Table 4.26 Descriptive: Approaches to Encourage Student Learning (Brain-Compatible Classroom Practices) and Age ......................................................................................... 136
Table 4.27 Analysis of Variance: Approaches to Encourage Student Learning (Brain-Compatible Classroom Practices) and Age .................................................................................. 137
Table 4.28 Post-Hoc Tests: Approaches to Encourage Student Learning (Brain-Compatible Classroom Practices) and Age .................................................................................. 137
Table 4.29 Descriptive: Traditional Teacher Attitudes (Brain-Compatible Classroom Practices) and Age ........................................................................................................ 138
Table 4.30 Analysis of Variance: Traditional Teacher Attitudes (Brain-Compatible Classroom Practices) and Age .......................................................................................... 139
Table 4.31 Post-Hoc Tests: Traditional Teacher Attitudes (Brain-Compatible Classroom Practices) and Age ........................................................................................................ 139
Table 4.32 Descriptive Statistics of the Items in Traditional Teacher Attitudes Dimension... 142
Table 4.33 Teacher Feedback for Question One ........................................................................ 146
Table 4.34 Teacher Feedback for Question Two ........................................................................ 148
Table 5.1 Dimensions from the Current Study and Elements from the Brain-Based Learning Principles .............................................................................................................. 157
Table 5.2 Movement of the Items from Previous Elements ......................................................... 162
Table 5.3 Learning Principles in Dimension 1 (Approaches to Encourage Student Learning) ............................................................................................................................ 164
Table 5.4 Learning Principles in Dimension 2 (Traditional Teacher Attitudes) ......................... 168
Table 5.5 Examples of Responses According to Themes for Question 1 ..................................... 171
Table 5.6 Examples of Responses According to Themes for Question 2 ..................................... 175
Table 5.7 Examples of Responses According to Themes for Question 3 ..................................... 177
List of Figures

Figure 2.1: A representation of Kegan’s (1996) model of learning environments involving a balance of challenge and support. ..........................................................37
Figure 2.2: Elements of the 12 Brain and Mind Learning Principles..........................42
Figure 2.3: Conceptual framework.........................................................................61
Figure 3.1: Sequential explanatory design. Source: Adapted from Creswell (2009) and Johnson and Onwuegbuzie (2004). Note: QUAN: Quantitative; QUAL: Qualitative. ......................................................................................................................72
Figure 3.2: School sampling method........................................................................73
Figure 3.3: Structure of the questionnaire. .................................................................80
Figure 4.1: Scree plot. .............................................................................................109
Figure 4.2: Scatterplot between approaches to encourage student learning (brain-compatible classroom beliefs) and approaches to encourage student learning (brain-compatible classroom practices). .........................................................125
Figure 4.3: Scatterplot between traditional teacher attitudes (brain-compatible classroom beliefs) and traditional teacher attitudes (brain-compatible classroom practices). ......................................................................................126
Figure 5.1: A brain-compatible classroom: Teachers’ pedagogical beliefs and practices. .............................................................................................................188
List of Appendices

Appendix 3-1 Items Designed Under Each Brain-Based Learning Principle ............ 226
Appendix 3-2 The Questionnaire for Teacher Survey ........................................... 229
Appendix 3-3 The Interview Protocol .................................................................. 236
Appendix 3-4 Ethics Approvals ............................................................................. 237
Appendix 3-5 Permission to Conduct Research in Malaysia .................................. 238
Appendix 3-6 Letter to the Principal .................................................................... 239
Appendix 3-7 Participant Information Statement .................................................. 240
Appendix 3-8 Consent Form ................................................................................. 242
Appendix 3-9 Withdrawal of Consent for Use of Data Form ................................. 243
Appendix 4-1 Total Variance Explained: 11 Items ............................................. 244
Appendix 4-2 Pattern Matrix (Items With Factor Loadings Smaller Than .40) ....... 245
Appendix 4-3 Total Variance Explained (Forced Four-Factor Solutions: 28 Items) .. 247
Appendix 4-4 Pattern Matrix: Items Moved (Item 29) and Removed (Items 19, 3) .... 248
Appendix 4-5 Total Variance Explained (Forced Four-Factor Solutions: 26 Items) .. 250
Appendix 4-6 Reliability Statistics and Item-Total Statistics (Factor 1) ................. 251
Appendix 4-7 Reliability Statistics and Item-Total Statistics (Factor 2) ................. 253
Appendix 4-8 Reliability Statistics and Item-Total Statistics (Factor 3) ................. 255
Appendix 4-9 Reliability Statistics and Item-Total Statistics (Factor 4) ................. 256
Appendix 4-10 Total Variance Explained (Forced Two-Factor Solution) ............... 257
Appendix 4-11 Examples of Teachers’ Interview Feedback ................................. 258
## List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AESL</td>
<td>Approaches to Encourage Student Learning</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>BBTA</td>
<td>Brain-Based Teaching Approach</td>
</tr>
<tr>
<td>BCC</td>
<td>Brain-Compatible Classroom</td>
</tr>
<tr>
<td>EFA</td>
<td>Exploratory Factor Analysis</td>
</tr>
<tr>
<td>ES</td>
<td>Empowering Students</td>
</tr>
<tr>
<td>ETeMS</td>
<td>Teaching of Mathematics and Science in English</td>
</tr>
<tr>
<td>HSD</td>
<td>Honestly Significant Difference</td>
</tr>
<tr>
<td>ICT</td>
<td>Information Communication Technology</td>
</tr>
<tr>
<td>IQ</td>
<td>Intelligence Quotient</td>
</tr>
<tr>
<td>KMO</td>
<td>Kaiser-Meyer-Olkin</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PCA</td>
<td>Principal Component Analysis</td>
</tr>
<tr>
<td>PISA</td>
<td>Programme for International Students Assessment</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
</tr>
<tr>
<td>TIMSS</td>
<td>Trends in International Mathematics and Science Study</td>
</tr>
<tr>
<td>TTA</td>
<td>Traditional teacher-centred attitudes</td>
</tr>
<tr>
<td>WTPL</td>
<td>Working Together Promotes Learning</td>
</tr>
</tbody>
</table>
Abstract

Research from neuroscience has implied that brain-based learning approaches are essential for effective teaching and learning processes in the classroom. Previous research has suggested that brain-based learning can result in better outcomes in classroom teaching and learning than the traditional teacher-centred approach. This research investigated teachers’ pedagogical beliefs and practices in regards to a Brain-Compatible Classroom (BCC). The data collection approach used sequential mixed methods research. First, a survey instrument was administered. This consisted of 36 items about teachers’ stated pedagogical beliefs and 36 items about teachers’ self-reported pedagogical practices in relation to a BCC. The items were adapted from other brain-based learning studies and the 12 brain and mind learning principles of Caine and Caine (1991) and Caine, Caine, McClintic and Klimex (2005). The questionnaire was administered to 153 secondary school science teachers at national schools in the central region of Malaysia (Selangor, Kuala Lumpur and Putrajaya). The data were entered into the Statistical Package for Social Sciences. Factor analysis revealed two dimensions (approaches to encourage student learning and challenges to traditional teacher attitudes) as representations of teachers’ pedagogical beliefs and practices in regards to a BCC. An email interview was subsequently conducted with eight participants to gain more insights regarding the teachers’ pedagogical beliefs. Feedback on the teachers’ pedagogical beliefs in this study showed a consistency with a BCC. There was also a strong relationship between teachers’ beliefs and practices. The findings suggest that in order to promote effective science teaching in classrooms in Malaysia, strategies are needed that focus on developing supportive learning environments and promoting a wide range of teaching strategies that give teachers and students greater flexibility.
Chapter 1

Introduction to the Thesis

1.1 Introduction

This chapter begins with a brief portrait of education development in Malaysia. The chapter continues by focusing on science education in Malaysia, including a brief discussion related to teaching and learning science in the classroom. The section continues with a statement of the problem followed by the research objectives. The research questions are outlined followed by the significance of the study. The limitations and the context of the study follow, along with a definition of terms and the organisation of the thesis. A summary of the thesis and chapter concludes the chapter.

1.2 Education in Malaysia

This study focused on an investigation into Malaysian secondary school science teachers’ pedagogical beliefs and practices in regards to a Brain-Compatible Classroom (BCC). A brief overview of the development of education in Malaysia follows.

Colonised by the British for two centuries (1786 to 1956), the education system in Malaysia has been shaped by the system originating from the British colonialists (Ratnavadivel, 2007). However, education in Malaysia (previously known as Malaya) has existed since the Malacca sultanate in the 15th century. As this was the time when Islam had also been established, children were only taught about Islamic religion in Koranic schools (Means, 1978). This education has been described as ‘localized, limited in scope and content, and rather disorganized’ (Ratnavadivel, 2007, p. 31). During the British colonial period, a large number of immigrants were brought from China and India to work in the rubber plantations and tin mines. Since then, more schools influenced by the

---

1 A place used for teaching Islamic religion. For example, a ‘pondok’, ‘madrasah’ and mosque.
colonialists were built to attract the Malays, Chinese and Indians (Malaysia, 1969). However, the establishment of the schools was based on the colonial political and economic agendas. Thus, though improved on the previous, the school curriculum was defined as one that was ‘ad hoc, uncoordinated and generally reflected tradition from the country of origin from the different group’ (Zin & Lewin, 1991, p. 226).

While the British held the policy that it was not their responsibility to provide education for the people in Malaya, it was the starting point of the enforcement of the Compulsory Education Act that encouraged parents to send their children to school (Malaysia, 1968). Further, the colony was also the time when formal primary and secondary education was first introduced, with equal educational privilege to all girls and boys (Ratnavadivel, 2007). Thus, a brief overview of the education system in Malaysia shows beginnings that were informal and religious based moving to formal and slightly structured curriculum before and during the British colonial period.

The importance of an Islamic education for the Malays has been reduced since the establishment of the Education Ordinance (1952), which outlined that Islamic education should only be enacted as one of the subjects taught during school hours (Malaysia, 1956). The British, usually considered initiating more accessibility towards education in Malaya, can be seen as insensitive to the needs and culture of those being colonised (Ratnavadivel, 2007). Currently, even though Islam is an official religion of the country, the Malaysian education system runs on the basis of a secular system, which reflects the country’s plural society and is also influenced by the scheme set up during the British colonial period (Zin & Lewin, 1991). However, Islamic education is becoming more prominent among Islamic society as parents begin to realise the importance of spiritual aspects for holistic individual development (Hamid, 2010).
Close to the time of the proclamation of independence of Malaya, the country’s education system demonstrated much improvement. The Razak Report (1956) provided the basis for the Education Ordinance (1957), which then formed the foundation of the National Education Policy (Zin & Lewin, 1991). Released on May 6, 1956, this report influenced the current education system (Ministry of Education Malaysia (MOE), 2003; Ratnavadivel, 2007), with the main recommendations as follows:

- Malay language (now known as Bahasa Malaysia) as the national language and main medium of instruction
- a national curriculum that is local-oriented for all types of schools
- two types of school to be made available for all races; fully aided and private schools
- secondary schools education to consist of lower secondary, upper secondary and pre-university
- central examination system
- qualified and fully trained teachers.

The Malaysian education system has witnessed drastic changes and development after Malaya achieved its political independence from British colonisation in 1957 (MOE, 2004). The establishment of the national schools with the choice of Bahasa Malaysia, the official national language of Malaysia, as the medium of instruction in classrooms since 1970 (Lan & Tan, 2008; MOE, 2008) formed the foundation in uniting Malaysia’s plural society, where the students come from three major ethnic groups: Bumiputra, Chinese and Indian (Govindasamy & DaVanzo, 1992; Lee, 1999). Since the Malaysian former Prime

---

2 Bumiputra means ‘native of soil’, which include the Malays and other indigenous tribes such as Kadazandusuns, Muruts, Bajaus and other tribes in Sabah; Dayaks, Ibans, Penans, and others in Sarawak (Lee, 1999).
Minister Tun Dr Mahathir Mohamad launched the policy of Vision 2020 in 1991, the country has been striving towards achieving the status of a developed nation by the year 2020 (Mahathir, 1991). In realisation of this vision, the Ministry of Education Malaysia in its National Philosophy of Education has emphasised the development of individual potential through quality education (MOE, 2008). The National Philosophy of Education is stated as follows:

   Education in Malaysia is an ongoing effort towards further developing the potential of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious based on a firm belief in and devotion to God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards and who are responsible and capable of achieving a high level of personal well-being as well as being able to contribute to the betterment of the family, society and the nation at large.(MOE, 2002a, p. ii)

   Recently, a reviewed National Education Blueprint (2013 to 2025) has been issued with the aim of raising the country’s international education standards, especially in science and mathematics education (MOE, 2012). This crucial step is taken to prepare Malaysia’s children for the needs of the 21st century and increased public and parental expectations (MOE, 2012).

   As with many other countries in the world, Malaysia has also prioritised education as one of the crucial elements in promoting national unity, social equality and economic development (Lee, 1999). The Academy of Science Malaysia (ASM) (2012) highlights that in the present economic environment, innovation through science and technology is the key to success and sustainability. Thus, science education in Malaysia is seen as one of the important aspects in keeping abreast with the technological advances.
1.3 Science Education in Malaysia

The teaching and learning of science subjects is bound by the syllabus and the curriculum specifications outlined by the Curriculum Development Division, Ministry of Education Malaysia (MOE, 2002a). Apart from the realisation of Vision 2020, the school curriculum saw many reforms since 1960 to improve the quality of education (Lee, 1999). In order to compete with the current and future demands in terms of knowledge and skills, the new and integrated curriculum was introduced in 1983 for primary schools and in 1989 for secondary schools (MOE, 2008). However, under the new school curriculum, science is only taught as a subject at the upper primary level (Years 4, 5 and 6) while for the lower primary level (Years 1, 2 and 3) the science elements are integrated across the curriculum. This has raised controversy regarding inadequate exposure of science elements among the primary school children. Hence, in 1993, science was re-introduced into primary schools as a separate and distinct subject. New steps were taken by the Ministry of Education to ensure the children’s interest in science and mathematics at an early stage. It is also an aspiration emphasised by the government, with the hope to produce scientific and technical human resources aligned with the vision of Malaysia becoming an industrialised country by the year 2020 (Lee, 1999).

Fundamental to the science curriculum at all levels is the mastery of scientific skills and thinking skills. Scientific skills comprise process skills and manipulative skills, whereas thinking skills consist of critical and creative thinking skills. Thus, among the objectives emphasised by the science curriculum for primary and secondary schools is the need to provide the students with knowledge and skills in science and technology (MOE, 2002a). Moreover, teachers are also expected to inculcate ‘scientific attitudes and noble values’ (MOE, 2002a, pp. 8–9) in their teaching approaches. The hope is to enable students to exhibit moral values in problem solving and decisionmaking in everyday life.
The skills, attitudes and values are exposed gradually, starting from the primary level, to lay the foundation for building a society that is culturally scientific and technological, caring, dynamic and progressive. These elements are then further developed, nurtured and reinforced at the secondary level of education (MOE, 2002a).

Nevertheless, starting from 2003, the medium of instruction for science and mathematics education was changed from the national language to English and applied to all national schools (MOE, 2002c) as well as vernacular\(^3\) schools (Chinese and Tamil) (MOE, 2002b). The Teaching of Mathematics and Science in English (ETeMS) policy, better known in the Malay acronym as PPSMI, has also been the aspiration of Tun Mahathir Mohamad in directing the young generations to the challenges of globalisation (Daniel, 2005). It was also hoped to help science students improve their proficiency in English language while upgrading their literacy in science and mathematics (Lan & Tan, 2008). The policy has been implemented in stages, beginning with Year 1(Grade1), Form 1(Grade 7) and Form 6 (Grade 12). The policy has been a great advantage, especially to the science teachers, because the government has provided many support programmes to ensure the successful implementation of the policy while indirectly upgrading the teachers’ personal and professional development. Teacher training, intervention classes, provision of Information Communication Technology (ICT) facilities, teaching course materials and additional textbooks have been developed for teachers at all levels as a continuous support from the government (MOE, 2008).

However, in 2009, the Malaysian government decided to reverse the ETeMS decision and revert back to Bahasa Malaysia for all national primary and secondary schools as well as vernacular schools. This decision has again led to changes in the medium of instruction in stages, starting from 2012, where students in Year 1, Form 1 and Form 4

\(^3\)Schools operating in their own native language.
will start using Bahasa Malaysia in national schools for their science and mathematics learning (MOE, 2010).

The Malaysian science curriculum for secondary school consists of three core subjects and four electives. The core science subjects are science at the primary school level, science at the lower secondary school level (Years 7, 8 and 9) and science at the upper secondary school level (Years 10 and 11). The elective science subjects offered at the upper secondary level consist of biology, physics, chemistry and additional science\(^4\)(MOE, 2002a). Students taking two or more electives are not required to study core science. However, it has been a trend that those who perform well and obtain a good grade at the national examination taken at the end of lower secondary level will pursue electives in their upper secondary level of schooling (Ismorning, 1997).

As the country is heading towards achieving the status of being a developed nation by 2020, various projects and activities have been planned and applied at the school level to elevate the quality of science education aligned with the National Science Education Philosophy (MOE, 2008). The government, especially at the ministry level, has established a great deal of systematic effort to facilitate the challenges faced by the teachers and to alleviate any problems related to the teaching and learning science in classrooms (Lee, 1999). Specific to the Malaysian science curriculum for primary and secondary schools, the National Science Education Philosophy has been written as follows:

\[\text{In consonance with the National Education Philosophy, science education in Malaysia nurtures a Science and Technology Culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and}\]

\(^4\)Additional science is a relatively new subject. It comprises elements of physics, chemistry, biology, earth science, agriculture, oceanography and space science (Curriculum Development Centre, 2006).
able to master scientific knowledge and technological competency. (MOE, 2002a, p. iii)

While the National Education Development Master Plan (2006 to 2010) has put great emphasis on the mastery of science (MOE, 2007), the newly reviewed National Education Blueprint (2013 to 2025) has prioritised science for benchmarking to international standards (MOE, 2012). The proposed blueprint has outlined 11 shifts in transforming the national education system, and the first shift is to provide equal access to quality of education of an international standard (MOE, 2012). Overall, in preparing the country to achieve the status of a developed nation by 2020, great effort has been made to raise the quality of science education, comparable to the best educational system.

1.4 Teaching and Learning Science in the Classroom

In education, the main concerns are student learning and student achievement (Wong, 2004). The teacher as the facilitator of learning who develops lifelong learners plays an important role in making sure that what has been intended has succeeded (Heywood, 2002). However, like many other professions, teaching has its own unique set of challenges (Idris, Loh, Nor, Razak, & Saad, 2007). What has been outlined by the government and the Ministry of Education Malaysia is the aspiration and intention to create individuals who are highly knowledgeable and skilled in the area of science and technology (MOE, 2002a). However, without proper action and profound effort by educators and teachers in the classroom, what has been intended by the government will be very difficult to accomplish.

In Malaysia, many students have a negative attitude towards science learning. This is demonstrated by a study carried out by Sulaiman (1996) at the national level about secondary students’ perceptions of their science classes. The findings showed that 53 per cent of the students perceived their science classes as ‘boring’ (Sulaiman, 1996). Almost a
decade later, the same trend was found in a study by Daniel (2005), which was undertaken with primary school science teachers in the state of Selangor (one of the 13 states in Malaysia). The results unveiled that both urban and rural science teachers didactically confined their teachings to lecture techniques and teacher-centred classrooms. Moreover, through the current education system, teachers and administrators are focused on students’ examination results rather than the learning process. Thus, the teaching and learning process in the classroom is considered overtly examination-oriented with aspects of cognitive development neglected. Consequently, most students found science learning is not interesting (ASM, 2012).

Currently, the intention to revamp examinations and assessments has been proposed in the 2013 to 2025 Malaysia Education Blueprint, with the objective to focus on higher-order thinking skills by 2016 (MOE, 2012). This transformation applies to science education and has been one of the substantial action plans at the ministry level, especially the Curriculum Development Division at the Ministry of Education Malaysia (ASM, 2012).

1.5 Statement of the Problem

In Malaysia, a rapid advancement of the development of science and technology has had a great effect on the educational system, especially science subjects. As a result, the science curriculum has shown tremendous changes (Osman, Halim, & Meerah, 2006). Inevitably, teachers need to be aware of all the changes and be well-equipped with appropriate knowledge to make sure what has been outlined in the curriculum can be realised with effective teaching in classrooms (Zakaria, 2009).

While it has been the National Educational Philosophy to provide students with scientific knowledge and technological skills in science education (MOE, 2002a), the classroom instructions that are inclined to follow traditional teacher-centred methods will
decrease students’ interests towards science subjects (Zakaria, 2009). The aspirations to nurture those students with a science and technology culture by focusing on the development of individuals who demonstrate the values as outlined in the National Science Education Philosophy (MOE, 2002a) would seem to be a distant hope.

The effect of classroom instructions in science subjects that influenced the students’ perceptions of the subject has already been explored by the North Carolina State Department of Public Instruction (1995) in the United States:

How students perceive science and their ability to succeed in science are influenced, to a large extent, by the way they experience science instruction. Traditional teaching strategies have been recognized as a factor related to why many students learn to dislike science. (State Department of Public Instruction, 1995, p. 11)

According to Zakaria (2009), lecture-based instructions and teacher-centred instructions have been recognised as two crucial shortcomings in traditional secondary education. However, these two pedagogical limitations will remain unchanged if no action is taken.

The Organization for Economic Co-operation and Development (OECD) Programme for International Students Assessment (PISA) aims at improving the quality of education throughout the OECD countries testing young adults’ (15-year-old students) skills in reading, mathematical and scientific literacy. Based on the 2009+ PISA report, out of 75 participating countries, Malaysian students ranked 52 for science literacy. Even though the results showed that 57 per cent of students are proficient in science at least at the basic level, the students’ performances are still considered way below other participating Asian countries, such as Singapore, Hong Kong, Japan and Korea (Malhi, 2012; MOE, 2012).
Further, a recent report from the 2011 Trends in International Mathematics and Science Study (TIMSS) has revealed a steep decline for the average score of the science subject from Malaysian students (Martin, Mullis, Foy & Stanco, 2012). This four-year global assessment, which compares the average performance of Malaysia’s Form 2 (Grade 8) science students with their peers from other countries, showed the biggest drop, where the average scores fell to 426 in TIMSS 2011 compared to 471 in TIMSS 2007 (Mullis, Martin, & Foy, 2008). In the 2003 TIMSS report, Malaysian Form 2 (Grade 8) science students scored 510 on average (Martin, Mullis, & Chrostowski, 2004), and out of 44 participating countries, Malaysia was outperformed by 20 countries, with the top five countries being Singapore, Chinese Taipei, Japan, Republic of Korea and England (Mullis et al., 2008). Today, based on the 2012 TIMSS report, the country’s ranking for science fell to 32nd place, showing that Malaysia’s education standards are falling in every four-year TIMSS assessment. Based on the report, 65 per cent of the students declared that the textbook had been used as the primary source by the Malaysian science teachers in science teaching. Further, the majority of the students (78 per cent) reported watching their teachers doing a demonstration of an experiment or investigation in a laboratory (Mullis et al., 2008) rather than doing it themselves. This report demonstrates how traditional teacher-centred attitudes (TTA) dominate science teaching. It is close to what has been referred to as ‘transmission learning’ by Miller (1993), where learning is driven by a one-way flow of information from teacher to student with very little opportunity for reflection (pp. 11–12).

As envisioned in Vision 2020, Malaysia has placed a greater emphasis on science and technology with the purpose of building an industrialised nation. However, this has been a great challenge facing the Ministry of Education Malaysia, with low participation rates from the students in the science stream, far from the targeted ratio set by the ministry.
The targeted ratio was set at 60:40, where 60 per cent represents students in science and technology compared to 40 per cent in arts (MOE, 2004).

In order to tackle the issues, there needs to be a mechanism to promote classroom instruction that is beyond the traditional teacher-centred teaching boundary. With students seemingly disengaged from science learning, new approaches need to be considered. Over the past 20 years, neuroscientists and others have identified many of the brain activities, especially those connected with learning (Wilson & Spears, 2007). This knowledge has been taken up by many educators to provide more evidence of what makes for effective teaching. In what has become known as ‘whole-brain learning’, theorists such as Caine and Caine (1991), McCarthy and McCarthy (2006), Caine, Caine, McClintic and Klimek (2005), Jensen (2008) and Blakemore and Frith (2005) have challenged many educational practices as engaging only part of a complex brain in the traditional teacher-centred approach. In simplistic terms, this is often referred to as the left-brain approach (Herrmann, 1993; Williams, 1986). This may have significant meaning for science teachers in Malaysia.

Previous studies have reported positive effects of using brain-based learning in classrooms (Caine & Caine, 1995; Kaufhold & Kaufhold, 2009; Kaufman et al., 2008; Ozden & Gultekin, 2008; Sadik, 2008; Wagmeister & Shifrin, 2000; Weimer, 2007) and in designing an online course (Tompkins, 2007). In Malaysia, a few researchers have reported the effectiveness of brain-based learning in classroom teaching (Baba, 2008; Baba & Sulaiman, 2010; Saleh, 2008; Saleh, 2009), which includes science teaching (Saleh, 2008; Saleh, 2009). Consequently, Wilmes, Harrington, Kohler-Evans and Sumpter (2008) argue that the findings and implications of brain-based research can no longer be ignored in the educational environment. Note that different terms have been used by different scholars in describing BCCs, all of which carry almost the same meaning in referring to
the context. These terms include: brain-based learning (Blakemore & Frith, 2005; Caine & Caine, 1991; Caine et al., 2005; Jensen, 2007); brain-based education (Jensen 1998, 2008); educational neuroscience (Campbell, 2011; Worden, Hinton, & Fischer, 2011); brain-based approaches; mind, brain and education science (Stein & Fischer, 2011) and BCC (Hart, 1993; Prigge, 2002; Wilson & Spears, 2007). In particular, these terms are used interchangeably in describing BCCs throughout this thesis.

1.6 Research Objectives

In this study, the research objectives are as follows:

1. Investigate science teachers’ pedagogical beliefs about a BCC.

2. Discover whether there is a relationship between science teachers’ pedagogical beliefs and practices in terms of a BCC.

3. Identify the science teachers’ pedagogical beliefs about a BCC according to their age groups and teaching experience.

4. Find out the science teachers’ pedagogical practices in regards to a BCC with regards to their age groups and teaching experience.

1.7 Research Questions

Based on the research objectives, this study was conducted mainly to investigate whether or not the science teachers’ pedagogical beliefs are compatible with a BCC. Thus, this study sought to find answers for the following research questions:

1. What are the main dimensions of science teachers’ pedagogical beliefs about a BCC?

2. Is there consistency between science teachers’ pedagogical beliefs about a BCC and their teaching practice?

3. Do science teachers from different age groups and teaching experience hold different level of pedagogical beliefs about a BCC?
4. Do science teachers’ pedagogical practices in regards to a BCC differ according to their age groups and teaching experience?

1.8 Significance of the Study

It is hoped that the results of the study will provide additional information on how to improve the teaching and learning process in the classroom, especially for secondary school science teachers in Malaysia. It is also expected that the findings will explain the scenario of the science teachers’ pedagogical beliefs in relation to a BCC. In turn, the relationship between teachers’ pedagogical beliefs and classroom action should inform educational practices. By gaining a better understanding of the teachers’ pedagogical beliefs, any steps to upgrade science teachers’ pedagogical knowledge, especially during professional teacher development, will be easier. This will be useful as a reference for the ongoing efforts in creating a teaching and learning environment that makes learning challenging, meaningful and motivating. The Ministry of Education Malaysia may be able to expose teachers to the application of a brain-based learning through in-service teacher training. Indirectly, the research will support teachers’ well-being and professional development while undoubtedly positively affecting student achievement. As a whole, it can be seen as an effort to raise the Malaysian national educational standard.

1.9 Limitations of the Study

Although the current study was deliberately designed to obtain as much information needed, several limitations were unavoidable. First, the respondents in this study were limited to teachers from schools in the central region of Malaysia. Three states were chosen to represent the central region of Malaysia: Kuala Lumpur, Putrajaya and Selangor. This was undertaken to discover teacher feedback from the most developed region in Malaysia. Nevertheless, due to unequal number of respondents from each state, data for each state were combined.
Second, this study was limited to secondary school science teachers only (pre-university level is not included). Secondary school science teachers were chosen instead of other levels of education in Malaysia because the secondary level is the most critical period for students. This is because it is the time where they prepare themselves for the most important examination before they proceed for higher education at any college, university or job application. Further, this is the group of students who sit for TIMSS and PISA assessments.

Third, although the respondents were among secondary school science teachers who teach science (core subjects), biology, physics, chemistry and additional science from Form 1 (Grade 7) to Form 5 (Grade 11), for the purpose of the study, the respondents were not grouped into specific subjects that they taught. However, this does not mean that specific subject matter was not important. The aim of this study was to discover general responses from the teachers about the compatibility of their pedagogical beliefs and practices with a BCC. Other follow-up studies may divide the teachers into their specific science subject and a comparison can be made if there is any difference in the teachers’ responses.

Fourth, the questionnaire used for the teacher survey was adapted based on other studies from Western countries, as no other particular studies were found in the local context. Moreover, the brain-based learning principles used as a guideline to design the questionnaire also originated from the United States. However, being aware of the contextual and cultural issues, proper procedures were taken into consideration to maximise the level of validity and reliability of the questionnaire. In fact, in designing the questionnaire, appropriate measures were undertaken to suit the Malaysian teachers’ socio-cultural context.
Fifth, in examining the questionnaire, the items were designed to reveal the compatibility of the Malaysian secondary school science teachers’ pedagogical beliefs and practices regarding a BCC. As mentioned previously, the items were adopted from other studies and the brain-based learning principles. The items were designed to closely fit possible classroom instructions in the Malaysian context. As a result, other brain-based classroom instructions, such as the use of music, drinking water, aroma or smells and movement during teaching and learning, were not highlighted in the questionnaire because it was generally known that those techniques were rarely used in the Malaysian classroom context. The justification was to discover the possible brain-related approaches being used as teachers’ pedagogical beliefs that could possibly influence their classroom practice.

Thus, the result of the study can only be generalised to a context that shares the same characteristics as Malaysia. The next section describes briefly the context of the study.

1.10 Context of the Study

This study was conducted in Malaysia focusing on the central region, which comprises one state and two federal territories: Selangor, Kuala Lumpur and Putrajaya. This was selected as the location of the study because it is the most developed region. It was assumed that respondents in this area had been well exposed to the latest technology and pedagogical knowledge. In addition, this area was accessible, and as Cohen (2007) has stated, easy accessibility and manageability are important criteria to consider when choosing a place for data collection.

Selangor, located in an area of approximately 8000 square kilometres between the west coast of the Malaysia peninsular and the northern outlet of the Straits of Malacca, is the most developed of 13 states in Malaysia. Rich in natural resources and with its advantageous geographic position, Selangor is also the most prosperous state in Malaysia.
Today, it has the distinction of being the most populated state in Malaysia, with a population of about 3.75 million (Selangor, 2012). Kuala Lumpur is the national capital of Malaysia and covers an area of 243 square kilometres. This most populous city has a population of 1.5 million as of 2010 and is among the fastest growing metropolitan areas in the country, in terms of population and economy. Putrajaya is the seat of the Malaysian government since it was declared as the Federal Administrative Capital of Malaysia since 1999. Located in the middle of the Southern Growth Corridor, which is between Kuala Lumpur and Kuala Lumpur International Airport, this 4391 hectare city forms part of the Multimedia Super Corridor. Based on the 2010 census, the garden city of Putrajaya has an estimated population of 85,636 (Putrajaya, 2012).

According to the state education departments, the number of secondary schools for the three locations in 2010 is as follows: Selangor, 256, Kuala Lumpur, 94, and Putrajaya, 9. Being the most developed region in Malaysia, this gives a total of 359 schools scattered in the central region of Malaysia. Since this study is using a teacher survey as the process for collecting the greatest amount of data possible, respondents of the study were a group of teachers selected from schools in this region.

### 1.11 Definition of Terms

- **Brain-compatible classroom**—The application of brain-based learning instruction in the classroom.
- **Classroom**—A place where teaching and learning takes place, which includes the laboratory and science room.
- **Beliefs**—Stated pedagogical beliefs.
- **Practices**—Self-reported pedagogical practices.
- **Science teachers**—Secondary school science teachers who teach science (core subjects at the lower and upper secondary school levels) and biology,
chemistry, physics and additional science (upper secondary school level) at the national schools in central region of Malaysia (Selangor, Kuala Lumpur and Putrajaya).

- Central region of Malaysia—states located in the middle of Malaysian peninsula: Selangor, Kuala Lumpur and Putrajaya.
- State—Selangor and two federal territories: Kuala Lumpur and Putrajaya.

### 1.12 Organisation of the Thesis

This thesis began with an introduction chapter (Chapter 1), which covered the history of education development and then narrowed down to science education in Malaysia. The discussion continued by covering teaching and learning science in the classroom, followed by the statement of the problem. All other important aspects in the research, such as research objectives, research questions, significance and limitations of the study, were also discussed in this chapter.

The following chapter (Chapter 2) discusses the literature review, which defines learning and how it is connected with the human brain. The discussion continues with how the characteristics of the brain help with the learning process, resulting with the suggestion of brain-based learning principles. Teacher beliefs and practices in education are outlined, and the chapter ends by demonstrating a conceptual framework of the study.

The next chapter covers research methods (Chapter 3), and describes the methodological aspect of this research. In this chapter, the discussion is specific to the paradigms existing in the world of research and the type of paradigm adopted as the worldview of this study. The chapter continues with the data collection process. Since quantitative and the qualitative approaches were used as the data collection method, all the important aspects of these two approaches are discussed.
The following chapter (Chapter 4) presents the results of the analysis according to teacher survey and email interview. The analysis for the teacher survey was completed using the Statistical Package for Social Sciences (SPSS), with the purpose of answering all the research questions. The email interviews, which were analysed manually, support the quantitative result. A discussion of the results of the study is in the next chapter (Chapter 5). This chapter outlines how the results can contribute to the field of knowledge, especially in brain-based learning. A diagram is provided to reflect the results of the study.

The thesis ends with a conclusion chapter (Chapter 6). This chapter outlines the summary of the thesis, theoretical contributions, methodological implications, pedagogical suggestions, limitations and suggestions for future research.

1.13 Summary

Moving beyond an education system defined by the British during colonisation, Malaysia has made much improvement. Since the establishment of the Razak Report (1956), which has been the foundation of the national education policy, the country has aspired to develop a world-class quality education, especially in science. However, despite greater emphasis on science and technology by the Malaysian government, science performance among the secondary school students in Malaysia has declined through the recent PISA and TIMSS assessments. An inclination towards TTA among secondary school science teachers has been identified as among the main factors influencing the science performance. Thus, the use of other approaches to improve classroom instruction has been suggested by other scholars.

Drawn from multiple disciplines, the 12 Brain and Mind Learning Principles (Caine & Caine, 1991; Caine et al., 2005), known as an effective teaching and learning approach, was chosen for this research to discover pedagogical beliefs and practices in regards to a BCC among science teachers from the central region of Malaysia. Research
objectives and research questions were outlined as the focus of the research. As a key to creating a brain-compatible environment, the results of this study could be used to upgrade science instruction in classroom and for whole-brain engagement. The next chapter discusses the literature review.
Chapter 2

Literature Review

‘What does the brain have to do with learning?’ (Campbell, 2011, p. 7)

2.1 Introduction

There has been a growing interest in neuroscience research in the last few decades, and this has revealed information about the brain, how it learns and the implications to educators. ‘Knowledge of how the brain learns could, and will, have a great impact on education’ (Blakemore & Frith, 2005, p. 1). Jensen (2008) argues that the focus on the brain in education started to emerge in 1970s, where books being published started to use the word ‘brain’ instead of ‘mind’. Since then, there have been many attempts to improve our educational practice by using the findings from neuroscience research.

In the 20th century, psychology was applied to education and developed into a field known as educational psychology, and the theories and findings were of benefit to educational practice (Ferrari, 2011). Then, beginning from the 21st century, a new dimension was introduced with a more specific field known as educational neuroscience. Among its earlier objective was finding ways to understand atypical students with special need such as autism, dyslexia, attention deficit-hyperactivity disorder or math disabilities (Campbell, 2011; Ferrari, 2011). Previously, scholars such as Caine and Caine (1995), Diamond and Hopson (1998), Jensen (1997) and Wolfe and Brandt (1998) had argued that neuroscience provided new insight into ways of improving the TTA approach to teaching. While there are those who consider that these ideas have been misused when applied to education and teaching (Goswami, 2008), there are others who see it as a valuable way of understanding learners and learning.
From the 1990s, educators such as Rose (1976), Jensen (2008) and Caine and Caine (2005) have argued that there needs to be a mechanism to improve classroom instruction and pedagogical issues, and neuroscience can help with this. The connections between brain function and educational practice embraces a more holistic view of education (Jensen, 2008; Wilson & Spears, 2007) than the conventional approach in which the teacher is seen as the transmitter of knowledge (Miller, 1993). Campbell (2011) argues that educational neuroscience is ‘a bona fide transdisciplinary activity’ (p. 8). Commonly known as brain-based education, this has widened the scope of educational thinking by bringing together mind, brain and education in dealing with pedagogical issues (Campbell, 2011; Jensen, 2008; Wilson & Spears, 2007). In 1989, United States President George Bush declared the 1990s as the ‘Decade of the Brain’ (Lucas, 2003; Wolfe & Brandt, 1998), and the findings from brain research opened a new dimension in education. Wolfe and Brandt (1998) suggest that the Decade of the Brain could lead to the Decade of Education, and this idea paved the way for the hope that research findings from the neurosciences would benefit the people, especially in education (Lucas, 2003).

In Malaysia, it has been an aspiration to produce individuals who are highly knowledgeable, innovative and creative to prepare for the policy Vision 2020. Crucial steps were taken to prepare the country for an era of the new wave known as the Creative Economy Era and the Century of the Brain (Ayob, 2007, p. 5).

This chapter provides further information on the human brain and its relationship to learning, and shapes the argument that underlies this research. The first section describes briefly the understanding of learning and the development of learning theories that led to the introduction of educational neuroscience. The following section provides an overview of the human brain, and the discussion narrows to the relationship between the human brain and the mind, as well as controversial issues emerging from the scholars. Further on,
brain characteristics and its functions that lead to the development of brain-based learning are also discussed. The chapter continues with a discussion of teacher beliefs in education. Definitions of teacher beliefs and a brief discussion of belief systems are also included. Then, the relationship between belief and practice is outlined, with previous research on the two discussed. The next section illustrates the framework of the study, followed by the concluding section.

2.2 Learning

In its simplest explanation, learning is defined as the acquisition of information (Lefrançois, 1972). However, definitions of learning vary with different types of theory. According to Lefrançois (1972), ‘learning theories are attempts to systemize and organize what is known about human learning’ (p. 21). Schunk (2000) claims that while it has been a trend to accept a definition of learning as changes in observable behaviour, he argues that this is no longer sufficient because learning involves far more complex processes than those that can be observed.

Chance (2009) also claims that many scholars understand learning as ‘a relatively permanent change in behaviour potentially as a result of practice or experience’ (p. 224). However, Lachman (1997) has argued that the changes as a result of learning are not necessarily permanent and that the word ‘practice’ is dubious, as the action of learning does not have to be repetitive. In fact, Lachman attempts to argue an idea from Kimble (1961), who incorporates reward or reinforcement as necessary for learning to occur. He claims that the word ‘reinforced’ implies some sort of force and discomfort. He proposes a more accurate definition of learning as ‘a process by which a relatively stable modification in stimulus-response relations is developed as a consequence of functional environmental via the senses’ (Lachman, 1997, p. 479).
Jensen (1998) and Schunk (2000) claim that the definition of learning first evolved from the groundwork of behavioural theories that were influenced by psychology. Behaviourism has been a powerful force in psychology, especially during the first half of the 20th century, and had a profound effect on the psychology of learning. As noted above, a behaviourist measures learning as changes in observable behaviour arising from forming associations between stimuli, responses and reinforcement (Catania & Victor, 1999; Lefrançois, 1972; Thorndike, 1985). Early behaviourists Pavlov (1927), Thorndike (1985), Hull (1943) and Skinner (1999) and their theories have significantly influenced the education system. Jensen (1998) sums up the thinking as follows:

Their behaviourist theories went something like this: We may not know what goes on inside the brain, but we can certainly see what happens on the outside. Let’s measure behaviour and learn to modify them with behaviour reinforcers. If we like it, reward it. If we don’t, punish it. (p. 2)

The use of rewards and punishment is still a dominant modus operandi for most education systems today, including Malaysia. It is often argued that the advantage of behaviourism is that learning can be observed explicitly (Martinez, 2010). However, as learning is a complex process, thinking of it merely from the perspective of overt measurable behaviour through conditioning is overly simplistic and ignores factors that come from the learner. To be more precise, behaviourists consider the individual learner as a passive object and give little or no credence to individual motivations, emotions, wishes, beliefs and hopes. These internal values do not fit easily into behaviourist theory (Martinez, 2010). Learning from the behaviourist perspective is considered solely a response to environmental stimuli or external factors, and seen in this light, Rychlak and Rychlak (1997) argue that such a position seems to ignore concerns for human worth and individuality. These are the qualities that humanistic psychologists such as Carl Rogers
brought to the attention of teachers and therapists in the 1970s (Rogers, 1970). Realising the importance of the sense of human worth in learning, the inculcation of scientific attitudes and noble values among the students has been emphasised by the Science Curriculum Specifications designed by the Curriculum Development Division (then Centre) at the Ministry of Education, Malaysia (MOE, 2002a).

While behaviourism was established from experiments in training animals, humans are more complex beings and it is inappropriate to generalise this directly to human beings. Thus, Skinner’s theory of behaviourism, or operant conditioning, is challenged, and according to Martinez (2010), its foundation shaken. Nevertheless, Skinner’s idea is pervasive and continues to have a great effect on our education system (Martinez, 2010).

While behaviourism focuses on tangible, observable behaviour and responses, cognitivism emphasises mental events and the formation of concepts (Lefrançois, 1972). Among cognitive psychologists who developed this idea were Bruner (1956) with his study of thinking and Ausubel (1962) with his concern about meaningful verbal learning. Cognitivism emerged from Gestalt psychology, which emphasised the pattern and wholeness of human experience rather than isolated events. Cognitivist theory sought to understand mental events and the formation of cognitive structures through the acquiring, processing, organising and storing of information (Hergenhahn & Olson, 1997).

The characteristics of the cognitive approach rely on more than behaviour to explain the learning process and by emphasising memory and prior knowledge has framed the individual learner as the central controller of learning. Significantly, Howard (2000) argues that without trivialising the behavioural aspect, the element of cognition that contributes to the wholeness of an effective learning process has provided a bridge for the introduction of brain-based education.
Blakemore and Frith (2005) add that the introduction of brain imaging, which measures the brain’s activity as people perform tasks, has provided a new dimension of how to describe learning. Goswami (2008) suggests that because it is the main organ of learning, ‘a deeper understanding of the brain would appear highly relevant to education’ (p. 381). Thus, as mentioned in the previous section, the application of brain-related research that benefits educational practice in the 20th century (Ferrari, 2011) has widened our understanding about how the brain acquires and lays down information in order to reach its optimal capacity in learning (Blakemore & Frith, 2005).

Based on the premise that the definition of learning has evolved explicitly throughout time, it is now accepted that learning covers both behavioural and mental aspects with the lattersupported by using sophisticated and advanced technology. The next section describes the human brain and its functions, which form the foundation of brain-based learning.

2.3 The Human Brain

The human brain, caged in a skull and sitting at the top of the human body, is the most important organ in our body. Weighing an average of about 1600g in men and 1450g in women (Hart, 1983; Saladin, 2008), the human brain is heavy in relation to body weight (Hart, 1983). Sprenger (2007) contends that learning starts with a basic brain cell called a neuron. A neuron comprises cell body, dendrites and axon and is responsible for processing information. Each neuron converts chemical electrical signals back and forth in the process of communicating (Jensen, 1998). Rose (1976) claims that the human brain carries 100 billion neurons, which are interconnected with each other. Most of the neurons are coated with a fatty substance known as myelin to ensure that messages are transmitted efficiently (Sprenger, 2007).
According to Sprenger (2007), learning takes place when two or more neurons communicate. Moreover, it has been argued by Koizumi (2011) that the involvement of external environmental stimuli is believed to trigger communication among the neurons and add up to the definition of learning. Continuous communication between neurons forms a neural network that strengthens the knowledge of what has been learnt before (Sprenger, 2007). Therefore, these neurons help the brain with learning tasks (Jensen, 1998, 2008). Essentially, while learning is related to external environmental stimuli, education is how you control or increase the stimuli and motivate the will to learn (Koizumi, 2011).

Meanwhile, the importance of the human brain and its function has become significant as findings from brain research provide greater insight into its functioning. Springer and Deutsch (2001) report an example of specific brain function that was identified by Pierre Paul Broca in the early to mid 19th century. Broca identified the area of the brain that is concerned with language production. This idea was challenged, although it is now widely accepted.

Early brain researchers could only do their research after patients died in order to discover which part of the brain was injured. Now, the change to an advanced new technology, the invention of scanning machines such as Magnetic Resonance Imaging (MRI) and functional MRI (fMRI) allows neuroscientists to locate injured tissue in living patients (Carter, 1998). Further, fMRI and Positron Emission Topography (Erikkson et al., 1998) can also be used to scan a person’s brain while the person is performing various cognitive or motor tasks and discover which parts of the brain region are the most active while doing tasks (Saladin, 2008).
2.3.1 Brain and mind.

Many theorists, (Hart, 1983; Hattie, 1992) claim that, since the time of early philosophers such as Socrates, Plato and Aristotle, the brain was not understood as being the central organ of human functioning and cognitive processes. The early Greeks understood the mind, soul and brain to be totally separated and independent of each other, whereas recent research tells us that the mind and body is one integrated and complex entity (Goodman, 1991). In the 17th century, Rene Descartes argued that the essence of the self is related to cognitive factors and proposed the metaphysical conception of dualism where the body is understood to be separated from the mind (Hattie, 1992). Descartes viewed the brain as a machine with functions that can only be explained by the mathematical laws of physics (Restak, 1991) and dismissed emotions and feeling as irrelevant (Damasio, 1999).

However, since then the issue of the relationship between the brain and mind has been the focus of discussions by philosophers and researchers for many years (Schwartz, 2003). Schwartz goes on to claim that with the development of neuroscientific research in the mid1600s, the gap between the two entities: the brain and the mind, has been narrowed and the complexity of the interactions increasingly identified. The involvement of biological mechanisms such as conscious feelings and thoughts in the functioning of the mind has been identified as fundamental to who we are. Campbell (2011) argues that educational neuroscience must attempt to bridge the gap between the conscious mind and the living brain. He is among the scholars who relate the ideas of the mindbrain to education. He argues that educational neuroscience has the potential to inform educational researchers, policy makers and educators about ways of using the findings to increase the effectiveness of education in our schools and other educational institutions.
In consideration of the mindbrain, Schwartz (2003) claimed that understanding this concept avoids the separation of the biological and the mental. He writes that ‘mind and the brain are merely two aspects of the same physical entity, and that this three-pound collection of cells sitting inside our skull either entirely determines, or is somehow identical with, mental experience’ (p. 34). The concept of mindbrain has also been accepted in Malaysia’s education system since it has been explicitly expressed in numerous education missions and visions, which include schools (Alhabshi & Loganathan, 1999).

Thus, the idea of the mindbrain by Schwartz (2003) has surpassed the concept of dualism, which had been accepted since the early Greeks. The idea brought by the neuroscience research gives a clear picture regarding our understanding about the human brain. However, the issue rises regarding how well it is understood by the Malaysian teachers and educators in an effort to produce individuals who are intellectually, spiritually, emotionally and physically balanced. Hence, the field of educational neuroscience can play a significant role in associating the knowledge about how the brain functions in learning and how learning takes place effectively. In the following sub-sections, some of the issues related to focusing on education through understanding the human brain were identified. In addition, some of the arguments from those who are sceptical about the establishment of brain-based education were also identified.

2.3.2 Thetwo sided-brain.

Scientists, including Hobbes, Pavlov and Freud, contend that the brain can be partitioned into two parts: left and right (Mayer, 1977). Rose (1976) portrayed the brain as a twin structure that is bilaterally symmetrical. In terms of the brain’s anatomy, the two hemispheres might look the same, although advanced technology tools have led many researchers to agree that the brain is asymmetrical, with each side having its own strengths in various functions (Carter, 1998; Gur et al., 1980; Herrmann, 1993; Saladin, 2008).
Brain imaging studies confirm that the two hemispheres really do have quite specific skills that are ‘hard-wired’ to the extent that, in normal circumstances certain skills will always develop on a particular side. (Carter, 1998, p. 35)

Roger Sperry received a Nobel Laureate for identifying that each hemisphere of the human brain processes information differently. The discovery of the brain hemispheres that differ functionally provided crucial evidence about the function of the commissural tracts that pass through the corpus callosum to enable the two cerebral hemispheres to communicate with each other (Saladin, 2008). Consequently, Rose (1976) outlines the discovery as an example of the localisation of particular functions in particular regions. She added that the most intriguing observations in humans are related to the speech asymmetry, which is said to be dominant on the left side of the brain. However, for left-handed people, the right hemisphere, often, though not always, is found to be dominant for the speech centre.

Identifying these distinctive functions of the two hemispheres has led to a controversial issue of enthusiastically labelling people as ‘left-brained’—referring to focused, verbal, analytical and logical—or ‘right-brained’—concerning random, unreliable, dingy and creative (Jensen, 2008). Jensen (2008) argues that the notion of left-versus-right is logically incorrect and creates an oversimplification, unless the person has had a hemispherectomy. Nor is it correct to say one side of the brain is logical and the other side is creative. Carter (1998)labelled the public’s enthusiasm for such oversimplification as ‘dichotomania’. Neurological empiricists such as Ansari (2008) argue that certain researchers tend to oversimplify and misrepresent neuroscientific findings and this proliferates simplistic ideas or ‘neuromyths’ that are without scientific support. The term ‘neuromyths’ has been used by brain scientists (OECD, 2001)such asGoswami (2008) to express their dissatisfaction with themisrepresentation of the
neuroscientific research. The notion of how the two halves of the brain works differently has been considered one of the best-established neuromyths and is known as brain laterality (Hall, 2005). Among other neuromyths is the idea of critical periods in the early years and enriched environments for young children (OECD, 2001). Recently, research into educators’ beliefs and practices and practices about the neuromyths was undertaken and the result showed a complex belief among the participants that indicated they had insufficient knowledge about the brain (Alekno, 2012).

In an attempt to clarify the truth from the neuromyths, Ansari (2008) claims that while it is true that the two hemispheres differ in their functions, we use both sides of our brains, and damage to one side can be compensated for by the other (Jensen, 1995). In fact, by using logical options, patterns and sequences, people can still become creative (Jensen, 1995). Both hemispheres, which are complementary to each other, are now known by ‘relative lateralisation’ (Jensen, 2008). As Jensen (2008) puts it ‘the brain is designed to process spatially from left to right hemisphere, but it processes time (past to future) from back to front’ (p. 19). ‘Relative lateralisation’ is widely used to describe the functions of both hemispheres.

Moreover, many researchers, such as Blakemore and Frith (2005); Dobson (2009); Genovese (2005); McCarthy and McCarthy (2006); Saleh (1997); Sperry et al. (1969) and Szirony, Burgin and Pearson (2008), have agreed that the two sides of the brain work together. Neurological empiricist, such as Ansari (2008); Bennett (1977); Gazzaniga (1978) and Springer and Deutsch (1993), talk about the immense complexity of the brain and its highly interdependent, interrelated and integrated structure. Thus, the claim of hemispheric specialisation should not be overstated (Geschwind & Galaburda, 1984; Trevarthen & Colwyn, 1978). Based on the claims and arguments by those researchers, it is worth pointing out that even though one hemisphere may be dominant, both sides of the
brain work together in almost all situations, tasks and processes (Blakemore & Frith, 2005). Both of the hemispheres depend on each other for their overall functioning (Jensen, 2008), and Levy (1983) argues that both sides of the brain are involved in almost all human activity.

In education, the concept of hemispheric specialisation provides a useful way of thinking about the way students learn. According to Szirony (2008), hemispheric laterality can be a useful concept in teaching, learning, training and in understanding more about human development. He stresses that knowledge of hemispheric preference is knowledge of self. As a learner, Blakemore and Frith (2005) and Hart (1983) claim that school learning favours the left-brain mode of thinking while trivialising the right-brain mode of thinking. Ornstein (1985) claims that split-brain studies have led to a new appreciation of the idea that all knowledge cannot be expressed in words. This awareness of brain activity has implications for the classroom, where engagement of the students may depend on activating the thinking process of the whole brain in all its complexity. This idea is central to the current study because the researcher’s experience suggests that much of the teaching in Malaysian science classrooms involves the kind of activities that engage only some parts of the brain capacities.

Hart (1983) claims the trend of education today is to educate only half of the brain in the classroom. This refers to the preference for educating students by focusing only on a certain preferred style of learning. Researchers such as McCarty and McCarthy (2006) and McCarthy and O’Neill-Blackwell (2007) have also argued that how a person designs, delivers and evaluates training is greatly influenced by the individual’s preferred style. Nevertheless, Hart (1983) limits the claim by adding that the brain existed long before classrooms and, therefore, a few hours in school can hardly influence the brain to become ‘educated’. Above all, Jensen (1995) highlights that since both parts and wholes are
important to learning, neither of should be emphasised at the cost of the other. To be more precise, it is better to promote the whole-brain thinking rather than focusing on either side of the brain. In fact, students labelled as ‘unintelligent’ or even worse as ‘retarded’ may possess different kinds of intelligence that in the end benefits the society (Ornstein, 1985).

Sprenger (2007) claims that by understanding the brain and its development, teachers can fulfil the physical, emotional and social, and cognitive needs of the students. For example, how the information is processed and transferred from one side to the other by mass fibres known as corpus callosum connecting the two hemispheres provides important knowledge about the learning process (Blakemore & Frith, 2005). The corpus callosum that comprises of the anterior commissure develops at a fairly slow rate and is often not mature until our late teens (Jensen, 2008). Thus, it is important to note that it is the role of the teacher to identify how to teach students effectively according to ways in which their brains receive, process and express information (Prigge, 2002). Knowledge about the brain leads the teacher to recognise the uniqueness of each student and present the material in many different ways to help students to reach their full potential and for whole-brain engagement (Blakemore 2004).

2.3.3 Brain characteristics and learning.

Wilson and Spears (2007) have claimed that education today has embraced various teaching techniques with the main objective of creating effective classroom instruction. By doing so, new educational concepts with the aim to promote beyond the conventional classroom environments have been comprehended, such as mastery learning, experiential learning, cooperative learning, multiple intelligence and problem-based learning, to name a few (Wilson & Spears, 2007). However, having had an experience as a teacher for more than 10 years and having been introduced to a variety of teaching techniques, it is easy to dismiss them as ‘just another technique’ unless it is clear what makes a particular one
worth understanding and adopting. In the researcher’s experience, the effect of particular approaches to the students’ learning has seldom been made clear and it is hard to believe in a new idea unless it is associated with our knowledge and we are able to make sense out of it. From this perspective, if teachers understand the interconnections between the activities of the brain and how they can use these to promote effective classroom engagement, it is contended that they are more likely to adopt new techniques.

The findings from the brain research clearly showed that Intelligence Quotient (IQ) is not fixed at birth (Gordon, 2000). Ramey and Ramey’s (1996) research with children revealed that an intervention programme introduced for impoverished children could prevent those children from having low IQs and mental retardation. Frederick Goodwin, a former director of the National Institute of Mental Health, significantly stated that we would never make a 70 IQ person into a 120 IQ person, but that we could change their IQ in different ways with a range of 20 points up or down based on their environment (Gordon, 2000). This changing of the brain’s capacity has led to the publication of exciting new ideas about brain plasticity (Doidge, 2008).

Defined as a capacity for continuously changing its structure and function throughout a lifetime, brain plasticity or neuroplasticity has been argued as one of the most interesting properties of the brain (Blakemore & Frith, 2005; Kolb, 1995). As early scholars emphasised the brain as static and the nervous system as essentially fixed throughout adulthood (Restak, 1991), research undertaken by Jernigan and Tallal (1990) revealed that the plasticity of the brain endures through life. Regardless of age, our brain is flexible and can grow new cells and make new connections. Hence, Blakemore and Frith (2005) argue that even though the efficiency of laying down new information decreases with age, there is no age limit for learning.
However, Blakemore (2004) argues that it is important to note that the developmental of the brain is according to one’s age, which is unique and fairly not the same. Changes in the brain continue to occur as a function of use and its adaptability to an environment (Blakemore & Frith, 2005). Hebb (1949) proposes a basic mechanism for synaptic plasticity, commonly known as Hebbian Theory or Hebb’s Synapse. Through this theory, Hebb argues that enriched learning experiences could cause synaptic changes that increase the brain’s performance. Kolb (1995) agrees that an enriched experience helps develop a brain with more synapses and more synapses leading to improved brain capacity. Thus, Greenough and Anderson (1991) urge teachers to use all sorts of activities that contribute to enriching the learning environment. In particular, Malaysian teachers are encouraged to vary their activities by using different types of teaching aids (MOE, 2003). However, it was reported that most of the teaching and learning activities in classrooms still depend largely on printed teaching materials such as textbooks (MOE, 2003). In this sense, an enriched learning environment as suggested by Greenough and Anderson (1991) in the classroom in Malaysia is still limited practically.

As mentioned in the previous sections, the issue of an enriched environment has also been called a neuromyth among the neuroscience researchers (Goswami, 2008; OECD, 2001). Moreover, the term ‘enriched environment’ is very subjective and the definition of the term is ambiguous. An experiment was undertaken with rats by isolating them into two different extreme environments: ‘enriched’ and ‘deprived’ (in regards to a ‘normal’ classroom surrounding, the researchers claimed that it is unreliable to label that accordingly as there is no specific guidelines, see OECD, 2001). In OECD (2001), Greenough has argued that ‘one can use rats to make inferences about human behaviour because not only are they mammals but their overall brain architecture is somewhat similar
to that of humans’ (p. 7). As a consequence, it can be seen that the above conditions could also be applied to human beings in the process of teaching and learning.

Another dimension of teaching that is neglected by most teachers is the use of suggestion, as identified by Lozanov (1978). The key point of this method is to focus on peripheral messages along with direct ones. Peripheral messages engage the unconscious mind and can lead to long-term learning. Neville (2005) further supports the idea that much of our knowing does not occur in our mental awareness and teachers need to be aware of this.

Emotions are now recognised as having a powerful influence on learning (Goleman, 1995). Damasio (1999) argues that our thoughts and actions are followed by emotion. Jensen (1998) stressed that ‘[t]here is no separation of mind and emotions; emotions, thinking and learning are all linked’ (p. 71). The brain researcher LeDoux (1994) claims that emotions affect attention and meaning and the creation of memory pathways. Students who are able to find the relevance in what they are learning will be emotionally engaged and able to associate the information with the knowledge they already have (LeDoux, 1994).

Also, when emotions are involved in learning, it is likely that memory will be enhanced (Hobson, 1994). While most educational neuroscience researchers agree that understanding helps in memorising the materials learnt, there are also those who believe that these two works oppositely. In Malaysia, memorising what is learnt has become part of the beliefs of certain people, especially the Chinese in mathematics learning (Sam, 2002). Learning through memorising has also been a purposeful pedagogical choice used in Islamic schools for Qur’anic learning in most parts of the world (Boyle, 2006). While mathematics and Qur’anic learning serve as two different contexts, both hold the premise that the memorising technique is considered the first step to understanding (Boyle, 2006; Sam,
2002). Thus, culture and context are factors that affect the learning approach related to memorisation.

According to Kegan (1996), students learn best in an environment that has a creative mix of challenge and support. Too great challenge with too little support and too much support without sufficient challenge are both bad for learners. Heywood (2003) draws on this idea to create the diagram in Figure 2.1.

High challenge

<table>
<thead>
<tr>
<th>Toxic environment</th>
<th>Exciting environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotes defensiveness and constriction leading to withdrawal</td>
<td>Promotes interest and achievement leading to vital engagement</td>
</tr>
</tbody>
</table>

Low support | High support

<table>
<thead>
<tr>
<th>Alienating environment</th>
<th>Boring environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotes isolation leading to despair</td>
<td>Promotes devitalisation leading to disassociation</td>
</tr>
</tbody>
</table>

Low challenge

*Figure 2.1: A representation of Kegan’s (1996) model of learning environments involving a balance of challenge and support. Source: Heywood, 2003, p. 42.*

While success creates positive emotions, the fear of failure creates stress, and this inhibits learning. Sapolsky (1998) defines stress as the activation of the stress response, which releases specific hormones into the body and brain. While a moderate amount of stress hormones can actually help learning, large amounts, either momentarily released or released over time, will affect the brain, body and immune system negatively. Caine, Caine, McClintic and Klimek (2005) advance the view that too much stress generated by fear leads to a sense of helplessness, also resulting in inhibition in learning.
As well as emotions, all our senses are important in learning. Lucas (2003) and Jensen (2008) suggest that paying attention to colour, light, sound, temperature, aroma and music is one way of increasing learning. In schools, this can be difficult to control, as classrooms tend to be rather formal and rigid in their design and layout and this also applies to schools in Malaysia (Ahmad, Halim, Meerah, Osman & Hassan, 2009). This may be overcome to some extent through positive relations in the classroom that promote a sense of community and belonging. In addition, the sense of sight, hearing and feeling (including touch) are also important in learning. The more activities that teachers can create with these senses, the more alert the students will be. Lucas (2003) claims that 80 to 90 per cent of information is absorbed by our brain through visual input, and the use of illustrations, diagrams, posters and other visual displays are helpful in classroom. Rose (1988) concluded that on average people remember:

- 20 per cent of what they read,
- 30 per cent of what they hear,
- 40 per cent of what they see,
- 50 per cent of what they say,
- 60 per cent of what they do and
- 90 per cent of what they see, hear, say and do! (p. 30)

Even if these numbers are not exact, the implication for the teachers is to teach through many more activities than merely giving lectures. Having students talking, doing, making, telling and creating will do more for their learning than listening alone. In addition, as noted above, Neville (2005) claims that good teaching takes care of both conscious and unconscious processes, while many teachers often think that only sequential and logical thinking can gain students’ understanding. On the contrary, as humans with a brain that seeks patterns and connections, if given a multitude of information students will
themselves work to make sense of it. Teachers need to value and engage the unconscious activity that, according to Neville (2005), has a strong effect on how students think, react, feel and behave.

When teaching heavy, new content, learners may require regular periods of processing time or down time to enable the brain to link information to what they already know. This association and consolidation process occurs in the unconscious when the student is engaged in other activities (Hobson, 1994). Conscious reflection is also a critical process in learning and teachers are advised to engage students in this process (Heywood, 2003).

Csikszentmihalyi (2008) claims an optimal state of learning is ‘flow’. He contends that flow is the state when someone is completely immersed in the task that they are doing and nothing else seems to matter. This reflects Kegan’s (1996) view, which argues that if the challenge is greater than the skills, there will be anxiety; when the skills exceed the challenge, there will be boredom. However, if the challenge and skills are matched, learning and engagement will occur (Csikszentmihalyi, 1996).

Above all, the brain functions discussed in this section are unique features of the brain that support effective learning taking place. The following section describes brain-based learning, which served as the foundation of the study.

2.3.4 Brain-based learning.

Caine and Caine (1991) and Caine et al. (2005) propose 12 Brain and Mind Learning Principles based on a wide range of research findings from psychology to biology and neuroscience that identify with increasing precision how the brain, mind and body are interconnected and interrelated and how these affect the way we learn. The 12 principles of learning that they identified are:

1. All learning is physiological
2. The brain/mind is social
3. The search for meaning is innate
4. The search for meaning occur thorough patterning
5. Emotions are critical to patterning
6. The brain/mind processes parts and wholes simultaneously
7. Learning involves both focused attention and peripheral perception
8. Learning always involves conscious and unconscious processes
9. There are at least two approaches to memory: archiving isolated facts and skills or making sense of experience
10. Learning is developmental
11. Complex learning is enhanced by challenge and inhibited by threat associated by helplessness
12. Each brain is uniquely organized. (Caine & Caine, 1991; Caine et al., 2005)

The authors have numbered the principles for identification purpose only and claim that no principle is more important than any other. While each principle has a specific focus and function, they are all interconnected and do not standalone. The researchers claim that understanding and using these principles in the classroom can provide enriched environments that help students learn and are consistent with constructivist learning, an approach that they support. They claim that these principles promote natural learning: something that is not widely appreciated in education. They suggest that all principles are divided into three fundamental elements of great teaching that must be mastered by teachers. It is critical to understand that these three elements have profound effects on each other and are in fact interrelated. The three fundamental elements are: relaxed alertness (optimal mind-state), enriched experience and experience processing. Each of these elements relates to four of the principles, as detailed below.
2.3.4.1 Relaxed alertness (optimal mind-state).

According to Caine et al. (2005), relaxed alertness occurs when learners experience low threat and high challenge. In this state, a person is both relaxed and to some extent excited or emotionally engaged. They feel competent and confident and have a sense of meaning or purpose and are intrinsically motivated. This element includes the principles that the brain/mind is social, the search for meaning is innate, emotions are critical to patterning and complex learning is enhanced by challenge and inhibited by threat associated by helplessness. In this state, Dryden and Vos (2001) claim that information can be absorbed more quickly and effectively than usual. Jensen (2006) argues that creating environments that promote this state must be a primary focus for teachers and educators.

2.3.4.2 Enriched experience.

While relaxed alertness is related to an optimal learning environment, an enriched experience embraces the principles that all learning is physiological, learning is developmental, the brain/mind processes wholes and parts simultaneously and the search for meaning occurs through patterning (Caine & Caine, 1991; Caine et al., 2005). Classrooms containing enriched environments and a variety of experiences provide the learning milieu in which students need to be immersed. Novelty, variety, instant feedback, experiences and opportunity for student choices (Diamond & Hopson, 1998) are among the factors that need to be available to students. Caine et al. (2005) stress that it is the teacher’s role to ‘orchestrate’ the immersion of these constituents in the teaching and learning process provided with continual student input.

2.3.4.3 Experience processing.

The four principles that fall under this element are: the two approaches to memory (archiving isolated facts and skills or making sense of experience learning involves both focused attention and peripheral perception), learning is both conscious and unconscious and
each brain is uniquely organised. An optimal state of mind with enriched and complex experiences is not enough on its own and students must also be given a chance to reflect or process their experiences. Reflection allows students to make sense of what is learnt, they may sometimes need to memorise facts and practice skills over and over in a process that involves memory. The relationship of the elements and principles is illustrated in Figure 2.2.

### Figure 2.2: Elements of the 12 Brain and Mind Learning Principles. Source: Caine et al., 2005, p. 3.

Caine and Caine (1991) and Caine et al. (2005) are not the only researchers to recognise that educators have not focused sufficiently on how to bring about learning. Hart (1983) stressed that this is the main problem faced by educators who do not recognise the brain as the organ for learning and do not fit instruction and environment to the ‘shape’ of
the brain. Making these adjustments to the manner of instruction and the classroom environment creates a BCC.

Hart believes that many classrooms are now brain-antagonistic and moving to a brain-compatible environment could produce strikingly better outcomes. Prigge (2002) also argues for the importance of creating a brain-compatible environment where students can learn and thrive in a comfortable atmosphere in a school where students feel happy and safe as if they are at home. The happy feeling allows the brain to access higher levels of functioning where the real learning takes place (Prigge, 2002). Indeed, the stress on higher-order thinking skills among the students in Malaysia, especially in science subjects, is now central to the country's education system. The reviewed Malaysia Education Blueprint (2013 to 2025) through the proposed transformation of the education system has planned to revamp national examinations where students are encouraged to think critically and apply their knowledge in different settings (MOE, 2012). Thus, an exposure to knowledge and concepts of a BCC among science teachers is a good platform in preparing students with a comfortable yet challenging school atmosphere.

Essentially, the brain-based learning principles outlined by Caine and Caine (1991) and Caine et al. (2005) are derived from all aspects of effective learning that take place, which covers cognitive, social, physical, spiritual and emotional elements. As a point of comparison, part of the elements have been mentioned in the Malaysian National Philosophy of Education in regards to developing individuals in a holistic manner. However, with part of science classroom practice still favouring the conventional way of teaching, to what extent these aspirations have been realised by teachers and educators is not known (ASM, 2012).

Since the BCC has been declared by scholars as a comprehensive approach to instruction using current research from neuroscience (Wilson & Spears, 2007), quite a
number of studies have been undertaken to test the brain-based learning theory in various educational contexts.

2.3.5 Research related to the BCC.

A crucial distinction that leads to the growth of the BCC approach is the thinking of how the result of brain research can help with the teaching and learning process in the classroom (Campbell, 2011; Wilson & Spears, 2007). Through related brain research, scholars such as Caine and Caine (1991), Caine et al. (2005), Jensen (2000) and Sousa (2006) have proposed effective teaching and learning approaches derived from educational neuroscientific research.

It is important to note that brain-based learning is not simply based on solid findings from the brain or other neuroscientific research. In fact, Ansari, Coch and Smedt (2011) argues that it is unrealistic and incorrect to expect a linkage between a direct application of neuroscientific findings from the laboratory to the classroom. However, Jensen (2000) claims that it was established on the basis of understanding how the brain is naturally designed to learn. Jensen (2008) stresses further that ‘[b]rain-based education is best understood in three words: engagement, strategies and principles. Brain-based education is the engagement of strategies based on principles derived from an understanding of the brain’ (p. 4). The three elements complement each other in order to explore how the brain works in terms of information processing, memory and retention in learning (Jensen, 2006). Further, theories and principles that are associated with brain functions emerge as the main focus to help educators in classroom instructions. Above all, learning is not just about remembering, what is more important is understanding and knowing when to apply what has been learnt in everyday life. Moreover, the learner needs to make meaning from what they learn by connecting their prior knowledge with the present information (Caine & Caine, 1991).
Undeniably, it is also an interesting fact that our brain is not a machine that exhibits constant performance. Jensen (2008) advocates that brain efficiency could be affected by other factors such as threat, stress and motivation, which may affect our emotional well-being and lead to decreasing attention. Jensen (2008) also highlights that the brain has its own rhythms and does not learn on demand according to a school’s rigid, inflexible schedule. Therefore, in order to increase the brain’s performance in instructional process, engagement of approaches is needed (Caine & Caine, 1991; Sousa, 2006). Based on the findings from the neuroscientific research, more educational concepts were developed to improve classroom instruction, such as mastery learning, experiential learning, learning styles, multiple intelligences, cooperative learning, practical simulations and problem-based learning (Wilson & Spears, 2007). Meanwhile, a set of approaches underpinning brain-based education that summarise exclusively how the brain works effectively and efficiently in teaching and learning has also been created by Caine and Caine (1991) and Caine et al. (2005), who suggested the 12 Brain/Mind Learning Principles.

Above all, brain-based education has been claimed as a key to a new dimension of classroom instructions that expose brain-friendly student-centred approaches as opposed to traditional teacher-centred teaching (Kaufman et al., 2008). Thus, research had been widely undertaken in testing the new approaches in classroom instruction, especially in the United States, the country where it was first developed (Bell-Hanson, 2008; Bello, 2007; Green, 2010; Klinek, 2009; Krummick, 2009; Materna, 2000; Morris, 2010; Sikes, 2009; Tompkins, 2007; Walsh, 2010).

Based on the previous studies, it was indicated that brain-based education promotes meaningful learning (Materna, 2000) where students who are emotionally connected can emotionally engage in the classroom (Weimer, Walsh, 2010; 2007). Thus, Green (2010) argues that brain-based education has improved students’ development
and achievement, including in mathematics (Bello, 2007; Sikes, 2009) and science subjects (Ozden & Gultekin, 2008). Moreover, Sikes (2009) claims that brain-based education influences students’ attitudes towards reading.

Based on the positive influence of brain-based learning theory upon learning, the theory was also tested in developing a theoretical brain-based online course design model for college courses in higher education by Tompkins (2007) through qualitative inquiry. The result yields useful methodological findings that are potentially transferrable across various college courses and course management systems. The effects of brain-based approaches have also been tested widely from kindergarten to Grade 12 students (Green, 2010; Sikes, 2009) and nursing students (Materna, 2000). Teachers at the school level have also been the main target as participants in the study of brain-based education (Bello, 2007; Krummick, 2009; Morris, 2010; Sikes, 2009; Walsh, 2010) as well as educators at the university level (Klinek, 2009). Thus, almost all researchers argue for the positive effect of the theory upon students, teachers and educators in their studies.

In Malaysia, very few studies have been undertaken specifically relating to educational neuroscience or brain-based education. Among the research undertaken is that of Saleh (2009) employing the brain-based learning theory in the development of the Brain-Based Teaching Approach Module (BBTA module) in relation to Newtonian physics conceptual understanding and physics learning motivation among students. Based on the results, it was reported that students who followed a BBTA module demonstrated a better Newtonian physics conceptual understanding and expressed better learning motivation compared to those who were exposed to the conventional teaching method. Baba (2008) and Baba and Sulaiman (2010) conducted two studies and concluded that using brain-based education to teach language was more effective than traditional teacher-centred teaching approaches. A positive influence of the theory has also been reported by
Aziz and Baba (2011), who integrated the brain-based learning theory in developing a prewriting research model related to smart teaching and learning strategy. They argue that the three fundamental elements in the theory (active processing, relaxed alertness and orchestrated immersion) fit the model as they accommodate and improve creative and critical thinking skills in the prewriting process.

Based on studies undertaken in Malaysia, it can be argued that the brain-based learning approach tested in the local context has proven to produce positive outcomes in the teaching and learning process in classroom. While it has been undoubtedly true that the application of brain-based approaches provides effective classroom teaching and engages students’ learning, it is worth considering that past studies focused more on the relationship between brain-based learning and skills in language learning, such as reading and writing. Very few studies had been undertaken in the field of science education and related to science teachers.

Further, most of the studies were undertaken through quasi-experimental study by testing the theory on one sample group and comparing it to the control group, which applied the traditional teacher-centred approach. However, in a real classroom context, with the teachers’ exposure to new technology and knowledge, question arises as to whether teachers and educators have solely confined their teaching techniques to the traditional teacher-centred approach. In fact, Wolfe (2010) argues that numerous teaching practices aligned with brain-based education have been employed by teachers in their classroom instruction. Typically, Morris (2010) makes the point that while teachers may not be familiar with the theoretical aspect of brain-based education, they could be utilising the strategies intuitively in the classroom. However, Miller (1998) claims that not all the techniques applied in classroom teaching have taken the brain-friendly approaches into consideration:
The task before educators and neuroscientists then is to take what is known about brain development and apply it to the policies and strategies we use to educate the nation's children. Until that occurs, education will continue to be out of step, and some students will continue to miss out on certain opportunities to expand their learning capacity. (p. 6)

Thus, it is imperative to know what teachers have and have not applied in the classroom, as this may give us a rough idea of how far they have been applying brain-based learning approaches in educating the students.

By examining the perspective of current Malaysian education, lower achievement results from the PISA 2009+ and TIMSS assessments in 2003, 2007 and 2011 reflect that Malaysian students’ performance in science is way below the international educational standard. In an attempt to challenge what Miller (1998) mentioned above and as a mechanism in helping the country improve science performance, there should be a greater emphasis upon the implementation of brain-based classroom approaches among teachers and educators. As the report about the assessments demonstrates, one of the problems in Malaysia related to the use of didactic teaching approaches among science teachers in classroom (Martin, Mullis, Foy & Stano, 2012). In-service teacher training that stresses brain-based education from a theoretical aspect as well as its application should be promoted (Bello, 2007). This is aligned with what has been aspired to in wave 1 (2013 to 2015) of Malaysia’s education transformation, which is focusing on up-skilling the existing pool of science teachers for better quality science education (MOE, 2012). Thus, exposing comprehensive knowledge about brain-based learning to science teachers hopes to improve the quality of classroom teaching and learning, which later will improve the students’ performances.
2.3.6 Summary

New in the era of education and derived from transdisciplinary activity, educational neuroscience has proposed a new set of pedagogical knowledge based on how the human brain learns naturally. Also known as brain-based learning theory, Caine and Caine (1991) and Caine et al. (2005) have suggested the 12 Brain and Mind Learning Principles. This approach has proved to be one of the effective teaching and learning techniques (Kaufhold & Kaufhold, 2009; Baba, 2008; Baba & Sulaiman, 2010; Kaufman, et al., 2008; Ozden & Gultekin, 2008; Sadik, 2008; Salleh, 2008; Wagmeister & Shifrin, 2000; Weimer, 2007) that could be introduced to science teachers in Malaysia to raise the country’s educational standard. This approach has also been tested by researchers in schools in Malaysia and received positive feedback in terms of students’ performances and motivations (Baba, 2008; Baba & Sulaiman, 2010; Salleh, 2008).

However, in order to ensure the effectiveness of the teacher training, teachers’ prior knowledge of the techniques is very important. In this context, ‘prior knowledge’ is not just referring to ‘knowledge’ that they have, but is also what they thought would work and be effective in their teaching. In other words, it is essential to know about teachers’ beliefs regarding the application of brain-based education.

2.4 Teacher Beliefs in Education

Belief in the education context has long been discussed in the literature by scholars such as Kagan (1992), Nespor (1987), Pajares (1992) and Fang (1996). Previous studies have witnessed investigations of teachers’ pedagogical beliefs, particularly in history (Wilson & Wineburg, 1988), mathematics (Vacc & Bright, 1999), reading (Fang, 1996), science (Czerniak & Lumpe, 1996), integration of information technology (Ertmer, 2005), the standards of foreign language learning (Allen, 2002) and analysing classroom cases narratively (Kagan & Tippins, 1991). The following sub-sections describe the reason
why ‘belief’ has been chosen instead of ‘knowledge’, specifying the type of belief meant by this study and the relationship between beliefs and practice. Previous studies about beliefs and practice from the context of brain-based learning are also discussed.

2.4.1 Definition of teacher beliefs.

Many scholars have attempted to define teacher beliefs but ironically discovered the complexity of describing the term specifically. Pajares (1992) has marked teacher beliefs as a ‘messy construct’ and further contends that ‘the difficulty in studying teachers’ beliefs has been caused by definitional problems, poor conceptualizations, and differing of understandings of beliefs and belief structures’ (p. 307).

Nevertheless, Ertmer (2005) and Pajeras (1992) denote that despite the entangled definition, the central problem in describing teacher beliefs lies with how it has been distinguished from knowledge. A crucial distinction has been made by Pajeras (1992) by claiming that ‘belief is based on evaluation and judgement whereas knowledge is based on objective fact’ (p. 313). Seen in this light, Ertmer has also conceded the distinction between ‘belief’ and ‘knowledge’ recommended by Calderhead (1996), who evokes belief as ‘suppositions, commitments, and ideologies’ whereas knowledge refers to ‘factual propositions and understandings’ (p. 75). Thus, two people who have the same knowledge may differ in their beliefs about the knowledge. Unlike knowledge, Pajares (1992) further asserts that other scholars in educational psychology often regard beliefs as attitudes, values, judgements, axioms, opinions, ideology, perception and conception, to name a few. Hence, belief covers a wide range of values that primarily exist in tacit form (Kagan, 1992; Nespor, 1987).

Rokeach (1968) holds that all beliefs have cognitive components that represent knowledge, affective and behaviour components. However, Rokeach classifies knowledge as only part of the belief structure. Even so, Nisbett and Ross (1980) adopt the view that
beliefs have stronger affective and evaluative components. These two components make them different to knowledge, which stands on the basis of the cognitive element and is schematically organised (Nisbett & Ross, 1980), and these differences have been supported by Pajares (1992) and Ernest (1989). However, Ernest (1989) stressed that belief also holds a slender but significant cognitive component. Consequently, belief covers bigger aspects of components that are more appropriate when describing the complexity of teachers’ actions in their everyday life. In fact, Kagan (1992) puts forward the view that ‘most of a teacher’s professional knowledge can be regarded more accurately as belief’ (p. 73).

Another interesting point has been made by Nespor (1987), who contends that, physiologically, beliefs reside in episodic memory with material drawn from experience or cultural sources, whereas knowledge system information is stored semantically. Nespor (1987) advocates that the nature of teacher’s job is often ill defined, which leads to an entangled domain. Thus, in facing inconsistencies and problems, they apply their episodic core of beliefs instead of cognitive and information-processing techniques. In relation to this study, ‘belief’ has been chosen as the term used in investigating the compatibility of teachers’ classroom instruction with a BCC because it reflects the ill-defined and complex situations facing by those teachers in the classroom context.

As teachers may have a broad range of beliefs, which include their general beliefs, Pajares (1992) has made a suggestion to differentiate between teachers’ general beliefs and their educational beliefs. In fact, he further contends narrowing down educational beliefs to specify the belief to which we are referring. Taking Pajeras’(1992) point of view, teachers’ educational beliefs was chosen, focusing on classroom teaching and the learning approach, or, as the preferred term used in this study, ‘pedagogical belief’ (Ertmer, 2005).
2.4.2 Belief system.

As mentioned by the belief scholars in the previous section, the belief structure covers cognitive, affective and evaluative components and is highly influenced by experience and cultural elements. Thus, it clearly shows that beliefs vary in their strength and types under the belief system. In demonstrating the belief system, Rokeach (1968) has outlined five types of beliefs that vary from the most highly resistant to change and gradually moves to the very least. The more the belief is connected to an individual’s personal identity, the stronger the belief. This is central to the belief system and, with the association to the previous experience (Pajares, 1992), will result in high resistance to changes (Rokeach, 1968).

The five types of beliefs described by Rokeach (1968) only apply to the beliefs of individuals in general and none has been specifically related to teacher beliefs. Thus, for the current study, classifying the beliefs is restricted according to what has been proposed by Griffin and Ohlsson (2001), who stressed that there are two types of beliefs: first, beliefs that are highly dependent on motivational influence, named as affect-based beliefs, and second, beliefs that espouse epistemological values, known as knowledge-based beliefs. In their research, Griffin and Ohlsson (2001) discovered that their participants were not willing to change their affect-based beliefs. This explicates that the affect-based beliefs demonstrate strong connection to the participants’ personality and thus fail to influence them with any new information. Conversely, knowledge-based beliefs are less personal and relatively easier to be changed. The study also revealed that the willingness of people to change their beliefs lies according to their underlying reason for holding the beliefs. In the context of the current study, despite having been exposed to individual teaching experience for so many years, which influences their belief systems, an assumption has been made that the type of belief adopted by the participants are more
knowledge-based. It is hoped that this kind of belief will render positive implications for the teachers if new teaching approaches such as BCCs are going to be integrated in their classroom instruction.

Ultimately, Nespor (1987) and Pajares (1992) have indicated that beliefs can change. Nespor further contends that it is not argument or reason that changes the beliefs but rather a conversion process or Gestalt shift. Thus, the existing beliefs must be challenged, or if the individuals are dissatisfied with their existing beliefs, then the beliefs are prone to be changed (Posner, Strike, Hewson, & Gertzog, 1982). In order to be successful in changing teachers' beliefs, Kagan (1992) has proposed giving opportunities to teachers to examine, elaborate, and integrate new information into their existing belief system. Thus, beliefs can be changed, especially those knowledge-based.

2.4.3 Link between belief and practice.

‘Individual’s beliefs strongly affect their behaviour’ (Pajares, 1992, p. 326).

In describing the relationship between teachers’ beliefs and practice, Nespor (1987) claims that beliefs are far more convincing than knowledge in determining how individuals orchestrate and define tasks and problems, and thus are stronger predictors of behaviour. The point made by Nespor is strengthened with the claim proposed by Pajares (1992), which emphasises that how a person demonstrates action is not because they have knowledge about it but because of beliefs that are influenced by their perceptions and judgements. Typically, Tobin, Tippins, and Gallard (1994) support the view by highlighting that ‘[t]eachers’ beliefs are a critical ingredient in the factors that determine what happens in classroom’ (p. 64). It is logical to argue that a relationship between teachers’ beliefs and practices exists.

Teachers’ beliefs have strongly influenced their actions, especially in classroom instruction. One study undertaken by Meehan (2007) explored the relationship between the
stated beliefs and practices of early childhood school teachers regarding teaching and learning. The findings illustrate that the participants had taught according to their beliefs. By demonstrating this key finding, the researcher outlined all the factors that influenced teachers’ decision to practice their beliefs in the classroom: ‘the school context, support from administration, clear guidelines for teaching, access to professional development, education background, personal understanding of content, and confidence’ (Meehan, 2007, p. 245).

However, despite the fact that what happens in classroom is strongly influenced by teachers’ beliefs, researchers such as Fang (1996) and Calderhead (1996) have put forward inconsistencies between teachers’ beliefs and their classroom practice. Indeed, Ertmer, Gopalakrishnan, and Ross (2001) have proved in their study about technology use in the classroom that teachers’ beliefs about the use of technology have not been realised in their classroom practice. Conversely, Readence, Konopak, and Wilson (1991), as cited in Fang (1996), have long argued that there are mixed outcomes in the relationship between beliefs and practice that varies from very consistent to very inconsistent.

Alternatively, Fang (1996) advocates that the incompatibility between teachers’ beliefs and their classroom practice is not unpredictable. Fang (1996) further holds that contextual factors are probably the reason why teachers are unable to turn their beliefs into practices consistently. Ertmer (2005) asserts that ‘[c]urricular requirements or social pressure exerted by parents, peers, or administrators’ (p. 29) are among the contextual factors. Moreover, it has been argued by Duffy and Anderson (1984) and Duffy and Roebler (1986) that the complexity of classroom life would likely be among the contextual factors that prevent the connection between teachers’ beliefs and their practice. Even though these researchers undertook their research in language teaching and specific to
classroom reading, the justification for disassociation between beliefs and practices would likely acceptable for other subjects as the difference is solely in the subject taught.

When comparing the factors suggested by Meehan (2007) that influence teachers to realise their beliefs into practice, the contextual factors claimed by Ertmer (2005), Duffy and Anderson (1984) and Duffy and Roebler (1986), which prevent the relationship between beliefs and practices, are totally discouraging to teachers. Thus, the implication of contextual factors, which influence the relationship between the beliefs and practice, can be regarded as either positive or negative. Regardless of beliefs and practices, science teachers in Malaysia are also facing a range of complexities in classroom life that is similar to what has been acknowledged by Duffy and Anderson (1984) and Duffy and Roebler (1986). Examples include lacking classroom or laboratory infrastructure, poor school facilities and resources, irrelevant curriculum and low support from administrators (ASM, 2008). While those examples may cause the inconsistency between beliefs and practices, the National Education Development Plan (2001 to 2010), which outlines an ongoing effort to provide a conducive school environment equipped with functioning infrastructure (MOE, 2003), may have improved the situation. In fact, this effort is again put into action in the Malaysia Education Blueprint (2013 to 2025) which advocates continuously upgrading the school, classroom and laboratory facilities (MOE, 2012).

As a response to the literature on beliefs and practices in the classroom context, one of the objectives of this study is to discover the relationship between teachers’ pedagogical beliefs and their practices in regards to a BCC. Above all, even though researchers have proved that teachers’ beliefs underpin their classroom practice, contextual factors may influence the relationship between teachers’ beliefs and their classroom practices, a phenomenon that could likely affect science teachers from Malaysia.
2.4.4 Beliefs and practices in regards to brain-based education.

So far, not many studies have explored teachers’ beliefs and practices relating to brain-based education. One study had been undertaken by Klinek (2009) through a web-based survey using a Brain-Based Learning Questionnaire Survey to investigate knowledge, beliefs and practices around brain-based learning among educators at the university level. Based on the findings of the study, Klinek contends that the participants had an average amount of knowledge and beliefs about brain-based learning and, therefore, were not able to realise their knowledge and beliefs about brain-based learning into practice. However, surprisingly, the researcher proved that there was a strong positive correlation between knowledge and beliefs as well as knowledge and practice among those educators. Moreover, there was no significant relationship between the variables (knowledge, beliefs and practice of brain-based learning among the participants) and demographic factors such as teaching experience. Thus, Klinek concludes that faculty members in higher degree colleges had insufficient knowledge about brain-based learning and thus failed to show the relationship between knowledge and beliefs in classroom practice.

In reflecting on Klinek’s (2009) study, one could argue that the survey was focusing more on the theoretical aspect of brain-based learning rather than its application. In fact, only a few items were concerned with the application of brain-based learning itself. Unfortunately, this ignores the crucial fact that the participants may have knowledge or beliefs about the application of the theory and not the theory per se. Moreover, if participants did not have the knowledge about the theory, it would be impossible for them to translate the theory into their classroom practice. This could be the reason why they were deemed to have minimum knowledge about brain-based learning.
Research by Krummick (2009) employed a quantitative survey to investigate the application of brain-based education in the classroom and in professional development through teaching techniques such as problem-based learning, student-centred projects, multiple intelligence, service learning and parallel curriculum. The participants of the study were the pre-kindergarten through Grade 3 teachers (primary schools) in Florida. Participants were asked to rate their usage of those techniques in the range of ‘never’, ‘1 to 2 times per month’, ‘1 to 2 times a week, almost every day’ and ‘every day’ in a five-point Likert scale. The findings showed that problem-based learning, multiple intelligence and student-centred projects were applied in the classroom at least one to two times per month. Thus, Krummick indicates that brain-based education strategies are being applied in classroom teaching and learning processes. However, those strategies were reported as not being mentioned in regards to professional development.

With reference to the studies mentioned above, even if Klinek (2009) discovered that participants had very little knowledge and beliefs about brain-based concepts, Krummick (2009) demonstrated that certain brain-based approaches had been applied in classroom teaching and learning processes by teachers even without their being exposed to this theory and its application during their professional development. Presumably, even though those studies were undertaken in two different contexts, regarding place and group of participants, those participants likely have knowledge or beliefs about techniques or application that are aligned with brain-based education and practice in their approaches to their classroom instruction. However, the amount of knowledge that they have may vary among the teachers, as it depends on the sources to which they have been exposed.

Seen in this light, teachers may not know about the theoretical dimension of brain-based education but they may have the pedagogical beliefs that are aligned with the BCC approaches and have been practicing them intuitively. According to Thomas (2008), in his
definition of intuition among classroom facilitator: ‘The term intuition is used…to describe
the circumstances when facilitators are not able to articulate a clear rationale for their
actions, yet they are still able to facilitate effectively’ (p. 5). Even though the definition
was derived on the basis of intuitive responses from facilitators, it does apply to teachers as
both play the same role as educators for classroom learners (Heywood, 2002).

Meanwhile, another study was undertaken by Morris (2010), who claimed
utilisation of brain-based education strategies among primary and secondary urban school
teachers across all the subjects in the Memphis city school district. Based on the results of
the study, it was discovered that elementary school teachers, especially the national board
certified teachers and teachers with teaching experience between 11 to 20 years,
significantly employed several brain-based approaches in their classroom instruction.
Among the reported activities were class discussions, brain storming and question and
answer sessions to encourage classroom communication. Similar with the findings
reported by Krummick (2009), the majority of the participants in Morris’ (2010) study also
declared not having been exposed to any training or professional development related to
brain-based education. However, another interesting finding is that among the subject
teachers, those who taught English, mathematics, science, social studies and electives
applied the least number of brain-based practices in their classroom instruction.

Thus, it can be concluded that regardless of professional development, teachers
may have beliefs about the application of a BCC and may be utilising the approaches
intuitively in their classroom instruction. Moreover, there could be certain factors that
influence the extent of teachers’ beliefs about brain-based education that later translate into
their classroom practice. So far, demographic factors such as age, teaching experience and
level of teacher education are the variable factors that have been examined.
2.4.5 Summary

In this study, ‘belief’ has been chosen instead of ‘knowledge’ because it is related to evaluation and judgement, whereas knowledge is only based on objective fact. However, the type of belief that is focused on in this study is knowledge-based, which is less personal and relatively easier to be changed. For the purpose of the study, ‘pedagogical belief’ is used to specify the type of educational belief adopted.

Previous researchers claim that teachers’ classroom practices are greatly influenced by their beliefs. However, contextual factors have been identified as factors that could influence the relationship between the two. The complexity of classroom life is an example of contextual factors that result in inconsistencies between belief and practice. In relating this to the context of the study, the complexity of classroom life is also faced by the science teachers in Malaysia.

Very few studies have examined the relationship between beliefs and practices in regards to brain-based education. Based on those studies, little knowledge and beliefs have been demonstrated by the teachers towards the concept of brain-based education. However, there is evidence of the application of brain-based learning in their classroom practice. Thus, teachers may have practiced the concept intuitively.

2.5 Framework of the Study

Learning is a complex activity that is now understood to include an individual’s cognitive, emotional, psychological and social processes. Thus, how we understand learning and what best promotes it has been the focus of the study. For the purpose of the study, the 12 Brain and Mind Learning Principles (Caine & Caine, 1991; Caine et al., 2005) have been selected as the principles of the brain-based learning that served as a guideline in conducting the investigation. The 12 principles can be grouped into three
different but interrelated fundamental elements: relaxed alertness (optimal mind-state), enriched experience and experience processing.

Since this study takes place within the context of classroom settings, the term BCC is used throughout the thesis to represent the application of brain-based learning in the classroom, as suggested by Caine and Caine (1991) and Caine et al. (2005). Teachers are chosen as the target of the study as this group of people initiates the teaching and learning process in the classroom. Specifically, the context of the study is science teachers from the central region of Malaysia.

In this study, the focus is on two aspects of pedagogy—beliefs and practices. The term ‘pedagogical belief’ has been used to represent educational beliefs that focus on classroom teaching and learning among the teachers (Ertmer, 2005). The term ‘pedagogical practice’ refers to the classroom practices based on what the teachers claim as their pedagogical beliefs. This is very important as an implementation of new teaching practices beyond traditional teacher-centred methods needs to take teachers’ beliefs and practices into consideration (Allen, 2002). As it is not possible to observe all the teachers at work, the study focused on their stated beliefs and self-reported practices.

Teachers may not be familiar with the theory nor trained in this approach, but they may already have beliefs about teaching that is aligned with the principles of brain-based learning. If so, they may be using brain-based learning principles in their classroom teaching intuitively (Morris, 2010). However, to what extent their beliefs are compatible with the brain-based learning principles and to what extent they have been utilising the approach in their classroom instruction is not known. By investigating their beliefs and practices in relation to a BCC, whether the approach has or has not been accepted and applied in their classroom practice will become known. Hence, science teachers’ pedagogical beliefs will be the main objective of this research and the relationship between
teachers’ pedagogical beliefs and practices in regards to a BCC will also be part of this investigation.

Different group of teachers may exhibit different patterns of beliefs and practices in relation to a BCC. Therefore, this study takes into account teachers’ demographic factors to ascertain whether or not these factors affect their beliefs about a BCC. Above all, this research is an investigation of pedagogical beliefs and practices concerning a BCC among science teachers. Since a BCC, pedagogical beliefs and pedagogical practices have been the main constructs in this research, these contentions can be regarded as the conceptual framework of the study and are illustrated in Figure 2.3.

A Brain-Compatible Classroom

Based on the conceptual framework, the following research questions framed the study:

1. What are the main dimensions of science teachers’ pedagogical beliefs about a BCC?
2. Is there consistency between science teachers’ pedagogical beliefs about a BCC and their teaching practice?
3. Do science teachers from different age groups and teaching experience hold different level of pedagogical beliefs about a BCC?

4. Do the science teachers’ pedagogical practices in regards to a BCC differ according to their age groups and teaching experience?

2.6 Conclusion

The introduction of brain-based learning in the era of education has bridged the gap between the physical brain and the mind, which contributes to a more holistic view of learning. Drawn from various studies across multiple disciplines, educational neuroscience has proposed new approaches for effective learning based on how the brain works naturally in learning. As the issue of Malaysian students’ performances in science education, which has recently declined, has been central among teachers and educators, a new and improved pedagogical approach should be introduced.

Shown to be an effective classroom instruction, the 12 Brain and Mind Learning Principles represent important aspects of students’ engagement in learning. They are used in this study to discover science teachers’ pedagogical beliefs and practices in regards to a BCC. Teachers’ beliefs, which demonstrate a stronger construct compared to knowledge, were selected as one of the aspects to be investigated. Thus an investigation of teachers’ pedagogical beliefs about a BCC and whether or not their beliefs are consistent with their practice was conducted. What the teachers hold as their pedagogical beliefs and how those beliefs are compatible with the theoretical aspect of the brain-based learning is the focus of interest in this study.

2.7 Summary

In this chapter, the literature related to unique features of the human brain and its functions that help in effective learning have been reviewed. Significant results from the neuroscientific research that could be applied in an educational context have also been
discovered. The important components from the brain functions and the neuroscientific findings were combined and integrated, suggesting brain-based learning principles. These principles have been used by many scholars as guidelines for replacing traditional teacher-centred approaches with engaging and brain-friendly student-centred classroom instructions. With an awareness of teachers’ pedagogical beliefs and practices of the BCC instruction, these principles are used in this study to investigate pedagogical beliefs and practices in regards to BCC among secondary school science teachers from the central region of Malaysia.

The next following chapter on the research approach discusses the research methodology adopted to investigate the research questions.
Chapter 3

Research Methods

3.1 Introduction

Chapter 1 stressed the need to have a mechanism to promote classroom instruction that is beyond the traditional teacher-centred teaching boundary. Chapter 2 presented the literature review that covers investigations into how some of the neuroscientific findings have been applied in education. In this context, brain-based education has proved to be an effective approach for helping teachers think about engaging the students’ whole brain in classroom learning and challenging the traditional teacher-centred approach. In this chapter, the research methods for this study are presented.

The research was aimed at an investigation into Malaysian science teachers’ understandings of how to teach in a manner compatible with how the brain learns. The research was initially designed to answer the following questions:

- What are the main dimensions of science teachers’ pedagogical beliefs about a BCC?
- Is there consistency between science teachers’ pedagogical beliefs about a BCC and their teaching practice?
- Do science teachers from different age groups and teaching experience hold different pedagogical beliefs about a BCC?
- Do science teachers’ practices in regards to a BCC differ according to their age groups, and teaching experience?

In order to answer all the research questions, this chapter starts with a section that describes the current study from different philosophical foundations. Then, the chapter continues with a brief acknowledgement of the existence of a third paradigm in the world.
of research and how it is related to the current research. Next, the research design of the study is illustrated. Then, the chapter continues with the first part of data collection, which concerns how the teacher survey was conducted with all the related details. The second part of data collection, which was email interviews, is described in the following section. Next, the instruments used in data collection are also discussed. Validity and reliability issues as well as ethics approvals in conducting research are outlined in the next section. The final section summarises all the discussion in Chapter 3.

3.2 The Selection of Paradigm

In the process of undertaking the research, ways that different worldviews affect the way researchers design their studies were explored. However, as the researcher was steeped in the traditional way of research in science, positivism was adopted as the paradigm of the research. Nevertheless, this worldview has been challenged throughout the journey of the research, especially as the qualitative methods were reviewed. Thus, the research design acknowledges the subjectivity of the researcher and the legitimacy of emotions in our experiences.

3.2.1 Practical considerations.

In this study, teachers’ pedagogical beliefs and practices relating to aBCC were investigated among secondary school science teachers in the central region of Malaysia. Finding an appropriate approach to reveal teachers’ pedagogical beliefs and to examine whether or not their practices are in fact aligned with their beliefs was challenging. This is related to practical considerations of social research. Bryman (2008) makes the point that the research questions and the context of the research are central to selecting a methodological approach. If the interest is to generalise inferences from samples about characteristics, attitudes or behaviours of populations, then a quantitative approach is more relevant (Babbie, 1990). However, if the aim is to collect the data in natural settings where
the researcher is more interested in observations and having face-to-face interaction
time with participants, then a qualitative approach would be more appropriate
(Creswell, 2009). As the concern was to generalise inferences from a group of teachers
about the compatibility of pedagogical beliefs and practices in regard to developing BCCs,
it was determined that a quantitative approach was the appropriate way to do this.
However, in considering any possible approach, the focus of the study, in this case beliefs
and practices, is a major influence in deciding the way the research should be conducted.

According to researchers such as Munby (1982) and Schunk (1991), the study of
belief is best approached by using a qualitative rather than a quantitative approach. Open-
ended interviews, responses to dilemmas and vignettes as well as observations of
behaviour are among the measures suggested by Munby (1984), Munby (1982), Schunk
(1991) and Wilson (1990). However, Pajeras (1992) stresses that the ultimate choice of
research approach depends on what and how the researchers wish to know: ‘The choice of
quantitative or qualitative approach will, of course, ultimately depend on what researchers
wish to know and how they wish to know it’ (Pajares, 1992, p. 327).

Again, by referring to the aim of the study, the focus was to gather general
feedback from secondary school science teachers in the central region of Malaysia
regarding their beliefs and practice in terms of BCCs. Pajeras (1992) states that the
quantitative approach that gathers data is a commonly used technique and a survey was
chosen to gather information from a large number of respondents. A questionnaire was
constructed to mirror a BCC. It was the main tool for unearthing teachers’ beliefs and
practices about classroom instruction to answer the research questions in this study.
Ultimately, responses were received from 153 teachers from a range of secondary schools
in Malaysia’s central region.
3.2.2 Theory

As indicated above, at the outset the research was to be quantitatively oriented. The positive influence of brain-based education in terms of the effective learning principles identified by Caine & Caine (1991) and Caine et al. (2005) seemed relevant to the study. These principles were used as the framework for developing the survey. Using a survey would not necessarily gain deep insights into all the respondents’ beliefs, but as Pajeras (1992) argues, these must be inferred and this is certainly true of this study. In his study of beliefs, Rokeach (1968) argues that the deeper a belief is held, the more resistant it is to change. However, it is difficult to uncover these deep beliefs within the limits of this study and no claim to change participants’ beliefs is made. Rather, responses to the questions were gathered and aimed at identifying at least some of the beliefs about students and learning that the teachers take with them into the classroom. Once the responses were gathered, they may be generalisable to the greater population of Malaysian science teachers (Babbie, 1990).

While a questionnaire might not probe deeply into each person’s inner beliefs, and this has been agreed by Munby (1982) and Schunk (1991), it will allow the participants to respond with the beliefs that they consider important to their pedagogy. To be accurate, what was measured was their stated pedagogical beliefs. In particular, the question of whether their beliefs aligned with their practices was investigated through a separate section of the same questionnaire. Items included queried the teachers’ self-reported pedagogical practice to investigate whether or not their actions reflected their beliefs.

3.2.3 Epistemology.

Coming from a science background, a positivist paradigm has been selected as the preferred approach. However, the aim of identifying teachers’ pedagogical beliefs and
practices about brain-compatible teaching needed more exploration than would be possible with statistics alone.

This is in agreement with Darlaston-Jones (2007), who contends that by adopting the worldview that a single universal reality applies to all of us fails to acknowledge the human ability to interpret and make sense of the world and its surrounding. In support of this stance, Tuli (2011) asserts that ‘reality is subjective, multiple and socially constructed by its participants’ (p. 99). In this sense, individuals interpret their own reality (Darlaston-Jones, 2007). As the interpreter of the data, the researcher’s subjective reality must be considered to influence the results. However, the researcher is experienced in and familiar with the context in which the participants work, and as Lincoln and Guba (1985) recognise, in this capacity a researcher can bring validation, rigour and authenticity to the research. As Heywood (2003) states, when the researcher is validated as a research instrument with finely developed insight, knowledge and analytical capacity, it is not impossible to claim scientific objectivity. Originally, the researcher considered that objectivity was possible and was happy to work within this paradigm. However, investigations into methodologies and the worldviews they reflect have led to a view that subjectivity is inescapable. The findings from this study will, and must, reflect some of the researchers’ own beliefs and experience. These insights are used to enlighten the views of the participants, and provide a reliable interpretation of the data.

Further reading led to Kagan and Tippins (1991) and Pajares (1992), who acknowledge the difficulties involved in drawing out the beliefs that teachers hold, especially in education. According to Kagan (1990), teacher belief cannot be directly accessed for a number of reasons. He argues that beliefs are often held unconsciously and that teachers may not have the language to describe them. The teachers might also be unwilling to express their real beliefs if these are different from other people and, finally,
teachers’ beliefs are created within the contexts in which they work and are thus dependent on those contexts.

Based on claims by Kagan and Tippins (1991) and Pajeras (1992), it was clear that the study of teachers’ beliefs is more complex than originally thought. Brain-based learning principles were used as the framework and as part of the guidelines in designing the research instrument, such as the questionnaire for the teacher survey. A survey method for 153 science teachers was adopted to discover if they had intuitive understanding of how to teach in a way that caters for how the brain learns, and whether or not their practice reflects this understanding. In an attempt to find out a little more about their ideas, email interviews were conducted with eight respondents seeking further information about issues that arose from the survey.

Kagan (1990) classified the measurement of teacher beliefs into two types. The first type is a direct and non-inferential way of assessing teacher beliefs by using predetermined, verbal descriptions of desirable teacher beliefs, such as Likert self-report scales. These were used in the questionnaire. The other method relies on teachers’ descriptive language in responding to open-ended questions and this approach was adopted in the email questions, which also gave teachers the opportunity to write down their thoughts. The questions for the emails were derived from the outstanding results from the survey that warranted further exploration. The email interviews took place in the second phase of the study and are referred to as the qualitative part of this research. These were conducted after the completion of the statistical data analyses and drew on Kagan and Tippins’ (1991) ideas about the use of teachers’ narrative discourse, including structured written tasks, to discover teachers’ underlying pedagogical beliefs. They contend that writing tasks serve as an opportunity for teachers to express their own experience and thus reveal their inner beliefs more reliably than may occur in a spoken interview. On
reflection, even at this early stage, the need to probe a little more deeply than the survey became evident.

Based on the above discussion, it is clear that in the study a combination of quantitative and qualitative approaches have been adopted in gathering the data to unveil teachers’ pedagogical beliefs and practices. However, in terms of the core focus of the research, the quantitative approach is regarded as the main method in this study since it contributed to answering most of the research questions.

3.3 Mixed Methods Research

While purists in both qualitative and positivist research maintain that special characteristics of the two paradigms are ideal for research, recently there has been an introduction of a new research approach that emerged from both quantitative and qualitative methods (Teddle & Tashakkori, 2003). Known as mixed research or integrative research (Johnson & Onwuegbuzie, 2004) or mixed methods research, the establishment of this approach aims to reduce any problems faced by using single methods (Sechrest & Sidani, 1995). In defining this third approach, Johnson and Onwuegbuzie (2004) propose a formal definition as: ‘the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study’ (p. 17). Johnson and Onwuegbuzie (2004) appreciate the importance of the third research paradigm in educational research and claim:

We hope the field will move beyond quantitative versus qualitative research arguments because, as recognised by mixed methods research, both quantitative and qualitative researches are important and useful. The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimize the weaknesses of both in single research studies and across studies. (pp. 14–15)
Apart from having two research methods that stand at different ends of the research continuum, the third approach is a combination of both qualitative and quantitative methods that are seen as complementary to each other in an attempt to solve research problems.

In reference to the use of quantitative and qualitative approaches in gathering the data, this research can be related to a mixed methods research, albeit with limited qualitative data. Creswell (2009) claims that mixed methods approaches that engage with both pre-determined closed-ended and emerging open-ended questions prove advantageous. Further, O’Cathain, Murphy and Nicholl (2007) stress that obtaining results from the statistical analysis from a sample and then following up with a few individuals helps to explain those results in more depth. Creswell (2009) and Tashakkori and Teddlie (2010) claim that the strengths of both quantitative and qualitative approaches can complement each other and provide the best understanding to answer the research questions.

However, there are certain issues that question whether this research does belong to the third approach. While it is not uncommon to have more than one approach in gathering the research data, in the context of this study the focus was simply the application of more than one single way of gathering data. Hence, the use of the term ‘mixed methods approach’ in this study is regarded as a utilisation of a combination of qualitative and quantitative methods in gathering the data rather than a third approach.

3.4 Research Design

The research design for this study covers two phases of data collection. The first phase of data collection focused on a quantitative approach by providing copies of the questionnaire to 153 sample science teachers. The second phase of data collection
focused on the qualitative approach and used email interviews with eight teachers as the participants.

This research applied a quantitative and qualitative approach in a sequential manner. A quantitative method was used by having a survey with a large number of respondents followed by a qualitative method that involved open-ended questions sent via email, which allowed detailed exploration of few cases or individuals (Creswell, 2009). The overall research design of the study is illustrated in Figure 3.1.

![Sequential explanatory design](image)

*Figure 3.1: Sequential explanatory design. Source: Adapted from Creswell (2009) and Johnson and Onwuegbuzie (2004). Note: QUAN: Quantitative; QUAL: Qualitative.*

Based on Figure 3.1, the difference in font size between the first phase and the second phase of the research highlights the emphasis given to the method. The next sections focus on the data collection process.

### 3.5 Teacher Survey

As the quantitative research was regarded as the main technique in gathering the data for this study, the following sub-sections detail the elements involved in conducting the survey. The details are discussed according to the objective of employing the technique in gathering the data, school sampling method, participants, procedures and data analyses.
3.5.1 Objective.

A teacher survey was conducted for this research with the main purpose of collecting enough data from this survey to allow generalisation across the larger population of secondary school science teachers in the central region of Malaysia. The survey was designed to collect the data that would help to answer the questions given in Chapter 1. Part one of the survey was based on the brain-based learning principles and was designed to identify the science teachers’ pedagogical beliefs. Part two of the survey sought to identify their classroom practices. Using the results of these two sections of the survey, it could then be determined if the teachers’ beliefs were compatible with the brain-based learning principles. Then, teachers’ demographic factors such as age groups and teaching experiences were collected to examine the degree to which these could be seen to influence their beliefs and practice.

3.5.2 School sampling method.

The selection of teachers as respondents started with the selection of the schools that would be asked to participate. Every school in the region could not be covered and so a disproportionate stratified random sampling method (Cohen et al., 2007; Sekaran, 2000) was used to ensure the schools were selected in a systematic way. A diagram showing the selection of schools is illustrated in Figure 3.2.

Figure 3.2: School sampling method.
The large number of schools meant that not all could be contacted, given the total cost and the manageability of such a large project for one researcher. In addition, because the number of schools in each state is unequal, it was decided to select only a certain proportion of schools in each state; this is presented in Figure 3.2. Also, because of the large number of schools in each area, it was clearly impossible to cover them all. It was decided to choose 10 per cent of the total schools in Selangor and Kuala Lumpur as these two states have quite a number of schools: Selangor (256) and Kuala Lumpur (94). However, 30 per cent of schools in Putrajaya were chosen since there are only nine schools in this state.

The selection of schools was based on the homogeneity of the schools within the region. To ensure the homogeneity of the school samples, only those that are located at the urban and suburban areas were selected for the study. Schools at the suburban area are included as there is no specific guideline in distinguishing the schools between the two locations in Malaysia. Putrajaya and Kuala Lumpur are the two states located in urban area. However, schools in Selangor are scattered in urban, suburban and rural areas.

Having decided on the number of schools from each state, the schools were then randomly selected: 26 schools from Selangor; nine schools from Kuala Lumpur and three schools from Putrajaya. As can be seen in Figure 3.2, a total of 38 schools from the central region of Malaysia were selected as possible samples for this study. Essentially, the selection of schools for this study follows the model of the disproportionate stratified random sampling method and also takes the elements of costing, manageability and accessibility into consideration.

3.5.3 Participants.

The participants of the study were specifically secondary school science teachers who teach science as the core subject at the lower and upper secondary school levels, and
pure science subjects such as biology, chemistry, physics and additional science for the upper secondary school level.

The average number of science teachers in schools was calculated by totalling the highest number of science teachers in one school with the lowest number of teachers in one school and dividing the result by two. Using this formula, it was discovered that the average number of science teachers in a school was 12. However, all the science teachers in each selected school were invited to be respondents in the study. The selection of all science teachers was to avoid an over estimation of small schools, which may have a less than average number of teachers, and an under estimation of big schools, which may have a more than average number of teachers. Thus, the number of questionnaires distributed was based on the population of the science teachers in one school. The total respondents of the study represents the sample of the population of teachers among schools in the urban areas in the central region of Malaysia.

According to Bryman (1994), there should be at least five respondents for each item in the questionnaire and not less than 100 respondents in the total sample. Since the total items for part one of the questionnaire (BCC Beliefs) was 36, it was anticipated that there would be at least 180 respondents, which was considered adequate for a 1:5 ratio. Another 36 items in part two of the questionnaire (BCC Practices) were not taken into consideration as the items matched items in part one but covered a different context. The justification of considering the 1:5 ratio also related to an acceptable minimum number of participants needed for Exploratory Factor Analysis (EFA), which is explained in detail in the data analysis section.

3.5.4 Procedure.

The questionnaires were prepared as detailed in section 3.8.1 and personally delivered to the principal of each school, who then hand-distributed them to the teachers.
The average time allocated by the principals for the administration of the questionnaire was two weeks. Once all the completed surveys were received, the data were entered into SPSS version 18 for data analyses.

3.5.5 Data analyses.

Data analysis was conducted specifically to answer all the research questions. Factor analysis was conducted to identify components that represent dimensions of teachers’ pedagogical beliefs about a BCC. Then, the relationship between teachers’ pedagogical beliefs and practices in regards to the particular item was investigated by using correlation analysis. In this study, a Pearson Product-Moment Correlation Coefficient ($r$) test was employed as a statistical test to measure correlation. Further, the influence of teachers’ age group and teaching experiences on teachers’ pedagogical beliefs and practice was examined by Analysis of Variance (ANOVA) and $t$-test. Part of the information gained from the results of the analyses was then used for the second phase of the study, which was email interviews.

3.6 Email Interview

Apart from conducting the teacher survey, email interviews were performed as part of the data collection process. This second phase of the study began after the quantitative data analyses had been completed. An initial plan was to conduct face-to-face interviews with four to six participants who participated in the survey. However, due to time factors where too much time would be needed to transcribe the data, the plan was changed to email interviews with the selected participants from the study. Since the feedback was written by the participants, it saved the time and expense of transcribing. It also enabled the participants to express the answers in their language and words (Creswell, 2009). Nevertheless, Cohen et al. (2007) mention the limitations of this method where not all
people are equally articulate and perceptive. Thereby, Cohen et al. claim that the feedback sent through email may be incomplete.

The following sub-sections describe the details of the email interview technique in terms of objective, procedure and participants.

3.6.1 Objective.

The email interviews were conducted with the purpose of getting further explanations based on the results of the data analyses. This approach supported the main research objective of the study regarding the compatibility of teachers’ pedagogical beliefs and practices in regards to a BCC.

3.6.2 Participants.

The secondary school science teachers who completed the questionnaires had been asked in the last section of the instrument whether they would agree to be interviewed or not. Those who were willing to participate could give their contact numbers and were considered potential participants. Then, from the total number of teachers who agreed to take part, eight teachers were chosen randomly as the participants. This sample selection approach for the email interview session was regarded as a combination of a volunteer and random sampling method. This step relied on volunteers from the respondents who answered the questionnaires and then chose a certain number of subjects randomly so as to avoid too many participants being interviewed.

3.6.3 Procedure.

Eight participants were selected from a group of teachers who had voluntarily agreed to take part in the study. Since all the participants came from different schools and locations, they were contacted through the telephone numbers that they had written in the questionnaire in the first phase of the study. This was to inform them that they had been selected for the email interviews and request their email address. Then, the email interview
protocol, which consisted of three questions, was sent through email to each of the participants to get their feedback. The feedback received via email was analysed for further explanation. There was no statistical test involved in analysing the teachers’ feedback and the data was analysed manually according to themes.

The next section describes the instruments that were used in this study to retrieve the data from the respondents.

3.7 Instruments

The survey and interview protocol designed for the study are discussed further in the following sub-sections.

3.7.1 The questionnaire.

According to Wilson and McLean (1994), a questionnaire is commonly used as a useful instrument for collecting information and provides structured and numerical data. It is easy to be administered without the presence of the researcher, and is often comparatively straightforward to analyse. In this study, a close-ended questionnaire was used with the purpose of collecting mass data regarding teachers’ pedagogical beliefs and practices in regards to a BCC. ‘Highly structured, closed questions are useful in that they can generate frequencies of response amenable to statistical treatment and analysis. They also enable comparisons to be made across groups in the sample’ (Oppenheim, 1992, p. 115).

An extensive search of the literature failed to find a single instrument that effectively measured teachers’ pedagogical beliefs and practices in regards to a BCC. Therefore, the items in the questionnaire were developed based on an adaptation of previous questionnaires proposed by Klinek (2009) and Morris (2010), with an integration of the 12 Brain and Mind Learning Principles suggested by Caine and Caine (1991) and Caine et al. (2005). Modifications were made to the Klinek’s (2009) and Morris’ (2010)
questionnaires to accommodate the current study. Klinek’s (2009) focused more on the theory rather than the application of brain-based learning and was meant for educators at the higher level of education. Meanwhile, Morris (2010) provided a teacher survey that was rather close to this study. Nonetheless, the structure of the questionnaire was different as it focused on the implementation of brain-based instructional practices between teachers from different levels of teaching. Thus, the items were re-designed according to the aims of this study with the brain-based learning principles as a guideline.

3.7.1.1 Structure of the questionnaire.

For the purpose of the study, the questionnaire comprised three parts. Part 1, labelled ‘Knowledge about Learning’, was meant to explore teachers’ pedagogical beliefs about a BCC. Part 2, labelled ‘Demographics’, inquired about the demographic factors of the respondents. Part 3, labelled ‘Classroom Practice’, was intended to investigate teachers’ classroom practices regarding their beliefs in part 1 of the questionnaire. All the items in part 3 were matched precisely with the items in part 1 with the aim of finding out if teachers’ pedagogical beliefs about a BCC were aligned with their classroom practice. However, for identification and statistical analyses purpose, part 1 is now labelled ‘BCC Beliefs’ and ‘BCC Practices’ represents part 3 of the questionnaire. The terms ‘BCC Beliefs’ and ‘BCC Practices’ are used throughout the following sections and in Chapter 4, which presents the quantitative results.

Altogether, there are 36 items for BCC Beliefs and 36 items for BCC Practices in the questionnaire. Refer to Figure 3.3 for the structure of the questionnaire.
As shown in Figure 3.3, the structure of the questionnaire was based on the three interrelated fundamental elements in the 12 Brain and Mind Learning Principles by Caine and Caine (1991) and Caine et al. (2005). These elements are relaxed alertness (optimal mind-state), enriched experience and experience processing. Each element contains four principles and three items were developed from each principle. Details of the items designed under each principle are illustrated in Appendix 3-1.

Part 2 (demographic factors) contains five items about age, gender, cultural background, highest qualification and teaching experience. These are the basic factors that may explain the differences among the teachers in Malaysia. Nominal scales that denote categories (Cohen et al., 2007) were applied to explain the demographic factors.

Instead of placing great attention on the construction of items in part 1, part 2 and part 3 of the questionnaire, it was important that other aspects were considered, such as the appearance and the instructions. This was to assist the respondents in answering the questionnaire. The questionnaire was designed to make it look simple and uncomplicated. Clarity of wording was prioritised during the development of the items.
and clear instructions were placed at the beginning of each section as complicated instructions and complex procedures may intimidate respondents (Cohen et al., 2007).

As this study employed a quantitative and a qualitative approach, which sought volunteers for the email interview sessions, the questionnaire also allocated a section at the end of part 3 for any feedback from interested respondents. Verma (1999) has suggested a section where the respondents can write down their names for a follow-up. However, for this study, it was decided for the respondents to only write their contact numbers in an effort to keep the anonymity and non-traceability of the respondents before the selection of the participants. Further, contact numbers are very important as the location and distance of the participants may vary. Thus, it made communication possible and easier between the researcher and the participants.

The questionnaire of this research can be seen in Appendix 3-2.

3.7.1.2 Development of the questionnaire.

Apart from the adaptation of the questionnaires from Klinek (2009) and Morris (2010), the items in the questionnaire were developed based on the 12 Brain and Mind Learning Principles and were grouped into the three fundamental elements that underpinned the principles. Brief explanations of each element with the four principles are illustrated in tables 3.1, 3.2 and 3.3. These principles were used as a guideline in designing the items in the questionnaire. Moreover, Table 3.4 demonstrates an example of items in the BCC Beliefs section of the teacher survey.
Table 3.1

*Relaxed Alertness (Optimal Mind-State)*

<table>
<thead>
<tr>
<th>Element 1</th>
<th>Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relaxed alertness (optimal mind-state)</strong></td>
<td><strong>The brain/mind is social</strong></td>
</tr>
<tr>
<td>Feeling low threat and high challenge; feeling competent and confident and has a sense of meaning or intrinsically motivated (Caine et al., 2005).</td>
<td>‘Social relationships, with an emphasis on belonging, being recognised, listened to, and noticed, all contribute to a sense of relaxed alertness’ (Caine et al., 2005, p. 49). As a result, learning increases. Every student has the capacity to learn through relationships with others (Caine et al., 2005). Caine further explained that cooperative learning, peer coaching and having students share their work and ideas are among activities suggested in the classroom. Shor (1992) stressed that teacher talk depresses students, which limits the students’ speech and development.</td>
</tr>
<tr>
<td>In a state of relaxed alertness, the brain can absorb information more quickly and effectively (Dryden &amp; Vos, 2001).</td>
<td></td>
</tr>
</tbody>
</table>

*The search for meaning is innate*

According to Jensen (1998), human beings are natural meaning-seekers. Shor (1992) claims that ‘[p]eople are naturally curious. They are born learners. Education can either develop or stifle their inclination to ask why and to learn’ (p. 12).

The need to make sense of things, which has been called the ‘explanatory drive’, is present in every human being from early childhood to adulthood (Gopnik, 1999). Aspects of meaning are: felt meaning, novelty and dissonance. Valuing and meaningfulness enhance relaxed alertness (Caine et al., 2005).

*Emotions are critical to patterning*

The students will be emotionally engaged when they see the relevance of what they are learning and how they can use the knowledge in other areas. Among suggested activities are drama, role-plays, quiz, shows, music, debates, larger projects, guest speakers and celebrations (Jensen, 1995).

*Complex learning is enhanced by challenge and inhibited by threat associated with helplessness*  
All students can learn more effectively in a supportive, empowering and challenging environment (Caine et al., 2005). Moderate amounts of stress can actually help learning, but in large amounts, either momentarily released or released overtime, they will affect the brain, body and immune system negatively (Sapolsky, 1998).
Table 3.2

**Enriched Experience**

<table>
<thead>
<tr>
<th>Element 2</th>
<th>Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enriched experience</strong></td>
<td>All learning is physiological</td>
</tr>
<tr>
<td>The immersion of enriched and complex experience in learning</td>
<td>Our physical movement and the engagement of senses are important in learning (Lucas, 2003).</td>
</tr>
<tr>
<td>(Caine et al., 2005).</td>
<td>Colour (Lucas, 2003), light, sound, temperature, aroma and music are all important elements</td>
</tr>
<tr>
<td></td>
<td>that increase learning (Jensen, 2008).</td>
</tr>
</tbody>
</table>

**Learning is developmental**

Sprenger (2007) claims that by understanding the brain and its development, teachers can fulfil the physical, emotional and social, and cognitive needs of the students. Thus, it is important to note that it is the role of the teacher to help students understand the different ways in which their brains receive, process, and express information (Prigge, 2002).

**The brain/mind processes parts and wholes simultaneously**

Learning about small parts in isolation without being introduced to the big picture of what you are learning is inefficient. Making sense of experience requires both a big picture and paying attention to the individual parts (Caine et al., 2005).

In the classroom, teachers are encouraged to tell the students about the overall idea first before these are taught in small segments. Students then can associate these smaller segments that they are learning and they can always refer to the main idea to understand the pattern (Dryden & Vos, 2001).

**The search for meaning occurs through patterning**

Our brain has an unique ability to recognise patterns and this is how it stores information by making great use of associations (Dryden & Vos, 2001). According to Rose (1988), you cannot become involved in something unless you understand it and it has meaning for you personally. The ‘feeling’ about what we learn makes successful learning (McCarthy & McCarthy, 2006).
Table 3.3

*Experience Processing*

<table>
<thead>
<tr>
<th>Element 3</th>
<th>Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience processing</td>
<td>Two approaches to memory: archiving isolated facts and skills or making sense of experience</td>
</tr>
<tr>
<td>Making sense of what is learnt by giving enough time in processing the experience or reflecting (Caine et al., 2005)</td>
<td>In describing this principle, we are focusing on explicit memory; what people can consciously recall, describe and store intentionally (Kolb, 2003; Schacter, 1996) and implicit memory; what people just pick up unconsciously as a consequence of being in a situation or environment (Schacter, 1987). In the classroom, teachers can do activities such as discussion, art, mapping, thinking and debates (Jensen, 1998) and games based on quiz shows, songs and stories, repetition in rounds, puzzles, exaggeration, imitation, modelling and visualisation to help students to remember what has been learnt (Caine et al., 2005).</td>
</tr>
</tbody>
</table>

**Learning involves both focused attention and peripheral perception**

It was revealed that the brain learns from both focused attention and peripheral messages from surrounds (Lozanov, 1978; Rosenfield, 1988). Caine et al. (2005) demonstrate that novelty, emotion, meaning, patterning and helplessness are basic elements that provide attention.

**Learning is both conscious and unconscious**

Neville (2005) highlights that good teaching takes care of both conscious and unconscious processes, which has a strong effect on how students think, react, feel and behave. Sounds, smells, colours, decorations, facial expression, odour, movements and background noise are among elements processed by the brain at non-conscious level that influence learning (Neville, 2005).

**Each brain is uniquely organised**

Knowledge about the brain leads the teacher to recognise the uniqueness of each student and present the material in many different ways to help students to reach their full potential and for whole-brain engagement (Blakemore, 2004). All students can learn more effectively when their unique, individual talents, abilities and capacities are engaged (Caine et al., 2005).
**Table 3.4**

*Elements and Sample Items from Brain-Compatible Classroom Beliefs*

<table>
<thead>
<tr>
<th>Elements</th>
<th>Principles</th>
<th>Example of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxed alertness (optimal mind-state)</td>
<td><em>The brain/mind is social</em></td>
<td>09 Students’ interactions need to be encouraged in the classroom</td>
</tr>
<tr>
<td></td>
<td><em>The search for meaning is innate</em></td>
<td>05 It is a good idea to involve students in making decisions about their learning</td>
</tr>
<tr>
<td></td>
<td><em>Emotions are critical to patterning</em></td>
<td>13 Teachers need to pay attention to students’ emotions in classroom</td>
</tr>
<tr>
<td></td>
<td><em>Complex learning is enhanced by challenge and inhibited by threat associated by helplessness</em></td>
<td>*11 Students should be punished when they fail to give correct answers</td>
</tr>
<tr>
<td>Enriched experience</td>
<td><em>All learning is physiological</em></td>
<td>01 Learning activities are best when they involve the students’ senses</td>
</tr>
<tr>
<td></td>
<td><em>Learning is developmental</em></td>
<td>34 Students should be taught according to their capabilities</td>
</tr>
<tr>
<td></td>
<td><em>The brain/mind processes parts and wholes simultaneously</em></td>
<td>17 Teachers need to relate the lessons to the students’ life experiences</td>
</tr>
<tr>
<td></td>
<td><em>The search for meaning occurs through patterning</em></td>
<td>32 A useful way of explaining new knowledge is to use analogies</td>
</tr>
<tr>
<td>Experience processing</td>
<td><em>Two approaches to memories: Isolated facts and skills or making sense of experience</em></td>
<td>*07 It is important for students to memorise what they have learnt</td>
</tr>
<tr>
<td></td>
<td><em>Learning: focused attention and peripheral perception</em></td>
<td>21 The teachers’ attitude is an important influence on students’ learning</td>
</tr>
</tbody>
</table>
Table 3.4 illustrates examples of items in the questionnaire that were developed based on an adaptation of questionnaire items from Klinek (2009) and Morris (2010). Moreover, the items were also drawn from the ideas suggested by the 12 Brain and Mind Learning Principles, which were stated briefly in tables 3.1, 3.2 and 3.3.

Out of 12 examples of items in Table 3.4, nine items were aligned with the learning principles and the other three items (item 07, item 11 and item 30) were purposely designed in opposition to the learning principles. The reason for having the negative statements in the questionnaire was to make sure that the respondents read the items carefully and did not automatically respond without reading first. According to Cohen et al. (2007), avoiding the inclusion of negative statements can lead to biased research. Overall, there were 14 items with a negative statement in each part of the questionnaire (BCC Beliefs and BCC Practices). The rest of the items were aligned with the brain-based learning principles. Apart from designing the items, the type of scales acquiring the teachers’ responses was also taken into consideration.

**3.7.1.3 Scales to measure the items.**

In this study, two types of scales were chosen to measure the feedback. The first type of scale is an ordinal scale that introduces a set of rating scales for the feedback. Appropriate for asking opinions and attitudes, a common ordinal scale such as the Likert scale, named after its developer, Likert (1932), was used in this study. For the purpose of
this research, the scale was used to measure teachers’ responses regarding their pedagogical beliefs and practices in regards to a BCC and to see if there was any difference in the feedback to the given item statements (Cohen et al., 2007). The scale is called a five-point response format as it has five levels of agreement in reflecting the teachers’ feedback. Different sets of response formats were used in different parts of the questionnaire to serve the purpose of the items. Table 3.5 illustrates the type of response formats for the Likert scale used in each part of the questionnaire.

Table 3.5

<table>
<thead>
<tr>
<th>Types of Five-Point Response Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCC Beliefs</td>
</tr>
<tr>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Disagree</td>
</tr>
<tr>
<td>Neutral</td>
</tr>
<tr>
<td>Agree</td>
</tr>
<tr>
<td>Strongly agree</td>
</tr>
</tbody>
</table>

As indicated in Table 3.5, the five-point response format in BCC Beliefs seems appropriate to obtain the feedback regarding the teachers’ stated pedagogical beliefs about a BCC, whereas different response formats in BCC Practices were designed to purposely obtain feedback about teachers’ self-reported practice in regards to a BCC.

The second type of scale used in this study was a nominal scale, which indicates categories (Cohen et al., 2007). Thus, this scale was used in the demographics section (part 2) to identify demographic factors such as age, gender, cultural background, highest qualification and teaching experience from the respondents. Since the data are classified and have no order, this scale is also commonly known as a categorical scale (Cohen et al., 2007).
3.7.1.4 Language used.

Even though teachers’ general medium of instruction is Bahasa Malaysia, the questionnaire was prepared in English and was not translated into Malay language for the following reasons. First, the respondents were science teachers who have been teaching science in the English language since the ETeMS policy was introduced by the former Malaysian prime minister Tun Mahathir Mohammad in 2003 (MOE, 2002c). According to the policy, English language is used as a medium of instruction in teaching science, mathematics and technical subjects for all the national schools, which includes the primary and secondary schools in Malaysia. In 2009, even though the policy has been changed and has reverted back to the Malay language (MOE, 2002b, 2002c), the teaching process still takes place in both Malay and English during this transition period (starting from 2010) until 2015 (MOE, 2010). Therefore, it was anticipated that the respondents would be proficient enough to answer the questionnaires.

Second, the location of the respondents supports the use of English. Selangor, Kuala Lumpur and Putrajaya are situated in the most developed region of Malaysia. Selangor is the most developed state in Malaysia. Kuala Lumpur is the capital city of Malaysia and Putrajaya is the new federal government administrative centre and is also known as the ‘intelligent city.’ Therefore, people in these areas are exposed to the English language, which is the second language in this country and is frequently used in most situations.

Apart from these reasons, the decision was also made to retain the questionnaire in English to make sure the original terms were not changed and the meaning remained the same. Thus, the language used is very simple and easy to understand to cater for those who have a very basic level of English. According to Sekaran (2000), the language used in the questionnaire should be within the respondents’ capabilities and their understanding. The
choice of words should depend on their education level, culture and the frame of references of the respondents to avoid biased responses (Sekaran, 2000).

3.7.1.5 Pilot test.

Prior to the data collection, a pilot test was conducted with secondary school science teachers from schools located in different regions to answer the questionnaire. This was to make sure that the respondents for the pilot test were not randomly chosen again during the actual data collection. However, those respondents were chosen from schools situated in urban and suburban areas to ensure factors such as homogeneity of the respondents was the same with the respondents in the actual survey. During the pilot test, 30 respondents were chosen randomly to answer the questionnaires and were asked to give any comments on how to improve the items. The questionnaire was also revised by colleagues and academics.

According to Oppenheim (1992), everything about the questionnaire should be piloted, which includes the typeface or the quality of the paper (p. 48). Several researchers have outlined the functions of a pilot study with the aim to increase the reliability, validity and practicability of the questionnaire (Oppenheim, 1992; Wilson & McClean, 1994). Below are among several functions suggested by other researchers which were taken into consideration for this pilot study:

- checking the clarity of the questionnaire items, instructions and layout
- checking readability levels for the target audience
- checking the time taken to complete the questionnaire
- checking whether the questionnaire is too long or short, too easy or too difficult
- eliminating ambiguities or difficulties in wording
- identifying redundant and irrelevant items. (Oppenheim, 1992; Wilson & McClean, 1994)
The second type of pilot test is based on statistical analysis and feedback, which reduces the number of items through factor analysis (Gorsuch, 1997; Kgaile & Morrison, 2006). However, due to limitations of time, this type of pilot test was not utilised. Thus, this pilot test only focused on matters of coverage and format of the questionnaire (Cohen et al., 2007).

After the pilot study, various feedback was received based on oral responses from the respondents, colleagues and academics. The results demonstrated positive feedback from the teachers in terms of the language used and how the questions were worded. It was revealed that the respondents did not have any problem in understanding the language when reading the questionnaires, even though it was written in English. However, a few modifications were made to improve the questionnaire by referring to the six guidelines above.

The modified questionnaire was finally used as an instrument to obtain quantitative survey data in an investigation of the compatibility of secondary school science teachers’ pedagogical beliefs and practices in regards to a BCC.

**3.7.2 Email interview protocol.**

Since this research was designed according to a sequential explanatory design (see Figure 3.1), questions for the email interview protocol were designed after the completion of quantitative data analysis. Open-ended questions were developed based on the results of the analysis, which required in-depth explanation about the findings from the participants. Sekaran (2000) argues that open-ended questions allow the participants to answer in any way they choose. Thus, this type of method may provide further explanation regarding the results of the quantitative data, especially dealing with teachers’ beliefs and practices in classroom.
The questions were designed based on ‘extreme’ categories in the feedback (example: Strongly Agree or Strongly Disagree) from the respondents in the findings of the quantitative data analysis. Even though the word ‘interview’ was used to describe the type of method used in this study, it was not conducted according to a normal interview with series of questions. For this study, there were only three open-ended questions developed. The questions were sent through email to receive feedback from the participants and no other follow-up occurred once the feedback was received. The email interview protocol is shown in Appendix 3-3.

3.8 Validity and Reliability Issues

Since validity and reliability issues have been interpreted differently according to the research approach, the following sections address both issues according to the specific methods applied in this study.

3.8.1 Reliability.

Among different aspects of reliability, factor analysis and Cronbach’s alpha were chosen as methods to increase the reliability of the questionnaire (Tin, 2012). According to Pallant (2011) and Cohen (2007), factor analysis is a ‘data reduction’ technique where large set of variables may be ‘reduced’ or summarised using a smaller set of factors or components. Two types of factor analysis have been generally mentioned in the literature. In this study, EFA was used to reveal the interrelationships among a set of variables at an early stage of research (Pallant, 2011). Hence, EFA reduced the number of original variables into a new set of linear combinations that captured most of the variability (Pallant, 2011). Then, Cronbach’s alpha played the role of ensuring the internal consistency of the components was maintained. The Cronbach’s alpha refers to an extent of how far the items fit together in measuring the same fundamental construct (Pallant,
The indicator used for the reliability test is the alpha coefficient of reliability (Cronbach’s alpha coefficient).

The items in the questionnaire were designed based on the brain-based learning principles and also adapted from other research. The instrument contains 36 items in BCC Beliefs, which examined teachers’ pedagogical beliefs, and 36 items in BCC Practices, which investigated their practices in regards to a BCC. The items were developed based on categories fixed by the brain-based learning principles and had not been tested in the context of this study before. Thus, 12 items were designed under each of the three fundamental elements in the principles: relaxed alertness (optimal mind-state), enriched complex experience and experience processing.

EFA was then conducted. It was considered a suitable reliability test by reducing and rearranging the related items (if perceived differently from the theory or principles) into new groups or components that reflected the feedback from the respondents’ point of view (Tin, 2012). The number of components to be retained was also based on several tests, such as a scree test, Eigenvalue Rule and Monte Carlo Principal Component Analysis (PCA) for Parallel Analysis, which purposely suggests factor extraction. The number of items in each component was based on factor loadings value. Items with weak factor loadings, below .4, were not taken into consideration.

Each component with a list of items was then tested for its internal consistency by using Cronbach’s alpha. The ‘alpha if item deleted’ test was conducted to get a higher Cronbach’s alpha value for each component as well as to increase the internal consistency level. At this stage, the decision to retain or remove the component with very low Cronbach’s alpha value was still considered. The items in the component with high Cronbach’s alpha value exhibited strong inter-item correlation.
As technical aspects were involved in managing the reliability issue of the instrument in teacher survey, a different perspective was mentioned in email interviews. The qualitative approach that was adopted for the interview regarded the reliability issue with ‘a degree of accuracy and comprehensiveness of coverage’ (Bogdan, 2007). In other words, it was concerned with the trustworthiness of data given by the participants compared to what actually happened in the natural setting being researched. In order to get optimal feedback from the participants in this study, a relationship similar to that of a friend between the researcher and a few of the participants was built. The friendship relationship was based on common experience as teachers and through this relationship and research those participants saw this research as a platform for them to share their experiences. Thus, it was hoped that reliable and genuine feedback from those teachers was possible.

3.8.2 Validity.

According to Cohen et al. (2007), ‘validity is an important key to effective research’ (p. 133). Thus, validity is also an essential element for both quantitative and qualitative research. Validity for the quantitative approach can be strengthened by appropriate instrumentation, careful sampling and appropriate statistical treatments of the data (Cohen et al., 2007). However, in qualitative research, validity may be addressed in different ways, for example: honesty, depth, richness and scope of data achieved and triangulation (Winter, 2000). This section focuses on internal, external and content validity.

Addressed in several ways by scholars, the internal validity is closely related to the authenticity and credibility of the data. Therefore, the major aspect for the internal validity of this study related to the context of the instrument used. The items in the questionnaire were adapted from two other studies by Morris (2010) and Klinek (2009), which were undertaken in the United States. Thus, the context in the previous study was different, as
the current study was undertaken in Malaysia. To suit the study, the items in the questionnaire were adapted according to the context of the research to best comprehend pedagogical beliefs and practices in regards to a BCC among secondary school science teachers in Malaysia.

For the email interviews, the questions were designed to probe as much details from the participants without changing the meaning of the original item in the teacher survey. Before sending emails to all eight participants, the participants had been contacted by telephone and explained the aim of the research to seek detailed explanation of the results from the teacher survey. By putting in effort to contact them personally, the researcher hoped to get honest feedback within the scope and thus contribute to the internal validity of the research.

The issue of generalisability is a strand related to the external validity of the study. According to Cohen et al. (2007), external validity is about how far the results of the study can be generalised to the wider population, cases or situations. Since the main method for this study was the quantitative approach, research designed with the procedure of how the samples were obtained for this study was central to the generalisation aspect. Cohen et al. (2007) stress that from the positivist’s point of view, variables have to be isolated and controlled and samples randomised. As this was an empirical study with no isolation and controlled variables, randomisation of the samples was taken into consideration. Even though all the science teachers in one school were chosen as the samples of the study, the selection of secondary schools in this study was undertaken randomly within the central region of Malaysia. By having quite high feedback from those teachers, the number of respondents gained after the data collection process was considered appropriate for generalisability within the range of the context of the current study.
Conversely, the issue of generalisability is not pivotal in the qualitative approach as it is subjective according to the context of the study. However, Lincoln and Guba (1985) stressed comparability and transferability in the generalisability of qualitative research. Thus, in relation to this study, it was hoped that the feedback from email interviews by those teachers were comparable and applicable to another situation.

Content validity is another factor. As mentioned earlier, an adaptation of the questionnaire in regards to context was made to suit the current situation. Further, the questionnaire was also modified specifically to be able to answer the research questions. Thus, for the purpose of content validity, the instrument used in this study was validated by two senior lecturers in the field of education in terms of content and language. Since the questionnaire was written in English, a pilot study was conducted with a group of secondary school science teachers with the same characteristics as the samples. The purpose of the pilot study was to receive feedback about the use of the language in terms of clarity and understanding of the items asked. Despite receiving positive responses, a few words were replaced with easier terms without changing the meaning to help the respondents understand the questionnaire.

The items in the questionnaire were arranged randomly and not according to the components in the theory. The title of each part of the questionnaire was chosen so as not to reveal what the research was aiming to discover. This was purposely done to make sure that the respondents were not aware of what they were being asked. The demographic section was also purposely located between part 1 and part 3 with the aim of posing as a distraction to the teachers so they did not realise the connection between BCC Beliefs and BCC Practices. Therefore, the position of demographic factors hoped to draw teachers’ attention away from information in BCC Beliefs that may possibly affect their answers.
All the feedback from the respondents were analysed according to the specific statistical analysis depending on the research questions addressed. In making sure that the right statistical technique had been chosen, preliminary tests were performed on the data to understand the underlying assumptions and requirements needed before running any statistical tests. In this study, tests were performed to discover the normality of the distribution of the scores before conducting factor analysis to ensure the type of distribution of the data. ‘Normal’ distribution of the scores refers to a symmetrical, bell-shaped curve graph of data (Pallant, 2011) and is a pre-requisite for factor analysis to take place.

Overall, validity and reliability measures were taken into consideration to raise the standard of the research and to best ascertain the research questions. The following section discusses ethical elements of this research.

### 3.9 Ethics Approvals

This study was carried out in Malaysia and science teachers were selected from secondary schools in the central region of Malaysia, which covers three states: Selangor, Kuala Lumpur and Putrajaya. Therefore, ethics approvals were sought from the Education Faculty’s Human Ethics Committee at La Trobe University in Australia and permission to conduct research was sought from the Economic Planning Unit at the Prime Minister’s Department in Malaysia.

Upon obtaining the ethics approvals (see Appendix 3-4) and being granted permission to conduct the research (see Appendix 3-5), the state education departments in Malaysia were notified of the research, which took place in Selangor, Kuala Lumpur and Putrajaya. Then, a letter acknowledging the study (see Appendix 3-6) and the questionnaires were brought to the selected schools and handed to the principals to be distributed to the teachers. Together with the questionnaires, there were ethics related...
forms: the Participant Information Statement, Consent Form, and Withdrawal of Consent for Use of Data Form. The Participant Information Statement (see Appendix 3-7) explains briefly the research and the Consent Form (see Appendix 3-8) acquires permission from the respondents for their participation in the study. Both forms needed to be signed by the participants. Participation was voluntary based and in any case of withdrawal from the study, a Withdrawal of Consent for Use of Data Form (see Appendix 3-9) was needed and signed by the participant. All the information and data given by the respondents were strictly confidential. Thus, all the questionnaires completed by the respondents and the signed ethics forms were kept in a lockable cabinet for safety and privacy purposes.

Ethics approval had also been sought and extended for the email interview data collection. The extension of the approval was needed as the email interview could only commence after data analysis of the teacher survey had been completed, which was almost a year later. Since the technique of collecting the data for the second phase of the study was changed from face-to-face interview to email interview, modification of the ethics was undertaken. The modifications also included email interview protocol, which contained three open-ended questions. The questions were designed based on emerging questions from the findings of the survey. Those questions sought further explanation regarding certain items relating to teachers’ pedagogical beliefs about BCC instruction. Email interviews began once the ethics modifications had been approved. An email was sent to each of the participants with an attachment of the email interview protocol and a modified Participant Information Statement. The feedback from the participants was printed as a hard copy and kept in a lockable cabinet for confidentiality. The emails from the respondents were then deleted to make sure the information was safe.
3.10 Summary

This chapter described the research orientation from different philosophical foundations that have influenced how social research is to be conducted. Practical consideration, theory and epistemology were among the foundations considered in explaining the research paradigm. In order to investigate teachers’ pedagogical beliefs and practices in regards to a BCC, both quantitative and qualitative research methods were employed. Thus, teacher surveys and email interviews were used as techniques in gathering the data. Items for the questionnaire were developed based on an adaptation from other brain-based learning studies and using the 12 Brain and Mind Learning Principles as a guideline. As this study adopted a sequential mixed method research design, the interview protocol was developed following the results of the teacher survey. Reliability and validity of the instruments was considered to ensure the authenticity and trustworthiness of the instrument. The questionnaires were self-administered by secondary school science teachers in the central region of Malaysia, which covers Selangor, Kuala Lumpur and Putrajaya. Email interviews were undertaken with eight participants who voluntarily agreed to take part in the study.

The next chapter discusses the results of the quantitative part of the study.
Chapter 4  

Results  

4.1 Introduction  

This chapter reports the findings of the current study pertaining to an investigation of the compatibility of secondary school science teachers’ pedagogical beliefs and practices in regards to a BCC. The research adopted a sequential mixed methods approach by conducting a teacher survey and email interview sessions. This chapter reports the findings from the teacher survey based on the questionnaire administered to a sample of 153 secondary school science teachers from the central region of Malaysia. In order to answer the research questions, a series of statistical analyses were conducted with the data and the results are presented in the following sections.

This chapter starts by highlighting the background of the respondents based on the descriptive data from the samples. Then, the chapter continues by illustrating all the sequential processes of factor analysis utilised to identify the dimensions of teachers’ pedagogical beliefs about a BCC. The following section describes the dimension for both teachers’ pedagogical beliefs and practices. The chapter continues by demonstrating the characteristics of the dimension and proceeds by illuminating the relationship between teachers’ BCC Beliefs and their matched BCC Practices for all three dimensions. Analyses that compare the group means of the dimensions for both variables (BCC Beliefs and BCC Practices) according to demographic factors (age and teaching experience) are highlighted in the section that follows. The chapter continues by outlining the characteristics of all the items in the TTA dimension to justify further investigation. Then, the following section presents the results of the qualitative data. This chapter ends with a brief summary.

The following section describes the background of the respondents in this study.
4.2 Background of the Respondents

The respondents for this study were national secondary school science teachers from the central region of Malaysia, which covers three states: Selangor, Kuala Lumpur and Putrajaya. The science teachers included those who teach science subjects (core subjects at the lower and upper secondary school levels) as well as those who teach biology, chemistry, physics and additional science (upper secondary school level) in schools.

4.2.1 Schools and respondents.

Thirty-eight secondary schools from the three states (Selangor, Kuala Lumpur and Putrajaya) were identified for sampling purposes because the selection of schools was based on the research design highlighted in Figure 3.1. Out of the 38 schools, the questionnaires were sent randomly to 26 schools in Selangor, 9 schools in Kuala Lumpur and three schools in Putrajaya. The samples of the study were the population of the science teachers in each school. Out of 26 schools from Selangor that received the questionnaires, only 10 schools or less than 50 per cent (44.74 per cent) returned the questionnaires. A higher response rate was achieved from schools in Kuala Lumpur, where six out of nine schools responded (85.71 per cent). However, only one out of three schools from Putrajaya (33.33 per cent) returned the questionnaires.

The low response rate from the schools was due to the time of the data collection, which was between December to February, between the ending of the school holiday and starting of the new school year. This is a time when the teachers are very busy with school meetings and preparation for the beginning of the school term. In Malaysia, the school year starts in early January.

Table 4.1 illustrates the list of all secondary schools that returned the questionnaires and the number of teachers who responded to the questionnaires from each school. Based on the table, out of 106 questionnaires sent to schools in Selangor, a total of
90 respondents returned the questionnaires, which made the response rate 85 per cent. The majority of the respondents from schools in Kuala Lumpur responded to the questionnaires (53 out of 58) with a response rate of 91 per cent. Even though only one school responded in Putrajaya, the feedback from the respondents was good, with 100 per cent response rate (10 respondents responded out of the 10 questionnaires sent).

Table 4.1

Schools and Respondents (Response Rate)

<table>
<thead>
<tr>
<th>State</th>
<th>Schools</th>
<th>Number of Questionnaires Sent</th>
<th>Number of Questionnaires Received</th>
<th>Response Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selangor (Total)</td>
<td></td>
<td>106</td>
<td>90</td>
<td>84.91</td>
</tr>
<tr>
<td></td>
<td>SMK Taman Melawati</td>
<td>12</td>
<td>12</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SMK Hill Crest</td>
<td>10</td>
<td>10</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SMK Darul Ehsan</td>
<td>10</td>
<td>10</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SMK Tinggi Kajang</td>
<td>10</td>
<td>9</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td>SMK Jalan Reko</td>
<td>10</td>
<td>9</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td>SMK Sri Serdang</td>
<td>15</td>
<td>13</td>
<td>86.67</td>
</tr>
<tr>
<td></td>
<td>SMK Teknik Gombak</td>
<td>8</td>
<td>6</td>
<td>75.00</td>
</tr>
<tr>
<td></td>
<td>SMK Lembah Keramat</td>
<td>10</td>
<td>7</td>
<td>70.00</td>
</tr>
<tr>
<td></td>
<td>SMK Sungai Pusu</td>
<td>13</td>
<td>9</td>
<td>69.23</td>
</tr>
<tr>
<td></td>
<td>SMK Bandar Baru Bangi</td>
<td>8</td>
<td>5</td>
<td>62.50</td>
</tr>
<tr>
<td>Kuala Lumpur (Total)</td>
<td></td>
<td>58</td>
<td>53</td>
<td>91.38</td>
</tr>
<tr>
<td></td>
<td>SMK Seksyen 5, Wangsa Maju</td>
<td>8</td>
<td>8</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SMK (P) Air Panas</td>
<td>10</td>
<td>10</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SM Sains Selangor</td>
<td>12</td>
<td>12</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SMK Danau Kota</td>
<td>8</td>
<td>7</td>
<td>87.50</td>
</tr>
<tr>
<td></td>
<td>SMK Wangsa Melawati</td>
<td>10</td>
<td>8</td>
<td>80.00</td>
</tr>
<tr>
<td></td>
<td>SMK Setiawangsa</td>
<td>10</td>
<td>8</td>
<td>80.00</td>
</tr>
<tr>
<td>Putrajaya (Total)</td>
<td></td>
<td>10</td>
<td>10</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>SMK Putrajaya (Precinct 16)</td>
<td>10</td>
<td>10</td>
<td>100.00</td>
</tr>
</tbody>
</table>
While the response rate from the schools was quite low, the feedback from the teachers who took part in the study was favourable. The data from each state reveal that the response rate from the respondents in the surveyed schools is 85 per cent and above. Generally, as the head of school administrator, the school principal was the one who made the decision to take part in the survey or not. In this study, the low response rate from the schools may have been affected by the principals. However, this study has been unable to demonstrate whether good response rates from the teachers is the result of positive efforts in voluntarily committing themselves to the study or just the actions taken to obey the principals’ orders. Regardless of the responses from schools and teachers, the number of the participants, especially from Putrajaya, demonstrates extreme unequal numbers compared to the respondents from two other states. Thus, the data analysis was not conducted according to the states and instead all participants from the three states were put together into one group.

The teachers who took part in the study can be differentiated based on the details in the demographic factors section (see part 2) of the questionnaire. Some general demographic factors of the respondents such as age, gender, cultural background, highest qualification and teaching experience were to provide further understandings on the concept of a BCC. Therefore, frequencies were used to describe the variables. The following tables explain the details about the frequencies in the demographic factors.

4.2.2 Age.

The samples were classified into four groups according to their age, which suggests the differences among teachers. Table 4.2 shows the frequency of respondents according to the four age groups (n = 153).
Table 4.2

*Frequency of Age Group*

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–30</td>
<td>43</td>
<td>28.1</td>
</tr>
<tr>
<td>31–40</td>
<td>47</td>
<td>30.7</td>
</tr>
<tr>
<td>41–50</td>
<td>48</td>
<td>31.4</td>
</tr>
<tr>
<td>≥ 51</td>
<td>15</td>
<td>9.8</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Three groups of respondents aged 20 to 30, 31 to 40 and 41 to 50 have almost equal numbers of teachers in each group. The lowest number of teachers is shown from the age group of 51 years old and above, which is 15 (9.8 per cent). This low number could be due to several possible reasons. Most of the teachers at this age were promoted and given a choice to either remain as a normal teacher or change their main role to a school administrator with very minimum teaching hours in the classroom. They can also be transferred to a full time administrator role either at the ministry level, state or district education department and no longer involve themselves in classroom teaching. Another reason could be an early retirement, which makes the total number of teachers from this age group low. The retirement age at the time of data collection was 58. In spite of the imbalance in the number of participants from age group 51 and above compared to other age groups, it describes the reality of the education environment in Malaysia and was taken into consideration in further data analyses.

4.2.3 Gender.

In terms of gender (see Table 4.3) females were the majority of respondents in this study with 139 (90.8 per cent) compared to male respondents with only 14 teachers (9.2 per cent).
Gender imbalance in the teaching profession has been generally known where female teachers are the majority group of teachers in almost all of the countries in the world (Mukundan & Ahour, 2011). According to the World Indicator Database (2003), female teachers dominate (66.29 per cent) the number of secondary school teachers in Malaysia. In this study, since the difference between the number of males and females is large with very small numbers of males, gender was not taken into consideration for further analysis.

### 4.2.4 Cultural background.

As a multicultural country, the population in Malaysia is divided into three major cultural backgrounds: Malays, Chinese and Indians. For the purpose of the study, the respondents were divided accordingly. Table 4.4 illustrates the cultural background of the teachers in this study.

#### Table 4.3

*Frequency of Gender*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>14</td>
<td>9.2</td>
</tr>
<tr>
<td>Female</td>
<td>139</td>
<td>90.8</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>100.0</td>
</tr>
</tbody>
</table>

#### Table 4.4

*Frequency of Cultural Background*

<table>
<thead>
<tr>
<th>Cultural Background</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malay</td>
<td>141</td>
<td>92.2</td>
</tr>
<tr>
<td>Chinese</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td>Indian</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The majority of secondary school science teachers who took part in this study were Malays with a total of 141 respondents (92.2 per cent). Chinese and Indians were represented by six teachers (3.9 per cent) from each cultural background. The data were aligned with the findings by Govindasamy and Da Vanzo (1992) that the Malays remain as the majority in the teaching profession compared to other cultural backgrounds. Very unequal numbers of participants in each cultural group suggests that further statistical analysis was inappropriate.

4.2.5 Highest qualification.

Teachers’ highest qualification may also explain the differences among the respondents. Generally, teachers in Malaysia had diploma, bachelor’s degree or master’s degree as their highest qualification. Table 4.5 demonstrates the highest qualification of the teachers in this study.

Table 4.5

<table>
<thead>
<tr>
<th>Highest Qualification</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diploma</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>140</td>
<td>91.5</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>11</td>
<td>7.2</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Based on the data, the majority of the respondents, 140 teachers (91.5 per cent), hold a bachelor’s degree as their highest qualification. Only 11 respondents (7.2 per cent) had master’s degrees and two teachers (1.3 per cent) held diplomas. The majority of teachers in secondary schools had bachelor’s degree as their highest qualification as diploma holders normally teach in primary schools. However, there are certain cases where senior teachers with diplomas as their highest qualification remain in the secondary school.
The data support the general situation that not many diploma holders teach at secondary schools. The Education Planning and Research Department (2008) also reported offering in-service academic qualification enhancement programmes for science teachers to upgrade the teachers’ education level from non-graduate to graduate teachers. This may also be among the reasons why the number of teachers with a diploma is very small in secondary schools. Due to minor variations in numbers with groups of teachers’ highest qualification, further statistical analysis of this demographic factor was not considered.

4.2.6 Teaching experience.

The teachers’ teaching experience was divided into three categories. Teachers with zero to 10 years of teaching were considered fresh or junior teachers, 11 to 20 years of teaching was considered moderately experienced teachers and those who had been teaching for more than 20 years were regarded as experienced teachers. Table 4.6 identifies teachers’ teaching experience in this study.

Table 4.6

<table>
<thead>
<tr>
<th>Years of Teaching</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>71</td>
<td>46.4</td>
</tr>
<tr>
<td>11–20</td>
<td>51</td>
<td>33.3</td>
</tr>
<tr>
<td>&gt;20</td>
<td>31</td>
<td>20.3</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Almost half of the teachers in this study (71 or 46.4 per cent) had teaching experience of 10 years and below. There were 51 teachers (33.3 per cent) with 11 to 20 years of teaching experience and only 31 teachers (20.3 per cent) with experience in teaching for more than 20 years. The reasons why the number of teachers with teaching experience of more than 20 years is very small may also be related to promotion to administrative posts and early retirement.
The demographic data highlight the unequal number of respondents between gender, highest qualifications and cultural background. According to Cohen (2007), very unequal numbers of respondents between groups in one sample suggests it is inappropriate for statistical analysis to be performed. Hence, further investigations did not take those factors into consideration. However, demographic factors such as age group and teaching experience were suitable for statistical analysis.

The following section involves a series of data analyses investigating the compatibility of teachers’ pedagogical beliefs and practices in regards to a BCC.

4.3 Components of BCC

Since the questionnaire was based on the brain-based learning principles, the items in the questionnaire were originally grouped according to three fundamental elements of the principles for both BCC Beliefs and BCC Practices: enriched experience, relaxed alertness and experience processing. However, as the questionnaire was given to the respondents, they may have perceived the questionnaire differently. Thus, the first step involved in the analysis was to answer the first research question, which is to find out the dimensions of teachers’ pedagogical beliefs about a BCC. The feedback from those teachers may reflect what they perceive about the principles from their perspectives.

This section uses EFA with the aim to explore underlying patterns, clusters or groups of items from the teachers’ feedback in this study (Gorsuch, 1997). Thus, the number of components derived from the analysis represented the dimensions of teachers’ pedagogical beliefs in this study. EFA is a popular technique in factor extraction, which allows for the maximum possible amount of variance (Gorsuch, 1983). The components extracted from factor analysis answer research question 1, which aimed to identify the main dimensions of teachers’ pedagogical beliefs about a BCC in this study. All of the 36 items in part 1 of the questionnaire (BCC Beliefs) were analysed using SPSS version 18.
Like any other test in statistical analysis, assumptions were considered before conducting factor analysis. Pallant (2011) has listed four assumptions to be considered prior to conducting factor analysis: sample size, factorability of the correlation matrix, normality and outliers among cases. The sample size for this study was 153. The factorability of the data was tested by Bartlett’s test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (explained later in this section).

Another assumption for conducting factor analysis is related to the type of data (Cohen et al., 2007). Cohen et al. stress that factor analysis can only be conducted for parametric data or data with normal distribution of scores. Thus, tests of normality were conducted to identify the type of data of this study. All the 36 items in BCC Beliefs and BCC Practices were tested for normality of the scores. The results are illustrated in Table 4.7.

Table 4.7

Tests of Normality

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>BCC Beliefs</td>
<td>.062</td>
<td>153</td>
</tr>
<tr>
<td>BCC Practices</td>
<td>.073</td>
<td>153</td>
</tr>
</tbody>
</table>

Based on Table 4.7, a significance value of more than .05 indicates normality. Between the two tests, the Shapiro-Wilk test has been referred to as more suitable for quite a small sample (n = 153). As the significance values shown by the Shapiro-Wilk test for all the components of all variables are more than .05, it is assumed that the data are normally distributed. Thus, the data are considered parametric type. Therefore, it is appropriate to run factor analysis.
The KMO was 0.749, which exceeded the recommended value of 0.6 to be accepted for further analysis (Kaiser, 1970, 1974). Bartlett’s test of sphericity also showed statistically significant value ($p = 0.000$) (Bartlett, 1954). Therefore, factor analysis for BCC Beliefs was appropriate. Refer to Table 4.8 for details.

Table 4.8

*Kaiser-Meyer-Olkin and Bartlett’s Test of Sphericity*

<table>
<thead>
<tr>
<th>Measure of Sampling Adequacy</th>
<th>.749</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartlett’s Test of Sphericity</td>
<td></td>
</tr>
<tr>
<td>Approx. Chi-Square</td>
<td>1796.110</td>
</tr>
<tr>
<td>Df</td>
<td>630</td>
</tr>
<tr>
<td>Sig.</td>
<td>.000</td>
</tr>
</tbody>
</table>

Three techniques were considered in assisting the number of factors to be extracted under the PCA approach: scree test; Kaiser’s criterion and parallel analysis. The first extraction criterion used was Catell’s scree test (Cattell, 1966). Refer to Figure 4.1 for the screeplot.

*Figure 4.1: Screeplot.*

The screeplot clearly shows a change in the shape of the plot (elbow) with a break between factor 2 and factor 3, and a second, much smaller break after the fifth factor. This suggests the number of factors possible to retain was narrowed to between two and five.
The second extraction technique used in extracting the scales was Kaiser’s criterion (eigenvalue rule), which demonstrates 11 scales with eigenvalues greater than 1. This represents the total variance explained of 63.03 per cent (see Appendix 4-1). The use of Kaiser’s criterion to extract the scales resulted in too many scales being extracted (11 scales). Table 4.9 shows part of the total variance explained. If the probability of the factors to be retained were referring to the scree test, the total variance explained for the two or five scales were stated as 29 per cent or 43 per cent, shown in bold in Table 4.9.

Table 4.9

<table>
<thead>
<tr>
<th>Scale</th>
<th>Initial Eigenvalue</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>3</td>
<td>1.864</td>
<td>5.178</td>
<td>33.994</td>
</tr>
<tr>
<td>4</td>
<td>1.744</td>
<td>4.845</td>
<td>38.839</td>
</tr>
<tr>
<td>5</td>
<td>1.558</td>
<td>4.329</td>
<td>43.167</td>
</tr>
</tbody>
</table>

The final option carried out to assist in determining the number of factors to be retained was parallel analysis using Monte Carlo PCA for Parallel Analysis. Based on 100 replications, the average eigenvalues were calculated and the result of the analysis is illustrated in Table 4.10.
Table 4.10

Comparison of Eigenvalues from Principal Component Analysis and Criterion Value from Parallel Analysis

<table>
<thead>
<tr>
<th>Scale Number</th>
<th>Actual Eigenvalue from PCA</th>
<th>Criteria Value from Parallel Analysis</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.27</td>
<td>2.07</td>
<td>Accept</td>
</tr>
<tr>
<td>2</td>
<td>3.10</td>
<td>1.92</td>
<td>Accept</td>
</tr>
<tr>
<td>3</td>
<td>1.86</td>
<td>1.81</td>
<td>Accept</td>
</tr>
<tr>
<td>4</td>
<td>1.74</td>
<td>1.73</td>
<td>Accept</td>
</tr>
<tr>
<td>5</td>
<td>1.56</td>
<td>1.64</td>
<td>Reject</td>
</tr>
</tbody>
</table>

The eigenvalues from Kaiser’s criterion PCA approach were compared with the random results obtained by parallel analysis shown in Table 4.10. As can be seen, the eigenvalue from PCA shows a higher value than the value from parallel analysis up to factor 4. Thus, the result suggests that up to four factors may be retained. The final decision was made only after reliability of the component was taken into consideration for its internal consistency. Currently, the result of EFA is fixed according to a four-factor solution. The four-factor solution was chosen as it met all criteria.

Before conducting the factor analysis, the rotation method, which is based on the relationship among the factors, needed to be considered. If the factors were unrelated to each other, the appropriate analysis would be orthogonal and Varimax rotation. In this study, it was assumed that the elements of teachers’ beliefs about BCC were correlated to each other. Thus, the direct oblimin rotation method was selected. An appropriate factor analysis for this study was PCA with direct oblimin and Kaiser normalisation.

A cut-off point of factor loadings of 0.4 was specified with the purpose of producing factors with distinct concepts (Hardy & Reynolds, 2004). Then, two experts (senior lecturers in the field of education) were utilised to remove any items from the
analysis that did not contribute to the meanings of construct reflected in the total of all items in each respective factor. Eventually, Cronbach’s alpha coefficients based on the responses to items in each factor were examined to determine the internal consistency level for reliability, and whether the removal of items could increase the reliability of a scale constructed from items loading on respective factors.

The result of a PCA that displays the four-factor solution of the 36 items from BCC Beliefs (n = 153) was retrieved from the pattern matrix table. Four factors explained 39 per cent of the total variance explained (see Table 4.9). The extraction indicates that eight items (02, 05, 15, 16, 20, 25, 27 and 35) have factor loadings smaller than .40 and these were removed (see Appendix 4-2). The factor analysis was repeated with the remaining 28 items. The result shows the four-factor solutions extracted 46 per cent of total variance (see Appendix 4-3). However, at this stage, no more items were removed as all the items exhibited factor loadings greater than .40.

The involvement of expert raters’ validation for ‘peer debriefing’ (Cohen et al., 2007, p. 136) indicated that item 29, ‘Criticising is not a good way to motivate the students’, which shows a factor loading of .470 in factor 3 (see Appendix 4-4), had greater conceptual affinity with the items of factor 2 as it contributes to the same meaning for all the items in factor 2. In fact, the item also displayed another factor loading (.414) in factor 2 and the value, which is above .40, is acceptable for this item to be included in factor 2 (see Appendix 4-4). One item was removed, as it also did not appear related conceptually to the construct assessed by the remainder of the items. The item was item 3, ‘It is difficult for students to remember things that have no meaning to them’. Finally item 19, ‘Novelty in classroom promotes learning’ had also to be removed due to the word ‘novelty’, which has been reported as confusing by a number of respondents (see Appendix 4-4).
After removing these two items, the 26 remaining items were again subjected to a factor analysis. The output of this factor analysis had shown the total variance explained of 47 per cent (25 per cent, 11 per cent, 7 per cent and 5 per cent for respective factors; see Appendix 4-5). In summary, 10 out of the 36 items were removed and 26 items were retained. Based on the number of items, factor 1 consisted of 14 items; factor 2 consisted of eight items; factor 3 consisted of two items and factor 4 consisted of two items. Refer to Table 4.11 for the pattern matrix table.

These four factors portray dimensions for the teachers’ pedagogical beliefs and practice in regards to a BCC based on their feedback through the quantitative survey. All the items in the components derived from factor analysis were compared to the components from the brain-based learning principles, which were used as a guideline in designing the questionnaire. It was noted that the items no longer grouped according to the components in the 12 Brain and Mind Learning Principles. Thus, the scales derived from all the items had to be renamed, since each contained new combinations of items. Again, an expert (senior lecturer in the field of education) was employed for the renaming purpose. There was no specific procedure for renaming the new components. However, the items were analysed for their meanings as a whole and the name given to the component reflected the items in each respective scale.

The first component contains items related to classroom procedures encouraging students to engage in learning. Hence, this component was named Approaches to Encourage Student Learning (AESL). The second component consists of items confined to teachers challenging themselves in regards to inflexible TTA and was named TTA. The third factor contains two items and describes working together in a group. Thus, this component was named Working Together Promotes Learning (WTPL). The fourth factor is about choices being given to students in the classroom and was named Empowering
Students (ES). These four scales were the final output of factor analysis. However, the decision as whether to retain or discard any of the components was reconsidered at a later stage of further analysis.

Before showing the movement of items between the previous and newly developed components, the reliability of the components that made up the instrument is discussed.

Table 4.11

*Pattern Matrix Table (Brain-Compatible Classroom Beliefs)*

<table>
<thead>
<tr>
<th>Components</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 Students’ potential can be increased by exposing them to variety of experience</td>
<td>.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Teachers need to relate the lessons to the students’ life experiences</td>
<td></td>
<td>.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04 Teachers should encourage students to share their ideas</td>
<td></td>
<td>.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 The teachers’ attitude is an important influence on students’ learning</td>
<td></td>
<td>.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Students need to be given opportunities to reflect on what they have learnt</td>
<td></td>
<td>.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 Students need to be encouraged to have positive attitudes</td>
<td></td>
<td>.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 Students’ interactions need to be encouraged in the classroom</td>
<td></td>
<td>.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Teacher guide students to deepen their understanding of the concepts taught</td>
<td></td>
<td>.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*26 Using stories to teach new topics is a waste of time</td>
<td></td>
<td>.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Teachers need to pay attention to students’ emotions in classroom</td>
<td></td>
<td>.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Teachers help students understand a concept taught using meaningful themes</td>
<td></td>
<td>.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>01 Learning activities are best when involve the students’ senses</td>
<td></td>
<td>.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 Students need to be taught according to their capabilities</td>
<td></td>
<td>.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 A useful way of explaining new knowledge is to use analogies</td>
<td></td>
<td>.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students who talk a lot are not problematic</td>
<td>.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is not important for the students to memorise what they have learnt</td>
<td>.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students need not be punished when they fail to give correct answers</td>
<td>.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is not important for students to keep their work confidential</td>
<td>.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art has much relevance to science teaching</td>
<td>.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The teacher should not provide the same activity for all groups of students</td>
<td>.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers should not choose a teaching strategy which is comfortable for them</td>
<td>.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criticising is not a good way to motivate the students</td>
<td>.41</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Encouraging students to work in groups much of the time is important | .72 |
| Group projects are good in teaching | .65 |

| Students should be given choices in the activities they will be doing | .67 |
| *Students are not capable of making decisions in the classroom | .55 |

* Note. * Negative item.

### 4.3.1 Reliability of the instrument.

In this study, the reliability of the instrument was verified by measuring the internal consistency of the items in the component. In order to increase the internal consistency, the ‘item deleted’ method was applied, where items were removed to get the highest possible alpha. The most common indicator, Cronbach’s alpha coefficient, was used to measure the internal consistency of each component and then compared to the reliability guidelines.
outlined by Cohen et al. (2007, p. 506). However, based on the analysis, none of the items was required to be removed to achieve the highest Cronbach’s alpha.

Factor 1, AESL, which had 14 items, showed 0.88 for the Cronbach’s alpha value (see Appendix 4-6). According to the reliability guidelines table (Cohen et al., 2007, p. 506), 0.88 falls in the alpha range of 0.80 to 0.90, which is highly reliable. Factor 2, TTA, which had eight items, showed 0.70 for the Cronbach’s alpha (see Appendix 4-7). The value falls under the alpha range of 0.70 to 0.79, which is reliable (Cohen et al., 2007). Factor 3, WTPL, had only two items and showed a Cronbach’s alpha value of 0.60 (see Appendix 4-8). Based on the guidelines, the value was marginally acceptable. However, factor 4, ES, which also had two items, showed a Cronbach’s alpha value of 0.39 (see Appendix 4-9). The value was clearly unacceptably low in reliability, as mentioned in the guidelines. Table 4.12 shows the measure of internal consistency of the BCC Beliefs component through the alpha coefficient of reliability (Cronbach’s alpha).

Table 4.12

<table>
<thead>
<tr>
<th>Factor</th>
<th>Name</th>
<th>No. of Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Approaches to Encourage Student Learning</td>
<td>14</td>
<td>0.88</td>
</tr>
<tr>
<td>2</td>
<td>Traditional Teacher Attitudes</td>
<td>8</td>
<td>0.70</td>
</tr>
<tr>
<td>3</td>
<td>Working Together Promotes Learning</td>
<td>2</td>
<td>0.60</td>
</tr>
<tr>
<td>4</td>
<td>Empowering Students</td>
<td>2</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Even if factor 3 and factor 4 only had two items in each component that exhibited Cronbach’s alpha values below an acceptable value, consideration on whether to use these scales for further tests depended on the reliability test (Cronbach’s alpha) in the BCC Practices components. As mentioned in the previous section, the questionnaire consisted of two sets of related items: BCC Beliefs and BCC Practices. The reliability tests
determined the decision on whether to retain or to remove the factors. Hence, at this stage, it was decided to retain factor 3, WTPL, and factor 4, ES.

4.3.2 BCC Beliefs and BCC Practices.

Based on the questionnaire, all 36 items in BCC Beliefs mirrored all 36 items in BCC Practices. Hence, the items retained in part 3 follow according to the items retained in part 1. As a result, both BCC Beliefs and BCC Practices had the same items but with different contexts. In order to check the reliability of the BCC Practices components, the internal consistency of the components was measured using Cronbach’s alpha. Table 4.13 illustrates the Cronbach’s alpha of the BCC Practices component compared to the BCC Beliefs components.

Table 4.13

<table>
<thead>
<tr>
<th>Components</th>
<th>BCC Beliefs (Cronbach’s Alpha)</th>
<th>BCC Practices (Cronbach’s Alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approaches to Encourage Student Learning</td>
<td>0.88</td>
<td>0.86</td>
</tr>
<tr>
<td>Traditional Teacher Attitudes</td>
<td>0.70</td>
<td>0.61</td>
</tr>
<tr>
<td>Working Together Promotes Learning</td>
<td>0.60</td>
<td>0.61</td>
</tr>
<tr>
<td>Empowering Students</td>
<td>0.39</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 4.13 compares the Cronbach’s alpha of the four scales for both BCC Beliefs and BCC Practices. For component AESL, the Cronbach’s alpha for BCC Practices is 0.86, which is slightly lower compared to the same component in BCC Beliefs (0.88). However, the Cronbach’s alpha value is still considered highly reliable based on the reliability guidelines (Cohen et. al, 2007). The Cronbach’s alpha for the second component, TTA, shows the value of 0.61 for BCC Practices, which is lower than in the BCC Beliefs (0.70). Even though the value of 0.61 for BCC Practices is considered
marginally acceptable according to the reliability guidelines, the value of BCC Beliefs, which is 0.70, is reliable. By contrast, the third component, WTPL, demonstrates a Cronbach’s alpha of 0.61 for BCC Practices and 0.60 for BCC Beliefs, which falls within the marginally acceptable range in reliability guidelines (Cohen et. al, 2007). In particular, the fourth component, ES, highlights a very low Cronbach’s alpha, which is 0.026 in BCC Practices and 0.393 in BCC Beliefs. These values fall under unacceptably low reliability. Consequently, the decision was made not to include factor 3, WTPL, and factor 4, ES, for both BCC Beliefs and BCC Practices for further analysis.

To summarise the EFA, only two components were retained, which represents the dimensions of pedagogical beliefs and practices about a brain-compatible classroom among secondary school science teachers in the central region of Malaysia. Based on a forced two-factor solution, these two components accounted for 40 per cent of the total variance explained (see Appendix 4-10). The two components were AESL and TTA. By comparing the newly developed components with the three fundamental elements of the 12 Brain and Mind Learning Principles, those components were regarded as far different to what has been outlined in the principles. However, the two components demonstrate the insight of the teachers’ perceptions towards the items. These two components were then referred to as dimensions of teachers’ beliefs and practice. Conceptually, dimension 1 (AESL) was associated with classroom techniques, which were aligned with the brain-based learning principles. In contrast, dimension 2 (TTA) describes traditional teacher-centred attitudes, which reflects the negative approach of the principles. Further discussion takes place in Chapter 5.

Based on factor analysis, teachers in this study rated the dimension that reflects AESL as more important than the other dimension, which indicates TTA. Nonetheless, by relating to the internal consistency of the TTA component, BCC Practices exhibits the
lowest acceptable Cronbach’s alpha value, which suggests that there may be other approaches that have been regarded as traditional teacher-centred instruction that were not accounted for in the instrument of the study.

Since there were only two final dimensions accepted after a series of factor analysis and Cronbach’s alpha test, they were regarded as dominant dimensions of pedagogical beliefs and practices in regards to a BCC perceived by the secondary school science teachers in the central region of Malaysia. This result enabled a response to research question 1: ‘What are the main dimensions of science teachers’ pedagogical beliefs about a BCC?’

4.4 Dimensions and Items in BCC Beliefs and BCC Practices

Since all the items in BBC Beliefs were matched with items in BCC Practices, each dimension contains the same items with two different contexts for suitability of the two variables, BCC Beliefs and BCC Practices. The dimensions with all the items that underpin BCC Beliefs as well as BCC Practices in this study are illustrated in tables 4.14 and 4.15.

Table 4.14

Dimensions and Items in Brain-Compatible Classroom Beliefs

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension 1: Approaches to Encourage Student Learning (13 Items)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning activities are best when involve the students’ senses</td>
</tr>
<tr>
<td>4</td>
<td>Teachers should encourage students to share their ideas</td>
</tr>
<tr>
<td>8</td>
<td>Students’ potential can be increased by exposing them to a variety of experience</td>
</tr>
<tr>
<td>9</td>
<td>Students’ interactions need to be encouraged in classroom</td>
</tr>
<tr>
<td>10</td>
<td>Teacher guides students to deepen their understanding of the concepts taught</td>
</tr>
<tr>
<td>12</td>
<td>Teachers help students understand the concept taught using meaningful themes</td>
</tr>
<tr>
<td>13</td>
<td>Teachers need to pay attention to students’ emotions in classroom</td>
</tr>
<tr>
<td>17</td>
<td>Teachers need to relate the lessons to the students’ life experience</td>
</tr>
<tr>
<td>21</td>
<td>The teachers’ attitude is an important influence on students’ learning</td>
</tr>
</tbody>
</table>
As indicated in Table 4.14, the two dimensions with items delineated by the teachers according to BCC Beliefs in this study are illustrated. The two dimensions are: AESL (factor 1) with 14 items and TTA (factor 2) with eight items. The following table presents the components with all the items in BCC Practices.

Table 4.15

Components and Items in Brain-Compatible Classroom Practices

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension 1: Approaches to Encourage Student Learning (13 Items)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I involve the students’ senses in learning activities</td>
</tr>
<tr>
<td>4</td>
<td>I like students to share their ideas</td>
</tr>
<tr>
<td>8</td>
<td>I expose the students to a variety of experience</td>
</tr>
<tr>
<td>9</td>
<td>I encourage students’ interactions in the classroom</td>
</tr>
<tr>
<td>10</td>
<td>I guide students to deepen their understanding of the concepts being taught</td>
</tr>
<tr>
<td>12</td>
<td>I help my students to understand the concept taught by using meaningful themes</td>
</tr>
<tr>
<td>13</td>
<td>I pay attention to students’ emotions in classroom</td>
</tr>
<tr>
<td>17</td>
<td>I relate the lessons to the students’ life experience</td>
</tr>
<tr>
<td>21</td>
<td>I am aware of my attitude in the classroom</td>
</tr>
</tbody>
</table>
Table 4.15 listed all the items from two dimensions portrayed by the teachers according to their pedagogical practices of BCC in this study. The two dimensions were AESL (factor 1) with 14 items and TTA (factor 2) with eight items.

Previously, the items in the questionnaire were grouped into fundamental elements suggested by the 12 Brain and Mind Learning Principles. Then, after the data collection process, EFA was conducted, which identified how the items should be re-arranged and grouped into new dimensions based on the respondents’ perspectives. The new dimensions were again tested and validated by using a reliability test.

In providing a more insightful understanding of the new dimensions in regards to the relationship between the belief and practice of each dimension and the effect of teachers’ demographic factors upon the dimensions, further analysis was needed. Before undertaking the analyses, the two dimensions were analysed for descriptive statistics to
render information about the nature of the data essential for the next statistical analyses. This is illustrated in the following section.

4.5 Characteristics of BCC Dimensions

The descriptive statistics table (see Table 4.16) provided a guide for the following statistical analyses. The average score of the level of agreement of each scale was calculated for all the participants. This was achieved by adding all the scores and dividing by the number of items in the scale. Table 4.16 illustrates the details of the dimensions’ descriptive statistics.

Table 4.16

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>n</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCC Beliefs</td>
<td>AESL</td>
<td>153</td>
<td>3</td>
<td>5</td>
<td>4.39</td>
<td>.35</td>
<td>-.25</td>
</tr>
<tr>
<td></td>
<td>TTA</td>
<td>153</td>
<td>2</td>
<td>4</td>
<td>3.05</td>
<td>.54</td>
<td>-.11</td>
</tr>
<tr>
<td>BCC Practices</td>
<td>AESL</td>
<td>153</td>
<td>3</td>
<td>5</td>
<td>4.20</td>
<td>.41</td>
<td>-.14</td>
</tr>
<tr>
<td></td>
<td>TTA</td>
<td>153</td>
<td>2</td>
<td>4</td>
<td>2.87</td>
<td>.53</td>
<td>-.07</td>
</tr>
</tbody>
</table>

Table 4.16 presents the number of cases (n), range of responses, minimums and maximums of the five-point response format, mean level of agreement (response), standard deviation, skewness and kurtosis of each component. The BCC Beliefs section that unearthed teachers’ pedagogical beliefs about a BCC used the five-point response format as follows: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree Nor Disagree; 4 = Agree and 5 = Strongly Agree. Further, whether or not teachers’ beliefs were translated into their classroom practice was revealed in BCC Practices, which employed a different type of five-point response format: 1 = never; 2 = seldom; 3 = sometimes;
Based on the data recorded in Table 4.16, the AESL component for BCC Beliefs demonstrated 4.39 as the mean level of agreement and .35 as the standard deviation. The average for the minimum responses was three and five was the average of the maximum responses for a total of 153 respondents. By comparing the mean scores and standard deviations of AESL in BCC Beliefs (4.39 ± .35) and AESL in BCC Practices (4.20 ± .41) it was shown that the average teachers’ feedback for the component related to AESL was between ‘agree’ and ‘strongly agree’ for beliefs and ‘often’ and ‘always’ for practice.

Slightly lower, the mean score and standard deviation for the TTA component in BCC Beliefs was 3.05 ± .54 and the mean score for TTA component in BCC Practices was 2.87 ± .53. In reference to the mean scores and standard deviations of the component for both variables, it was shown that the average feedback for teachers’ pedagogical beliefs of TTA was ‘neither agree nor disagree’. Aligned with the beliefs, the average feedback for the teachers’ pedagogical practice of TTA was ‘sometimes.’

This preliminary observation proposed that even if the two dimensions were perceived as important as pedagogical beliefs and practice towards a BCC, the secondary school science teachers’ pedagogical beliefs varied with different dimensions. Between the two dimensions, AESL was most valued (M = 4.39 for BCC Beliefs and M = 4.20 for BCC Practices), followed by TTA (M = 3.05 for BCC Beliefs and M = 2.87 for BCC Practices). The results also indicated a relationship between teachers’ pedagogical beliefs and their practices for both dimensions.

Based on descriptive statistics, it can be concluded that 153 secondary school science teachers in the central region of Malaysia showed different responses in their beliefs towards the two dimensions: AESL and TTA. The majority of the teachers showed
their strong pedagogical beliefs towards the dimension that reflects AESL and realised their beliefs into practice. However, a wide range of beliefs was illustrated for the other dimension, which mirrored traditional teacher-centred approaches. In particular, these beliefs were also apparent in self-reported practice.

In order to provide a response to the second research question, a correlation test was conducted to examine the relationship between teachers’ pedagogical beliefs and their practice for both dimensions. The following section reports the test.

4.6 Relationship Between BCC Beliefs and BCC Practices

In this section, results are reported that contribute to answer the research question related to the consistency of the relationship between teachers’ pedagogical beliefs and practice of the dimensions AESL and TTA. The correlation between the two variables, BCC Beliefs and BCC Practices, for both dimensions was discovered by conducting a zero order correlation. However, before performing the test, preliminary analysis was conducted as a pre-requisite to ensure no violation of the assumption of linearity and homoscedasticity. The analysis generated a scatterplot to give an idea of the nature of the relationship between the two variables. The scatterplot between BCC Beliefs and BCC Practices variables for the two components is illustrated in figures 4.5 and 4.6.
Figure 4.2: Scatterplot between approaches to encourage student learning (brain-compatible classroom beliefs) and approaches to encourage student learning (brain-compatible classroom practices).

Based on the illustration in Figure 4.2, the scatterplot shown was in a cigar shape (Pallant, 2011) with a general direction pointing diagonally upward from left to right. This indicates a linear and positive correlation of moderate strength (Pallant, 2011) between AESL (BCC Beliefs) and AESL (BCC Practices). The next figure is a scatterplot between TTA (BCC Beliefs) and TTA (BCC Practices).
Figure 4.3: Scatterplot between traditional teacher attitudes (brain-compatible classroom beliefs) and traditional teacher attitudes (brain-compatible classroom practices).

The scatterplot illustrated in Figure 4.3 exhibits the scores between TTA (BCC Beliefs) and TTA (BCC Practices), which showed a linear and positive relationship. The distribution of the scores was evenly spread and narrow in a cigar shape, which suggests a strong positive correlation between the two variables (Pallant, 2011).

The scatterplots from figures 4.2 and 4.3 in the preliminary analyses exhibited the cigar shape cluster of points pointing diagonally upwards from left to right, assuming a linear and positive relationship between the two variables (Cohen et al., 2007; Pallant, 2011; Sekaran, 2000). Above all, the scatterplots confirmed that there were no violations of the assumptions of linearity and homoscedasticity\(^5\) for the relationships between the two variables of all the components: AESL (BCC Beliefs) and AESL (BCC Practices), TTA (BCC Beliefs) and TTA (BCC Practices). Therefore, the following correlation tests appeared relevant for ascertaining the strength of the correlation and the direction of the linearity between the two variables.

\(^{5}\) The variability in scores for variable X should be similar to all values of variable Y, which shows a fairly even cigar shape along its length (Pallant, 2011).
In order to ascertain the relationship between teachers’ pedagogical beliefs and the practice of AESL and TTA, a Pearson Product-Moment Correlation Coefficient \((r)\) test was conducted. The results are illustrated in Table 4.17.

Table 4.17

*Pearson Product-Moment Correlation Test*

<table>
<thead>
<tr>
<th></th>
<th>AESL (BCC Practices)</th>
<th>TTA (BCC Practices)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AESL</strong> (BCC Beliefs)</td>
<td>Pearson Correlation</td>
<td>(.55^{**})</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>(.000)</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>153</td>
</tr>
<tr>
<td><strong>TTA</strong> (BCC Beliefs)</td>
<td>Pearson Correlation</td>
<td>(.74^{**})</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>(.000)</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>153</td>
</tr>
</tbody>
</table>

*Note.* **Correlation is significant at the 0.01 level (2-tailed).**

Table 4.17 demonstrates a Pearson Product-Moment correlation test between BCC Beliefs and BCC Practices of the AESL component. The results showed a statistically significant and positive correlation, \(r = .55, p < .000;\) that is, higher levels of AESL (BCC Beliefs) were associated with higher levels of AESL (BCC Practices). The \(r\) value suggests a strong relationship between teachers’ pedagogical beliefs and practices of the AESL component. The coefficient of determination, which is \(.30\) (30 per cent shared variance), indicates a total of 30 per cent the two variables share in common.

The Pearson \(r\) test between TTA (BCC Beliefs) and TTA (BCC Practices) that is presented (see Table 4.17) shows a significant and positive correlation, \(r = .74, p < .000,\) with higher levels of TTA (BCC Beliefs) associated with higher levels of TTA (BCC Practices). The \(r\) value indicates a very strong relationship between teachers’ beliefs and practices of the TTA component. The coefficient of determination was calculated as \(.55,\) which indicates 55 per cent shared variance.
4.6.1 Summary.

Both types of correlation analysis demonstrated in this study established that a significant, linear and positive correlation was found between the two variables of the two dimensions. This indicates higher levels of teachers’ pedagogical beliefs about the dimensions were associated with higher levels of their practices about the particular dimension. Regardless of the dimensions, the zero order correlation suggests that the secondary school science teachers’ pedagogical beliefs about the BCC dimensions are strongly correlated to their practices. Between the two dimensions, the relationship between teachers’ beliefs and practices in regards to the dimension that describes TTA was found to exhibit the strongest correlation with the highest percentage of shared variance. This was followed by the dimension that explains AESL. The results of these analyses could answer research question 2: ‘Is there consistency between science teachers’ pedagogical beliefs about a BCC and their teaching practice?’

The next section examines the effect of demographic factors on teachers’ pedagogical beliefs of both BCC dimensions.

4.7 BCC Beliefs Dimensions and Demographic Factors

The effect of age and teaching experience on teachers’ pedagogical beliefs about BCC dimensions for both variables (BCC Beliefs and BCC Practices) was investigated to answer research questions 3 and 4. In order to answer the question, a parametric technique using the t-test and ANOVA was conducted. In the previous sections, descriptive statistics of the demographic factors conveyed very unequal group sizes for gender, highest qualification and cultural background, which were inappropriate for any analysis to take place (see tables 4.3, 4.4 and 4.5). Thus, only age and teaching experience were selected for further tests. For the purpose of the tests, the number of groups in age and teaching experience were changed. Any group that showed obvious unequal numbers of
respondents was merged with another group. Thus, the number of groups was reduced compared to the group number in the frequency tables from the previous sections (see to Table 4.2 ‘Frequency of Age Group’ and Table 4.6 ‘Frequency of Teaching Experience’).

The selection of test depended on the number of groups involved. The t-test was undertaken to compare the mean scores of two different groups of people whereas a one-way ANOVA was undertaken to compare three or more different group of participants.

Of four tests conducted, only three showed significant differences between groups. The next sub-sections present the following results: AESL (BCC Beliefs) and age; TTA (BCC Beliefs) and age, and TTA (BCC Beliefs) and teaching experience. There was no significant difference in scores discovered between AESL (BCC Beliefs) and teaching experience.

### 4.7.1 AESL (BCC Beliefs) and age.

In order to find out the effect of age levels on BCC Beliefs in AESL, ANOVA was employed. Note that the initial number of age groups from the frequency of respondents was four (see Table 4.2). However, since the number of respondents in the age group of 51 and above is very unequal compared to other age groups, this group was then merged with the age group between 41 to 50 years old. Thus, three age groups were applied to all the tests in this section. Tables 4.18, 4.19 and 4.20 illustrate details of the statistics.

**Table 4.18**

<table>
<thead>
<tr>
<th>Age Range</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–30</td>
<td>43</td>
<td>4.41</td>
<td>.34</td>
<td>.05</td>
<td>4.34 - 4.52</td>
<td>3.64</td>
<td>5.00</td>
</tr>
<tr>
<td>31–40</td>
<td>47</td>
<td>4.28</td>
<td>.36</td>
<td>.05</td>
<td>4.18 - 4.38</td>
<td>3.57</td>
<td>4.93</td>
</tr>
<tr>
<td>&gt;40</td>
<td>63</td>
<td>4.45</td>
<td>.34</td>
<td>.04</td>
<td>4.37 - 4.54</td>
<td>3.43</td>
<td>5.00</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>4.39</td>
<td>.35</td>
<td>.03</td>
<td>4.33 - 4.44</td>
<td>3.43</td>
<td>5.00</td>
</tr>
</tbody>
</table>
Table 4.19

Analysis of Variance: Approaches to Encourage Student Learning (Brain-Compatible Classroom Beliefs) and Age

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>.873</td>
<td>2</td>
<td>.436</td>
<td>3.663</td>
<td>.028</td>
</tr>
<tr>
<td>Within groups</td>
<td>17.869</td>
<td>150</td>
<td>.119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18.742</td>
<td>152</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A one-way between-group ANOVA was conducted to find out the effect of age levels on AESL component. Respondents were divided into three groups according to their age level: group 1 (20 to 30 years); group 2 (31 to 40 years) and group 3 (above 40 years). Based on the analysis, there was a statistically significant difference at the \( p < .05 \) level in AESL scores for the three age groups: \( F(2, 150) = 3.7, \ p = .028 \) (see Table 4.19). The \( p \) value was statistically significant, with the effect size calculated using eta squared .05, indicating the actual difference in mean scores between the groups was almost moderate.

Post-hoc comparisons using the Tukey Honestly Significant Difference (HSD) test (see tables 4.18 and 4.20) indicated that the mean score for group 2 (\( M = 4.28, SD = .36 \)) was significantly different from group 3 (\( M = 4.45, SD = .34 \)). Group 1 (\( M = 4.41, SD = .34 \)) did not differ significantly from either group 2 (\( M = 4.28, SD = .36 \)) or group 3 (\( M = 4.45, SD = .34 \)).
Table 4.20

Post-Hoc Tests: Approaches to Encourage Student Learning (Brain-Compatible Classroom Beliefs) and Age.

<table>
<thead>
<tr>
<th>Age Range (I)</th>
<th>Age (J)</th>
<th>Mean Difference (I–J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 20–30</td>
<td>2 31–40</td>
<td>.137</td>
<td>.073</td>
<td>.148</td>
<td>-.04</td>
<td>.31</td>
</tr>
<tr>
<td>3 &gt;40</td>
<td>.039</td>
<td>.068</td>
<td>.073</td>
<td>.148</td>
<td>-.20</td>
<td>.12</td>
</tr>
<tr>
<td>2 31–40</td>
<td>1 20–30</td>
<td>-.137</td>
<td>.073</td>
<td>.148</td>
<td>-.31</td>
<td>.04</td>
</tr>
<tr>
<td>3 &gt;40</td>
<td>.176*</td>
<td>.067</td>
<td>.068</td>
<td>.025</td>
<td>-.33</td>
<td>-.02</td>
</tr>
<tr>
<td>3&gt;40</td>
<td>1 20–30</td>
<td>.039</td>
<td>.068</td>
<td>.025</td>
<td>-.12</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>2 31–40</td>
<td>.176*</td>
<td>.067</td>
<td>.025</td>
<td>.02</td>
<td>.33</td>
</tr>
</tbody>
</table>

Note. * The mean difference is significant at the 0.05 level.

Among age groups, teachers aged 31 to 40 years old showed differences in their responses to teachers aged more than 40 in their beliefs in the AESL dimension. While higher mean scores were evident with teachers aged above 40 years ($M=4.45$) compared to teachers aged from 31 to 40 years ($M=4.28$), the difference between the two groups is very small.

The following test describes ANOVA between TTA (BCC Beliefs) and age.

4.7.2 TTA (BCC Beliefs) and age.

A one-way between-group ANOVA was conducted to find out the effect of age levels on the BCC Beliefs in TTA. Tables 4.21, 4.22 and 4.23 illustrate the details of the statistics.
Table 4.21

Descriptive: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Age

<table>
<thead>
<tr>
<th>Age Range</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–30</td>
<td>43</td>
<td>2.71</td>
<td>.54</td>
<td>.08</td>
<td>2.55-2.88</td>
<td>1.63</td>
<td>4.13</td>
</tr>
<tr>
<td>31–40</td>
<td>47</td>
<td>2.88</td>
<td>.56</td>
<td>.08</td>
<td>2.73-3.04</td>
<td>1.88</td>
<td>4.13</td>
</tr>
<tr>
<td>&gt;40</td>
<td>63</td>
<td>3.16</td>
<td>.47</td>
<td>.06</td>
<td>3.04-3.28</td>
<td>2.13</td>
<td>4.50</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>2.94</td>
<td>.54</td>
<td>.04</td>
<td>2.86-3.04</td>
<td>1.63</td>
<td>4.50</td>
</tr>
</tbody>
</table>

Table 4.22

Analysis of Variance: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Age

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>5.440</td>
<td>2</td>
<td>2.720</td>
<td>10.449</td>
<td>.000</td>
</tr>
<tr>
<td>Within groups</td>
<td>39.043</td>
<td>150</td>
<td>.120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>44.482</td>
<td>152</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A one-way between-group ANOVA was conducted to find out the effect of age levels on the TTA scale. Based on the analysis, there was a statistically significant difference at the $p < .05$ level in TTA scores for the three age groups: $F (2, 150) = 10.449$, $p = .000$ (see Table 4.22). The $p$ value was statistically significant, with the effect size calculated using eta squared 0.12, indicating the actual difference in mean scores between the groups was close to large.

Post-hoc comparisons using the Tukey HSD test (see tables 4.21 and 4.23) indicated that the mean score for group 3 ($M = 3.16, SD = .47$) was significantly different from group 1 ($M = 2.71, SD = .54$) and group 2 ($M = 2.88, SD = .54$). Group 1 ($M = 2.71, SD = .54$) did not differ significantly from group 2 ($M = 2.88, SD = .54$).
Table 4.23

*Post-Hoc Tests: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Age*

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Age</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>120–30</td>
<td>2 31–40</td>
<td>-.17</td>
<td>.108</td>
<td>.255</td>
<td>-.43</td>
</tr>
<tr>
<td></td>
<td>3 &gt;40</td>
<td>-.45*</td>
<td>.101</td>
<td>.000</td>
<td>-.69</td>
</tr>
<tr>
<td>231–40</td>
<td>1 20–30</td>
<td>.171</td>
<td>.108</td>
<td>.255</td>
<td>-.08</td>
</tr>
<tr>
<td></td>
<td>3 &gt;40</td>
<td>-.28*</td>
<td>.098</td>
<td>.015</td>
<td>-.51</td>
</tr>
<tr>
<td>3&gt;40</td>
<td>1 20–30</td>
<td>.45*</td>
<td>.101</td>
<td>.000</td>
<td>.21</td>
</tr>
<tr>
<td></td>
<td>2 31–40</td>
<td>.28*</td>
<td>.098</td>
<td>.015</td>
<td>.45</td>
</tr>
</tbody>
</table>

Note. *The mean difference is significant at the 0.05 level.

Among the age groups, teachers in the 20 to 30 and 31 to 40 groups showed a difference in their responses to teachers aged more than 40 in their beliefs about the TTA component. Based on the analysis, older teachers aged more than 40 years demonstrated higher mean scores ($M = 3.16$) for the TTA dimension compared to the younger teachers aged between 20 to 30 years ($M = 2.71$) and aged between 31 to 40 years ($M = 2.88$). The difference between those groups is close to large, which accounted for 12 per cent.

The next statistical analysis reported a $t$-test between TTA (BCC Beliefs) and teaching experience.

4.7.3 TTA (BCC Beliefs) and teaching experience.

The effect of teaching experience on TTA in BCC Beliefs was also tested by $t$-test. The number of group samples in teaching experience was reduced when a group of teachers with teaching experience of more than 20 years was merged with teachers with more than 10 years of experience. Tables 4.24 and 4.25 illustrate the findings of the analysis.
Table 4.24

*Group Statistics: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Teaching Experience*

<table>
<thead>
<tr>
<th>Teaching Experience</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTA (BCC Beliefs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–10</td>
<td>71</td>
<td>2.79</td>
<td>.56</td>
<td>.07</td>
</tr>
<tr>
<td>&gt;10</td>
<td>82</td>
<td>3.09</td>
<td>.48</td>
<td>.05</td>
</tr>
</tbody>
</table>

An independent samples *t*-test was conducted to compare TTA(BCC Beliefs) for different lengths of teaching experience. There was a significant difference in scores for teaching experience of zero to 10 years (*M* = 2.79, *SD* = .56) and more than 10 years (*M* = 3.09, *SD* = .48; *t*(151) = -3.59, *p* = .000). The magnitude of the differences in the means (mean differences = -3.30, 95 per cent CI: -.47 to -.14) was very small (eta squared = .001). Based on the results, teachers who had teaching experience of more than 10 years exhibited higher mean scores (*M* = 3.09) compared to teachers who had experience of between zero to 10 years of teaching (*M* = 2.79). However, the difference between the two groups is very small, which accounted for 0.1 per cent only.

Table 4.25

*T-Test: Traditional Teacher Attitudes (Brain-Compatible Classroom Beliefs) and Teaching Experience.*

<table>
<thead>
<tr>
<th></th>
<th>Levene’s Test for Equality of Variances</th>
<th>T-Test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F      Sig.</td>
<td>t    df</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*X</td>
<td>2.163</td>
<td>.143</td>
</tr>
<tr>
<td>*Y</td>
<td>-3.545</td>
<td>138.228</td>
</tr>
</tbody>
</table>

*Note.* *X:* Equal variances assumed; *Y:* Equal variances not assumed.
The next section is a summary of all ANOVA and \( t \)-test between BCC Beliefs dimensions (AESL and TTA) and demographic factors (age and teaching experience).

### 4.7.4 Summary of the analysis.

The effect of demographic factors such as age group and teaching experience on science teachers’ pedagogical beliefs towards AESL and TTA dimensions in BCC were investigated by conducting ANOVA and \( t \)-tests. Out of four analyses, only three analyses showed significant differences between groups.

Based on the analyses, senior teachers aged more than 40 years showed higher beliefs towards the TTA dimension compared to their junior counterparts. The detail shows that those senior teachers demonstrated positive beliefs whereas the junior teachers expressed their disbeliefs. Positive beliefs were demonstrated by teachers who had more than 10 years of teaching experience compared to their inexperienced counterparts regarding the same approach. However, the difference between the two groups was not so obvious.

Further, the same age group of senior teachers demonstrated higher beliefs towards the AESL dimension compared to their junior counterparts. However, the difference was similarly not distinctive. Interestingly, those senior teachers clearly demonstrated a quite high positive belief towards the aforementioned dimension. The results also demonstrated no significant difference between science teachers’ beliefs about AESL and their teaching experience.

In combination, different levels of pedagogical beliefs were demonstrated by science teachers from different age groups and teaching experience towards both BCC dimensions. These results suggest that for the research question ‘Do science teachers from different age group and teaching experience hold different level of pedagogical beliefs about a BCC?’ there is evidence to support the difference.
The following section reports the findings between BCC Practices dimensions and demographic factors.

4.8 BCC Practices Dimensions and Demographic Factors

ANOVA and t-tests were applied to compare group means of AESL and TTA dimensions on BCC Practices according to the demographic factors such as age and teaching experience. Among the tests, only AESL (BCC Practices) and age, and TTA (BCC Practices) and age, showed significant results. The results for AESL (BCC Practices) and teaching experience, and TTA (BCC Practices) and teaching experience, were not significant. This section shows the test with significant results only.

4.8.1 AESL (BCC Practices) and age.

A one-way between-group ANOVA was conducted to find out the effect of age levels on BCC Practices in AESL. Tables 4.26, 4.27 and 4.28 illustrate details of the statistics.

Table 4.26

Descriptive: Approaches to Encourage Student Learning (Brain-Compatible Classroom Practices) and Age

<table>
<thead>
<tr>
<th>Age Range</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>20–30</td>
<td>43</td>
<td>4.20</td>
<td>.41</td>
<td>.06</td>
<td>4.07</td>
</tr>
<tr>
<td>31–40</td>
<td>47</td>
<td>4.05</td>
<td>.36</td>
<td>.05</td>
<td>3.94</td>
</tr>
<tr>
<td>&gt;40</td>
<td>63</td>
<td>4.31</td>
<td>.40</td>
<td>.05</td>
<td>4.21</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>4.20</td>
<td>.41</td>
<td>.03</td>
<td>4.13</td>
</tr>
</tbody>
</table>
Based on the analysis, there was a statistically significant difference at the $p < .05$ level in AESL scores for the three age groups: $F(2, 150) = 5.7, p = .004$ (see Table 4.27).

The $p$ value was statistically significant, with the effect size calculated using eta squared 0.07, indicating the actual difference in mean scores between the groups was medium. Post-hoc comparisons using Tukey HSD test (see tables 4.26 and 4.28) indicated that the mean score for group 2 ($M = 4.05, SD = .36$) was significantly different from group 3 ($M = 4.31, SD = .40$). Group 1 ($M = 4.20, SD = .41$) did not differ significantly from either group 2 ($M = 4.05, SD = .36$) or group 3 ($M = 4.31, SD = .40$).

Table 4.28

Post-Hoc Tests: Approaches to Encourage Student Learning (Brain-Compatible Classroom Practices) and Age

<table>
<thead>
<tr>
<th>(I) Age</th>
<th>(J) Age</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 20–30 2 31–40 .15</td>
<td>.083</td>
<td>.189</td>
<td>.05</td>
<td>.34</td>
<td></td>
</tr>
<tr>
<td>3 &gt;40 - .11</td>
<td>.078</td>
<td>.330</td>
<td>-.30</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>2 31–40 1 20–30 .15</td>
<td>.083</td>
<td>.189</td>
<td>-.34</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>3 &gt;40 -.26*</td>
<td>.076</td>
<td>.003</td>
<td>-.44</td>
<td>-.08</td>
<td></td>
</tr>
<tr>
<td>3 &gt;40 1 20–30 .11</td>
<td>.078</td>
<td>.330</td>
<td>-.07</td>
<td>.30</td>
<td></td>
</tr>
<tr>
<td>2 31–40 .26*</td>
<td>.076</td>
<td>.003</td>
<td>.08</td>
<td>.44</td>
<td></td>
</tr>
</tbody>
</table>

*The mean difference is significant at the 0.05 level.
Based on the results, senior teachers aged more than 40 years showed higher and positive mean scores ($M = 4.31$) in their practices towards the AESL dimension compared to junior teachers aged 31 to 40 years ($M = 4.05$). However, the difference between the two groups is at the moderate level. Other age groups did not show any difference between them in their practices towards the particular dimension.

The following is an ANOVA between TTA (BCC Practices) and age.

**4.8.2 TTA (BCC Practices) and age.**

A one-way between-group ANOVA was conducted to find the effect of age levels on BCC Practices in TTA. The details of the analysis are described in tables 4.29, 4.30 and 4.31. Based on the analysis, there was a statistically significant difference at the $p < .05$ level in TTA scores for the two age groups: $F (2, 150) = 3.47, p = .034$ (see Table 4.30). The $p$ value was statistically significant, with the effect size calculated using eta squared, indicating the actual difference in mean scores between the groups was in the small category. Post-hoc comparisons using the Tukey HSD test (see tables 4.29 and 4.31) indicated that the mean score for group 1 ($M = 3.07, SD = .48$) was significantly different from group 3 ($M = 3.32, SD = .56$). Group 2 ($M = 3.10, SD = .60$) did not differ significantly from group 1 ($M = 3.07, SD = .48$) or group 3 ($M = 3.32, SD = .56$).

Table 4.29

*Descriptive: Traditional Teacher Attitudes (Brain-Compatible Classroom Practices) and Age*

<table>
<thead>
<tr>
<th>Age Range</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–30</td>
<td>43</td>
<td>3.07</td>
<td>.48</td>
<td>.07</td>
<td>2.92–3.22</td>
<td>2.13</td>
<td>4.13</td>
</tr>
<tr>
<td>31–40</td>
<td>47</td>
<td>3.10</td>
<td>.60</td>
<td>.09</td>
<td>2.92–3.27</td>
<td>1.88</td>
<td>4.38</td>
</tr>
<tr>
<td>&gt;40</td>
<td>63</td>
<td>3.32</td>
<td>.56</td>
<td>.07</td>
<td>3.18–3.46</td>
<td>1.75</td>
<td>4.50</td>
</tr>
<tr>
<td>Total</td>
<td>153</td>
<td>3.18</td>
<td>.563</td>
<td>.05</td>
<td>3.09–3.27</td>
<td>1.75</td>
<td>4.50</td>
</tr>
</tbody>
</table>
Table 4.30

Analysis of Variance: Traditional Teacher Attitudes (Brain-Compatible Classroom Practices) and Age

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2.116</td>
<td>2</td>
<td>1.058</td>
<td>3.471</td>
<td>.034</td>
</tr>
<tr>
<td>Within groups</td>
<td>45.726</td>
<td>150</td>
<td>.305</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47.842</td>
<td>152</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.31

Post-Hoc Tests: Traditional Teacher Attitudes (Brain-Compatible Classroom Practices) and Age

<table>
<thead>
<tr>
<th>(I) Age</th>
<th>(J) Age</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 20–30</td>
<td>2 31–40</td>
<td>-.10</td>
<td>.109</td>
<td>.608</td>
<td>-.36</td>
</tr>
<tr>
<td>3 &gt;40</td>
<td>-33*</td>
<td>.102</td>
<td>.004</td>
<td>-.58</td>
<td>-.09</td>
</tr>
<tr>
<td>2 31–40</td>
<td>1 20–30</td>
<td>.10</td>
<td>.109</td>
<td>.608</td>
<td>-.15</td>
</tr>
<tr>
<td>3 &gt;40</td>
<td>-.23</td>
<td>.100</td>
<td>.057</td>
<td>-.47</td>
<td>.01</td>
</tr>
<tr>
<td>3 &gt;40</td>
<td>1 20–30</td>
<td>.33*</td>
<td>.102</td>
<td>.004</td>
<td>-.09</td>
</tr>
<tr>
<td>2 31–40</td>
<td>.23</td>
<td>.100</td>
<td>.057</td>
<td>-.01</td>
<td>.47</td>
</tr>
</tbody>
</table>

Notes: *The mean difference is significant at the 0.05 level.

Among the age groups, teachers aged more than 40 years demonstrated higher positive responses ($M = 3.32$) towards their practice of the AESL dimension compared to teachers aged from 20 to 30 ($M = 3.07$) and 31 to 40 years ($M = 3.10$). However, the difference was at the small level.

The next section provides a summary of the analysis.

4.8.3 Summary of the analysis.

The effects of demographic factors such as age group and teaching experience on science teachers’ practices towards the AESL and TTA dimensions in BCC were
investigated by conducting ANOVA and t-tests. Out of four analyses, only two analyses showed significant differences between groups.

Based on the analyses, senior teachers aged more than 40 years revealed higher positive responses towards their practices of the AESL dimension compared to their junior counterparts aged 31 to 40 years. The same age group of senior teachers demonstrated higher positive responses in practising the TTA dimension compared to other younger age groups. However, none of the teachers with different levels of teaching experience showed any effect towards any of the BCC dimensions. Overall, the senior teachers reported that they deliberately practiced both dimensions of the BCC approach. There was no influence on teaching experience upon teachers’ beliefs about the AESL and TTA dimensions.

Above all, science teachers from different age groups demonstrated different levels of practice towards both the BCC dimensions and in part contributed to a response to the research question ‘Do the science teachers’ practices about BCC differ according to their age groups, and teaching experience?’

4.9 Summary of the Teacher Survey

In brief, the quantitative data revealed two main dimensions related to pedagogical beliefs and practices in regards to a BCC among the respondents: AESL and TTA. While AESL consists of items that describe approaches aligned with a BCC, TTA lists the items that explain the negative approach of a BCC. Between the two dimensions, it was revealed that senior teachers aged more than 40 years demonstrated higher positive beliefs towards approaches that encourage students in their learning than their junior counterparts aged between 31 to 40 years. Moreover, the senior teachers from the same age group had realised the beliefs in their classroom practices. Higher beliefs towards TTA instructions had also been demonstrated by teachers aged above 40 compared to all other age groups of teachers. In particular, the same pattern of results were demonstrated regarding their
practice towards the instruction. The difference in feedback from teachers with different lengths of teaching experience was very small regarding TTA and no difference was reported for their practices towards the dimension. The findings also suggested a strong association between teachers’ pedagogical beliefs and their practices for both dimensions. However, the TTA dimension demonstrates a stronger relationship between belief and practice.

Based on the results, three items from the TTA dimension were chosen for further investigation through email interviews to seek detail explanation. The following section describes how the items were selected and used in designing the questions for the follow-up interviews.

4.10 Dimension for Further Investigation

The research design was based on a sequential data gathering approach. The second study used the results of the first study. Thus, the two dimensions derived from factor analysis were supposed to be used for further investigations. Specific to the current study, AESL and TTA dimensions were supposed to be examined further in the email interviews. The purpose was to acquire more information according to the main objective of the research, which is to investigate the compatibility of science teachers’ pedagogical beliefs about a BCC. Nevertheless, since the TTA dimension had shown significant and interesting findings for almost all of the tests, it was decided to focus on this dimension only for further investigation. This was simply another way of choosing an issue for further investigation within the results derived from the survey.

The results revealed that senior teachers aged more than 40 years had expressed higher positive beliefs towards the dimension than their junior counterparts. Further, a very strong relationship between teachers’ pedagogical beliefs and their practices of the
TTA dimension was discovered. Thus, this dimension was chosen to be investigated in the email interviews.

Eight items in the TTA dimension were analysed at the descriptive level to reveal their characteristics. Based on the table, the description of items in TTA was according to the number of respondents (N), minimum and maximum score from the respondents, the mean score (M) and its standard deviation (SD). The characteristics of all the items described above were thought to be worth investigating for email interviews. Details of the items are illustrated in Table 4.32.

Table 4.32

Descriptive Statistics of the Items in Traditional Teacher Attitudes Dimension

<table>
<thead>
<tr>
<th>Item</th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. It is important for students to keep their work confidential</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>3.09</td>
<td>1.10</td>
</tr>
<tr>
<td>7. It is important for students to memorise what they have learnt</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>4.00</td>
<td>.85</td>
</tr>
<tr>
<td>11. Students need to be punished when they fail to give correct answers</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>2.17</td>
<td>1.01</td>
</tr>
<tr>
<td>23. Students who talk a lot are problematic</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>2.70</td>
<td>.90</td>
</tr>
<tr>
<td>24. Art has little relevance to science teaching</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>2.90</td>
<td>.97</td>
</tr>
<tr>
<td>29. Criticising is a good way to motivate the students</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>3.07</td>
<td>.98</td>
</tr>
<tr>
<td>30. Teachers should choose a teaching strategy which is comfortable for them</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>4.00</td>
<td>.73</td>
</tr>
<tr>
<td>33. Teacher should provide the same activity for all groups of students</td>
<td>153</td>
<td>1</td>
<td>5</td>
<td>2.48</td>
<td>1.04</td>
</tr>
</tbody>
</table>

Out of eight items, item 11 ‘Students need not be punished when they fail to give correct answers’ had the lowest mean scores (M = 2.17) and item 29 ‘Criticising is not a good way to motivate the students’ had a mean score that stayed in the middle (M = 3.07). However, two items showed the highest mean scores: item 7 ‘It is important for students to memorise what they have learnt’ (M = 4.00) and item 30 ‘Teachers should not choose a
teaching strategy which is comfortable for them’ (M = 4.00). However, by considering time constraints and teachers’ workload, only three items were chosen for the email interviews. Those items were item 11, item 30 and item 29. The reason item 30 was preferred rather than item 7 was because it was decided to investigate further the reason why those teachers choose to teach according to their comfortable teaching strategy. It was also hoped that it would further clarify their beliefs towards TTA.

Thus, three items were chosen for further investigation in the email interview regarding the compatibility of teachers’ pedagogical beliefs about a BCC. The next section presents the second part of the data collection, the email interviews.

4.11 Email Interviews

In this section, the data from email interviews are provided. There were eight respondents in this study and, as noted previously, they were selected from those who had answered the survey and indicated they were willing to receive further questions through email.

Being aware of the nature of teachers’ work, which is sometimes overwhelming and loaded with many tasks, all of the participants were contacted by telephone and were given explanations about the email interview process and made aware that this was the second stage of the data collection process. Once they agreed to participate, they were required to provide their email addresses. The possibility of not receiving genuine answers from the participants was anticipated and, when possible, a friendly colleague relationship with them was built. The researcher’s previous career as a teacher was mentioned in order to gain trust through identifying common experiences between the researcher and the participants. The aim of the good relationship was to narrow down the relationship gap between the researcher and those participants. It was undertaken in such a way that the researcher who was asking the questions would not appear as someone who was out to
judge the respondents or interfere with their teaching, as this might affect their responses. In the researcher’s experience as a teacher, teachers in Malaysia can be suspicious of people wanting their opinions.

4.12 Open-Ended Questions

While the main question of the study involved a focus on the science teachers’ pedagogical beliefs and their consistency with BCC, in this section three sub-questions that were identified after analysing the questionnaire data was explored. Three ‘extreme’ results that needed further examination were found. They involved the issues of punishing students for incorrect answers, choosing a comfortable teaching strategy and the use of criticism with students.

Based on the ‘extreme’ results, those that the analysis identified as being at one end of the spectrum by referring to the mean scores and its SD (see Table 4.32), questions to send to the participants were developed. The first question arose from item 11 of the questionnaire, ‘Students need to be punished when they fail to give correct answer’. The mean response to this item, $2.17 \pm 1.01$, exhibits the lowest mean score among the items and validates that most of the responses corresponded to the item. This shows that the majority of the respondents were against this item. The second question arose from item 30, ‘Teachers should choose a teaching strategy which is comfortable for them’. The mean score was $4.00 \pm .73$, which demonstrates the highest mean score among the items. The final question arose from item 29, ‘Criticising is a good way to motivate the students’. The mean score of $3.07 \pm .98$ shows a wide range of responses at both ends and this needed more exploration. Based on the characteristics mentioned above, these items were selected for further investigation.

In seeking more information about these three items, the following questions were developed and emailed to the participants:
1. Most teachers disagree with punishing students if they fail to give correct answers. Why do you think this is so?

2. The majority of teachers thought that teachers should choose a teaching strategy that is comfortable for them. What is your opinion?

3. Do you think criticism is a useful way to motivate students? (Why/Why not?)

The questions were emailed to the participants for feedback. Three took only a few days to reply to the email and the rest replied within two weeks. Their emails were printed as hard copies and analysed manually according to themes.

4.13 Teachers’ Feedback

The feedback was analysed by putting all the common terms mentioned by the participants together under one theme. Some of the feedback was answered in English, as respondents were given the choice to either write the answer in Malay or English. It depended on their preference and which language they were more comfortable with. The feedback written in Malay was translated into English before being analysed.

The following sub-sections discuss the participants’ responses to these questions. Examples of the written feedback are listed under each sub-section. The responses are labelled according to participants’ gender and age to keep their anonymity.

4.13.1 Question 1.

Question 1: Most teachers disagree with punishing students if they fail to give correct answers. Why do you think this is so?

Three themes emerged from the responses to this question that generally indicated that the respondents did not see punishment as an effective way of promoting learning and gave a possible elaboration on the survey results that had most of the teachers disagreeing with punishing students if they fail to give correct answers. The most common themes mentioned by the respondents were: a) seeing the teacher as a guide, b) the students
becoming afraid of making mistakes and c) having students feel embarrassed and lowering their confidence. Detail about these themes are shown in Table 4.33.

Table 4.33

*Teacher Feedback for Question One*

<table>
<thead>
<tr>
<th>Themes</th>
<th>Number of Times Mentioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Teachers should act as a guide</td>
<td>7</td>
</tr>
<tr>
<td>2 Students will never try to answer any more questions fear of the possibility of making more mistakes</td>
<td>6</td>
</tr>
<tr>
<td>3 Students feel embarrassed and lack of confidence</td>
<td>5</td>
</tr>
</tbody>
</table>

4.13.1.1 *Teacher as guide.*

Seven respondents stressed that teachers should act as a guide for the students, throughout the teaching and learning process in classroom. They also identified two types of ‘guide’ that teachers can adopt, one as guiding to acquiring the correct answers and the second as guiding and encouraging students to think about the questions. The concern with getting correct answers was expressed in the following comments and from the perspectives of this thesis suggests that these respondents were thinking in the more traditional teacher-centred approach.

- Teachers should just guide the students to get correct answers (Female B aged more than 50)
- I will guide them until they get the desired correct answers (Female F aged 31 to 40)
- If they make mistakes, correct them there and then, so as they realise their mistakes, relate to the correct answer and they will remember the correct answer well (Female E aged more than 50)

However, two of the respondents claimed that guiding students was about more than finding correct answers, it was about guiding them to think about how to solve the
problems and what was involved in finding the answer. These responses indicated a deeper level of reflection than the first group. It seems that the belief of these teachers includes the idea that the students are the central figures in the learning process and enabling them to develop thinking skills may be more important than simply getting the right answer.

- I like a relevant response from the students even if it doesn’t really follow the answer scheme set by the teacher. It shows the students are thinking about the questions (Female A aged 41 to 50)
- Teacher should encourage students to try and think in a wider scope (Female C aged 31 to 40)

**4.13.1.2 Fear of making mistakes.**

The second theme to emerge was concern about the students’ resistance to answering questions if they have been punished for getting something wrong. Most of the respondents agreed that students would not try to answer any more questions if they were punished for making mistakes, expressed as follows:

- Punishment will only make the students scared to try to answer any questions (Female B aged more than 50)
- Students who were punished will probably not answer any more questions for fear that they would make another mistake and be punished again (Female C aged 31 to 40)
- Punishment creates unnecessary fear in the students (fear to say something/fear to try to answer any more questions) (Male aged 41 to 50)

**4.13.1.3 Embarrassment.**

The last theme to emerge was the concern about embarrassing the students and making them lose confidence. These comments indicate a concern for the students’ well-
being and an understanding that feeling embarrassed and lacking confidence is not good for learning.

- The teacher will not be able to build up the students’ level of confidence (Female B aged more than 50)
- Students’ level of confidence will become lower due to punishment (Female C aged 31 to 40)
- Students’ lack of confidence due to the chances and opportunities not given (Male aged 41 to 50)
- Students who were punished will probably not answer any more questions due to feeling embarrassment (Female C aged 31 to 40)
- Students feel embarrassed should they make a mistake (Female E aged more than 50)

### 4.13.2 Question 2.

**Question 2:** The majority of teachers thought that teachers should choose a teaching strategy that is comfortable for them. What is your opinion?

All the responses for question 2 are outlined in Table 4.34.

Table 4.34

**Teacher Feedback for Question Two**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Number of Teachers Mentioned the Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aware of students’ ability, interest and difference</td>
<td>5</td>
</tr>
<tr>
<td>2 Teachers can teach confidently and effectively</td>
<td>4</td>
</tr>
<tr>
<td>3 Suitable teaching strategy for both teacher and students</td>
<td>2</td>
</tr>
</tbody>
</table>

### 4.13.2.1 Students’ ability, interest and difference.

In answering this question, the participants expressed the opinion that the most important thing to consider in choosing a teaching strategy was the students’ acceptance of
They also wrote that teachers needed to be comfortable as well. Five participants claimed that in choosing a teaching strategy, the teacher should be aware of student’s ability, interest and differences. These were illustrated in the following quotations under theme one in Table 4.34.

- Teacher needs to choose a teaching strategy that is able to raise students’ interest (Female C aged 31 to 40)
- Teaching technique must be according to the students’ interests, as they may have different understandings to the teachers (Female D aged 20 to 30)
- Different classes with different levels of students will make the teachers think how to best deliver the lesson and its effect on the students (Male aged 41 to 50)
- Students would love to be involved in planning the lesson with the teachers, as they would feel close to the selected approach (Female F aged 41 to 50)
- Different classes of students might need different strategies (Female G aged 41 to 50)

**4.13.2.2 Teaching confidently and effectively.**

Half the respondents who considered the teacher most important suggested that a comfortable teaching strategy could raise the teacher’s confidence level and lead to effective teaching. The importance of teachers’ confidence was also a major point for several respondents to the question about teaching strategies. Feeling at ease and confident were two important issues for them:

- Teachers feel at ease and confident with what they do (Female E aged more than 50)
- Something we have confidence in and have knowledge about (Male aged 41 to 50)
• Feeling comfortable is a factor that contributes to a high confidence level in delivering the lesson (Female C aged 31 to 40)

• It is very important that teachers should feel comfortable with their teaching strategies so that their teaching will be effective and genuine (Female G aged 41 to 50)

• Teachers like to choose the most appropriate and easiest way of teaching in classroom. (Female A aged 41 to 50)

4.13.2.3 Suitable strategy for teacher and students.

Two respondents showed great concern for the students’ well-being, and argued that their needs were as important as the teachers’.

• A teacher cannot rely solely on their comfortable teaching technique. Students’ acceptance of the technique should be taken into consideration (Female B aged more than 50)

• Teacher should not choose a teaching strategy that is suitable for them without taking the students into consideration (Female F aged 31 to 40)

4.13.3 Question 3.

This section describes teachers’ feedback for question 3 about the usefulness of criticism in motivating students: Why do you think criticism is a useful way to motivate the students? (Why/ Why not?).

Before going further, the focus is to explain the word ‘criticism’ from the participants’ point of view. Based on the feedback, almost all of the participants described ‘criticism’ as the type that may help in motivating the students. Generally, the word ‘criticism’ itself carries two different meanings. ‘Criticism’ can mean condemnation that conveys a negative meaning. Conversely, ‘criticism’ is also related to evaluation or appraisal with positive meaning. In reference to the teachers’ feedback, the type of
criticism they were referring to was related to evaluation or appraisal or what they called ‘constructive criticism’. To be precise, they were concentrating on constructive criticism as opposed to destructive criticism in motivating the students.

After analysing the feedback from the participants, the only theme they focused on was constructive criticism and the rest was the detailed explanation of it. There were also a few participants who mentioned destructive criticism and the implication of applying that kind of criticism to the students. Since there was no other theme outlined by the participants, the discussion for this section will only focus on constructive criticism and explain destructive criticism. The following are examples of quotations that mentioned constructive criticism in their feedback.

**4.13.3.1 Using constructive criticism.**

- Constructive criticism is good to motivate the students (Female A aged 41 to 50)
- Teachers have the right to criticise the students and this is referring to a constructive criticism (Female B aged more than 50)
- Criticism is useful if teacher applies constructive criticism and students can accept the criticism (Female F aged 31 to 40)
- Criticism can motivate the students if it means correcting mistakes step by step to achieve the desired objective (Male six aged 41 to 50)

In reference to the above quotations, four respondents mentioned constructive criticism explicitly in their feedback. There were also suggestions on the steps taken to make sure the type of criticism that they have chosen is effective in motivating the students. They argued that criticism should be conducted in a proper and positive way without involving the teachers’ emotional factors or the students’ personal matters. Teachers should praise the students before criticising them to make them feel appreciated.
and explain the rationale so that they know the reason they are being criticised. Good facial expression, body language and the use of language, such as avoiding the use of harsh words, should be taken into consideration for constructive criticism to take place. The participants stressed that constructive criticism would consequently prepare the student to be a positive-minded person. The followings are quotations that give more descriptions of constructive criticism.

- Praise the students before criticising them so that they feel appreciated (Female A aged 41 to 50)
- Teacher should praise the students before criticising them to create a positive thought to help to improve the learning process (Female F aged 31 to 40)
- Criticism should be given together with the rationale of why they’re criticised so that they know the reason of being criticised (Female B aged more than 50)
- Students will feel challenged and take an initiative to change to prove to the teachers that they can perform better (Female C aged 31 to 40)
- Facial expression, body language and language (avoid harsh language) should be taken into consideration in constructive criticism (Female E aged more than 50)

Above all, criticism is only effective in motivating students if they can take it positively and when performed in a proper way, as in constructive criticism. In contrast, if the students take it negatively, this will lead to discouragement and demotivation. The most difficult part is related to the sensitivity of the students towards criticism. Only a few participants spelt out more about destructive criticism.
• Students should not be criticised all the time, especially if it’s related to a personal matter or as a result of teachers’ emotional factor. This will lead to negative effects and the students will hate the teacher (Female B aged more than 50)
• Criticism can be bad if students cannot take it positively. This will lead to discouragement (Female aged 31 to 40)
• Destructive criticism can demoralise the students if language used is not appropriate in pointing out their mistakes (Male aged 41 to 50)

4.14 Conclusion

Based on the factor analysis, AESL and TTA were discovered as dimensions of secondary school science teachers’ pedagogical beliefs and practices in the central region of Malaysia. Based on the teacher survey and email interviews, it was revealed that part of the teachers’ beliefs and practices, especially the senior teachers aged above 40, were aligned with a BCC. However, another part was still following the TTA that influenced their classroom practices. In terms of the relationship between belief and practice, a consistency between teachers’ beliefs and practices in this study is indicated as very strong.

4.15 Summary

As a follow-up from the survey, eight participants from secondary school science teachers in the central region of Malaysia who answered the questionnaires were asked for their responses through email interviews involving three questions. Based on their feedback, teachers suggested their role as a guide as opposed to punishing the students in classroom. They clearly demonstrated their disbelief in punishment by outlining its negative effect on the students. However, they showed a range of complex responses in regards to choosing a comfortable teaching strategy. With criticism, they were keen on
constructive criticism and saw it as an effective way of motivating students. They were aware of the negative implications for the students if destructive criticism is used. Overall, two out of three questions posed to the participants showed that the teachers’ pedagogical beliefs were significantly aligned to the beliefs on which the BCC was developed. Even though the feedback is regarded as the respondents’ stated beliefs about their pedagogy, this is a good indication of how these teachers are able to intuitively employ an inspiring as well as engaging teaching and learning environment aligned with a BCC. Although the number of participants involved in the email interviews is too small to allow broad generalisations, it is likely comparable to those in the same context of the study. These findings support the main objective of the study and contribute to answering the research questions. Examples of teachers’ interview feedback are illustrated in Appendix 4-11.

The findings are discussed further in the next chapter.
Chapter 5

Discussion

5.1 Introduction

In this research, the data was gathered using a sequential mixed methods research approach. The data collection process started by conducting a teacher survey by using questionnaires that were self-administered to 153 secondary school science teachers in the central region of Malaysia. Then, the second stage of data gathering using email interviews commenced after the results of the survey were established. Based on EFA, it was suggested that the secondary school science teachers in the central region of Malaysia perceived their pedagogical beliefs and practices in regards to a BCC according to two dimensions: AESL and TTA. In order to discover more about the compatibility of teachers’ pedagogical beliefs and practices about BCCs, statistical analysis was conducted to unearth the relationship between their beliefs and practices. The effect of demographic factors such as age and teaching experience that influence their beliefs and practices were also investigated. Then, email interviews with eight participants were conducted with the purpose of examining certain aspects of the findings from the survey in detail.

In this chapter, all the findings from the quantitative and the qualitative data derived from this research are discussed. The discussion follows the four research questions with an integration of both the findings from the teacher survey and email interviews. In the first section, the discussion focuses on the BCC dimensions from EFA based on the science teachers’ pedagogical beliefs and practices. Then, the section continues by discussing the movement of items from the previous fundamental elements according to brain-based learning principles to the two new developed components identified from the factor analysis. In the following section, the discussion continues with
the feedback from the email interviews. The relationship between teachers’ pedagogical beliefs and practices regarding the two dimensions are described in the next section. Next, the chapter describes the differences in teachers’ feedback regarding their beliefs’ and practices in regards to a BCC according to demographic factors such as age groups and teaching experience. The last section summarises the chapter.

The following section discusses the two dimensions derived from factor analysis in Chapter 4.

### 5.2 BCC Dimensions

All the items designed in the questionnaire were adapted from other studies and also by using the 12 Brain and Mind Learning Principles suggested by Caine and Caine (1991) and Caine et al. (2005) as a guideline. Based on the questionnaire, 36 items in each BCC Beliefs and BCC Practices section were grouped equally into three fundamental elements of the principles: experience processing, relaxed alertness and enriched experience (see Figure 4.2). However, based on the EFA, secondary school science teachers in this study perceived their pedagogical beliefs and practices in regards to a BCC according to two dimensions: AESL and TTA. Further discussion occurs in the following section.

#### 5.2.1 Dimensions and elements in brain-based learning.

By comparing the current dimensions with the fundamental elements in the brain-based learning principles, it was discovered that the two dimensions perceived by the respondents were inconsistent from what has been outlined in the brain-based learning principles. Table 5.1 illustrates the comparison between the dimensions derived from the current study and the original elements suggested by the brain-based learning principles.
Table 5.1

*Dimensions from the Current Study and Elements from the Brain-Based Learning Principles*

<table>
<thead>
<tr>
<th>Dimensions from the Current Study</th>
<th>Elements from the Brain-Based Learning Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>AESL</td>
<td>Enriched experience</td>
</tr>
<tr>
<td>TTA</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td></td>
<td>Experience processing</td>
</tr>
</tbody>
</table>

As indicated in Table 5.1, the two dimensions derived from the current study are AESL and TTA, whereas the three fundamental elements proposed in the brain-based learning principles are enriched experience, relaxed alertness and experience processing. As mentioned in section 2.5.1, the three fundamental elements carry different interrelated aspects of classroom engagement on the basis of brain-based learning. However, based on the new dimensions, while AESL contains a set of instructions that suggest student-centred learning, TTA outlines a set of teaching techniques by adopting the traditional teacher-centred approach.

The first dimension of the science teachers’ pedagogical beliefs consists of 13 items that describe approaches to encourage students in learning. Conversely, the second dimension illustrates eight items that specified the utilisation of the traditional teacher-centred approach. The way the respondents in this study perceive the items can be related to how they perceive their teaching and learning process in a classroom context. All the items in AESL conceptualise a set of approaches that is more aligned towards the brain-based learning principles. The second dimension of eight items clearly emphasises the concept towards the application of the traditional teacher-centred teaching that is solely controlled by the teacher in the classroom. This suggests that the way they perceive their classroom instructions in this study can be divided into two: one which is aligned with
brain-based learning and the other one which is non-aligned or can be regarded as the traditional teacher-centred approach. Thus, while the three elements from the principles describe different but interrelated concepts of classroom engagement from the brain-based perspectives, the two dimensions that consist of two different, albeit related, constructs carries two different concepts. This indication demonstrates that the new dimensions from the current study are not aligned with the original elements in the principles.

So far, not many studies that investigate teachers’ beliefs and practices in regards to a BCC have conducted factor analysis. Thus, the emerging dimensions from the current study have no reference for comparison except for the brain-based learning principles. What can be done is to identify the pattern of the results from other related studies and make comparisons to the dimension from the current study. Based on research conducted by Klinek (2009), it was discovered that almost 50 per cent of her participants’ beliefs were aligned with the brain-based learning concept. This also indicates that another 50 per cent of their beliefs were in the opposite direction. While the overall feedback in Klinek’s study was not confirmed by using factor analysis, the pattern of the results reflectsthat part of the participants’ beliefs about classroom instruction were consistent with brain-based learning.

Thus, the result of Klinek’s study characterises the pattern of how the teachers as the participants in her study viewed brain-based learning. Comparing the results of the current study to the study by Klinek illustrates the same pattern with two contrasting situations: classroom instruction that is aligned with brain-based learning and classroom instruction that concerns the traditional teacher-centred approach. Although Klinek’s study took place in the United States and the current study took place in Malaysia, the general pattern of what the participants perceived about the BCCare comparable. The next section
delineates possible factors that influenced the emergence of AESL and TTA dimensions in the current study.

5.2.2 Factors influencing the emerging of the dimensions.

When the questionnaire was first developed for the teacher survey in this study, apart from using the brain-based learning principles as a guideline, the items were designed based on an adaptation of questionnaires from other studies conducted by Klinek (2009) and Morris (2010). However, none of those researchers had incorporated factor analysis in their data analysis. Therefore, the pattern of the dimensions perceived by the respondents in those studies was not known. Further, they did not have a picture of the association of the items designed with the respondents’ perspectives. As the questionnaire was adapted from those studies, this could be the reason why the dimensions perceived by the teachers in the current study were different than what has been outlined in the principles.

Another reason could be how the items in those studies had been designed. Even if those researchers used brain-based learning in designing the questionnaires, they did not design the questionnaires based on the three fundamental elements of the 12 Brain and Learning Principles by Caine and Caine (1991) and Caine et al. (2005). Klinek (2009) designed the questionnaire by integrating a multiple intelligence theory, cognitive learning theory, adult learning theory and theory of planned behaviour. Apart from adapting the questionnaire from other studies, the brain-based learning principles were also used by Morris (2010) as one of the guidelines in developing the questionnaire. However, the questionnaire was divided into categories, such as instructional strategies, classroom environment, emotions, curriculum, assessment, learning theory and discipline. This explains why the new dimensions are not consistent with the elements in the brain-based learning principles.
In particular, another factor that contributes to the mismatch between items in the original elements of the principles and the new dimension perceived by the science teachers was the failure of the researcher to conduct factor analysis during the pilot test. Even if an equal number of items were placed according to the elements in the principles, those items were not tested by using factor analysis in establishing the construct validity of the items. The importance of factor analysis has been mentioned by Gorsuch (1997), who highlights that ‘the purpose of factor analysis is to identify the fewest possible constructs needed to reproduce the original data’ (p. 533). Therefore, conducting factor analysis before the actual data collection can contribute to better outcome.

In reference to the questionnaire, several issues had also been found that might have influenced the emergence of the dimensions in this study. Among the issues is the use of negative items in the questionnaire. As mentioned previously in Chapter 4 (see section 4.4.1), there are altogether 14 items with negative statements in the questionnaire. While the purpose of having the negative items is to control acquiescent response biases in the research and to make sure the respondents read the answer carefully, having too many items with negative meanings is not effective. This has been confirmed by Sauro and Lewis (2011), who identified that three major potential disadvantages have been identified in alternating question items: ‘misinterpret, mistake and miscode’ (p. 3). In this study, the respondents may have misinterpreted the negatively worded items that led to lowering the internal reliability of the items. Further, the respondents may have mistakenly agreed with the statement when they meant to disagree. In the TTA dimension, it happens that all the eight items in the dimension carry a statement with negative meaning (tables 4.14 and 4.15 display all the items in TTA dimension for BCC Beliefs and BCC Practices). While the respondents may perceive the items according to the TTA dimension, it is also possible
that the negative items in the questionnaire may have also influenced the teachers’ feedback.

The emergence of the two dimensions could probably indicate how those teachers really perceive the items in the questionnaire. Based on factor analysis, the items that describe AESL were valued more than the items that explained TTA. This indicates that while those teachers perceived certain AESL as important, at the same time they were still putting their trust in certain TTA techniques. This also implies how those teachers perceive their classroom teaching, which could be related to their pedagogical beliefs and practices.

The next section describes the movement of items from their original elements to the new dimensions.

5.3 Movement of the Items

In order to discover more about the inconsistency between what was perceived by the science teachers and what has been suggested by the brain-based learning principles, all the 14 items in the first dimension, and the eight items from the second dimension, were compared based on two stages. The first stage of comparison is at the fundamental element level and the second stage is at the principle level of the brain-based learning principles.

At the fundamental element stage, the movement of items from the previous elements—enriched experience, relaxed alertness and experience processing—to the two new dimensions—AESL and TTA—were compared. Table 5.2 lists all the items in the new dimensions matched with the previous fundamental elements of the 12 Brain and Mind Learning Principles. Based on the table, out of 14 items in AESL dimension, six items came from enriched experience, five items from relaxed alertness and three items from experience processing. As illustrated in TTA, out of eight items in this dimension, four items were previously from experience processing and another 4 items came from relaxed alertness. None of the items came from enriched experience.
Table 5.2

Movement of the Items from Previous Elements

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension 1: Approaches to Encourage Student Learning</th>
<th>Previous Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Learning activities are best when involve the students’ senses</td>
<td>Enriched experience</td>
</tr>
<tr>
<td>04</td>
<td>Teachers should encourage students to share their ideas</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>08</td>
<td>Students’ potential can be increased by exposing them to variety of experience</td>
<td>Experience processing</td>
</tr>
<tr>
<td>09</td>
<td>Students’ interactions need to be encouraged in the classroom</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>10</td>
<td>Teacher guide students to deepen their understanding of the concepts taught</td>
<td>Enriched experience</td>
</tr>
<tr>
<td>12</td>
<td>Teachers help students understand a concept taught using meaningful themes</td>
<td>Enriched experience</td>
</tr>
<tr>
<td>13</td>
<td>Teachers need to pay attention to students’ emotions in classroom</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>17</td>
<td>Teachers need to relate the lessons to the students’ life experiences</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>21</td>
<td>The teachers’ attitude is an important influence on students’ learning</td>
<td>Experience processing</td>
</tr>
<tr>
<td>22</td>
<td>Students need to be given opportunities to reflect on what they have learnt</td>
<td>Experience processing</td>
</tr>
<tr>
<td>26</td>
<td>Using stories to teach new topics is not a waste of time</td>
<td>Enriched experience</td>
</tr>
<tr>
<td>31</td>
<td>Students need to be encouraged to have positive attitudes</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>32</td>
<td>A useful way of explaining new knowledge is to use analogies</td>
<td>Enriched experience</td>
</tr>
<tr>
<td>34</td>
<td>Students need to be taught according to their capabilities</td>
<td>Enriched experience</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimension 2: Challenges to Traditional Teacher-Centred Attitudes</th>
<th>Previous Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>06</td>
<td>It is important for students to keep their work confidential</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>07</td>
<td>It is important for the students to memorise what they have learnt</td>
<td>Experience processing</td>
</tr>
<tr>
<td>11</td>
<td>Students need to be punished when they fail to give correct answers</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>23</td>
<td>Students who talk a lot are problematic</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>24</td>
<td>Art has little relevance to science teaching</td>
<td>Experience processing</td>
</tr>
<tr>
<td>29</td>
<td>Criticising is a good way to motivate the students</td>
<td>Relaxed alertness</td>
</tr>
<tr>
<td>30</td>
<td>Teachers should choose a teaching strategy which is comfortable for them</td>
<td>Experience processing</td>
</tr>
<tr>
<td>33</td>
<td>The teacher should provide the same activity for all groups of students</td>
<td>Experience processing</td>
</tr>
</tbody>
</table>
By looking at the movement of items in Table 5.2, it seems that items from the enriched experience element dominated the AESL dimension with six items, followed by relaxed alertness with five items. This suggests that items related to enriching students’ exposure with a variety of activities and experiences (enriched experience) have been regarded as the most important by the science teachers in the dimension, followed by optimal emotional climate of learning (relaxed alertness). Conversely, since there are only three items from experience processing, this indicates that items related to consolidating what has been learnt in classrooms have been valued as less important by the science teachers in the AESL dimension.

Contrasted with the first dimension, none of the items from enriched experience element was found in TTA dimension. Conversely, experience processing items seem to be more valued as more items from this element appeared in the second dimension. Out of eight items in the dimension, four items came from relaxed alertness and another four came from experience processing. While items from relaxed alertness are considered equally important for both dimensions, items in experience processing element seem to be more important in the TTA dimension than the AESL dimension.

How the respondents perceived the importance of those items indicates that they were aware that these are among the important aspects in classroom instruction. While these are taken into consideration in their teaching and learning process, it is beneficial to know the type of principles that lie behind those elements. Thus, the next section discusses the second stage of the comparison where the items are compared at the principle level to know the specific concern of the teachers’ pedagogical beliefs about a BCC.

5.3.1 Principles of brain-based learning in dimension 1.

As was reported in the descriptive table (see Table 4.16 in section 4.5), the mean responses, $M = 4.39$, for the AESL dimension in BCC Beliefs demonstrates that the
average teachers’ responses towards the dimension was between ‘Agree’ and ‘Strongly Agree’. This highlights strong beliefs among secondary school science teachers towards the AESL dimension. Thus, it was revealed that secondary school science teachers have expressed their positive pedagogical beliefs towards the 13 items that describe AESL.

Table 5.3 illustrates the movement of the items from the fundamental element of brain-based learning principles to dimension 1, AESL. The items were grouped according to the elements and were matched with the principles of brain-based learning.

Table 5.3

<table>
<thead>
<tr>
<th>Enriched Experience</th>
<th>Brain-Based Learning Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Learning activities are best when involve the students’ senses</td>
<td>Principle 1</td>
</tr>
<tr>
<td>10 Teacher guide students to deepen their understanding of the concepts taught</td>
<td>Principle 4</td>
</tr>
<tr>
<td>12 Teachers help students to understand a concept taught using meaningful themes</td>
<td>Principle 4</td>
</tr>
<tr>
<td>32 A useful way of explaining new knowledge is to use analogies</td>
<td>Principle 4</td>
</tr>
<tr>
<td>26 Using stories to teach new topics is not a waste of time</td>
<td>Principle 6</td>
</tr>
<tr>
<td>34 Students need to be taught according to their capabilities</td>
<td>Principle 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relaxed Alertness</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>04 Teachers should encourage students to share their ideas</td>
<td>Principle 2</td>
</tr>
<tr>
<td>09 Students’ interactions need to be encouraged in the classroom</td>
<td>Principle 2</td>
</tr>
<tr>
<td>13 Teachers need to pay attention to students’ emotions in classroom</td>
<td>Principle 5</td>
</tr>
<tr>
<td>17 Teachers need to relate the lessons to the student’ life experiences</td>
<td>Principle 5</td>
</tr>
<tr>
<td>31 Students need to be encouraged to have positive attitudes</td>
<td>Principle 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience Processing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>08 Students’ potential can be increased by exposing them to a variety of experiences</td>
<td>Principle 12</td>
</tr>
</tbody>
</table>
As mentioned previously, in AESL, six items came from enriched experience, five items came from relaxed alertness and three items came from experience processing element. Based on the number of principles in the element, it shows that enriched experience and relaxed alertness have been perceived as more important than experience processing in affecting pedagogical beliefs. For the principle level, which builds the element, the items in the enriched experience element came from four types of principles of brain-based learning: principle 1, principle 4, principle 6 and principle 10. Item 1 was related to principle 1 (All learning is physiological), which explains the effectiveness of learning activities that involved senses such as smell, sight, touch, taste and hearing. Item 26 was associated with principle 6 (the brain/mind processes parts and wholes simultaneously), which concerns the importance of smaller parts of information for a big picture or ideas. Item 34 came from principle 10 (Learning is developmental), which describes learning that develops according to stages. Among the items, three items (item 10, item 12 and item 32) came from principle 4 (The search for meaning occurs through patterning), which describes the importance of patterning to make meaning of what is learnt in the classroom. Thus, out of all the principles, principle 4 seems to be dominating teachers’ pedagogical beliefs in the enriched experience element.

In relaxed alertness, the items only came from two types of principles: principle 2 and principle 5. Item 4 and item 9 came from principle 2 (The brain/mind are social), which describes the relationship between the brain and mind with the social aspect in learning. Three items (item 13, item 17 and item 31) came from principle 5 (Emotions are
critical to patterning), which explains the importance of emotions in how we make sense in learning and this justifies the importance of principle 5 in relaxed alertness element.

Three items were perceived as important under the experience processing element. However, each item came from different types of principles. Item 8 relates to principle 12 (Each brain is uniquely organised), which explains a unique difference among individuals. Principle 7 (Learning involves focused attention and peripheral perception), which describes the involvement of focused attention and peripheral perception in learning, is associated with item 21. Item 22 came from principle 8 (Learning is both conscious and unconscious), which delineates how learning takes place both consciously and unconsciously.

Overall, in this dimension, the fundamental element that describes enriching students’ experience and the optimal state of learning is considered more important than processing the learning experience. Moving further, teachers have expressed their positive beliefs about the importance of patterning to assist students to make meaning of what they have learnt. High exposure to a vast range of classroom activities may drive the students’ brain to create patterns that are subjective to their understanding. Indirectly, patterning will assist them to make meaning of what they have learnt. Moreover, teachers have also valued the relationship between emotion and patterning, which affects the process of making sense. Seen in this light, those teachers have demonstrated their positive beliefs towards students’ emotions, which could be related to the safe and engaging classroom environment. Since emotions are a useful indicator of how beneficial an environment is to our well-being (Damasio, 1999), teachers who had positive beliefs about the importance of students’ emotions promote a learning environment that is conducive to good social relationships between teachers and students.
The science teachers also realised the importance of social interaction in learning. Buster (2008), in research about brain-compatible strategies, revealed the effectiveness of socialising and interaction in teachers’ professional development. Even if the outcome of Buster’s research was related to teachers’ training, it shares a common attribute of a learning situation with classroom teaching and learning. Thus, the implication of Buster’s research can also be applied to other learning contexts, which includes secondary school classroom instruction.

Thus, it can be concluded that for the AESL dimension, teachers have expressed their positive pedagogical beliefs more towards the importance of patterning for making meaning, students’ emotions and social interaction in learning.

5.3.2 Principles of brain-based learning in dimension 2.

The descriptive statistics table (see Table 4.16) in section 4.5 demonstrates the mean responses for the TTA dimension, which is $M = 3.05$ for BCC Beliefs. This shows that the science teachers exhibit a wide range of responses from ‘Strongly Disagree’ to ‘Strongly Agree’ towards the TTA element. These complex responses were discussed in detail according to the items when they were matched with the principles of brain-based learning.

Table 5.4 illustrates the items in the TTA dimension that were grouped into elements and matched with the principles of the brain-based learning. All the items are worded negatively have concepts opposed to the brain-based learning principles.
Table 5.4

*Learning Principles in Dimension 2 (Traditional Teacher Attitudes)*

<table>
<thead>
<tr>
<th>Items</th>
<th>Brain-Based Learning Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>07 It is important for students to realise what they have learnt</td>
<td>Principle 9</td>
</tr>
<tr>
<td>24 Art has little relevance to science teaching</td>
<td>Principle 8</td>
</tr>
<tr>
<td>30 Teachers should choose a teaching strategy which is comfortable for them</td>
<td>Principle 12</td>
</tr>
<tr>
<td>33 Teachers should provide the same activity for all groups of students</td>
<td>Principle 12</td>
</tr>
</tbody>
</table>

*Experience Processing*

*Relaxed Alertness*

<table>
<thead>
<tr>
<th>Items</th>
<th>Brain-Based Learning Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>06 It is important for students to keep their work confidential</td>
<td>Principle 2</td>
</tr>
<tr>
<td>11 Students need to be punished when they fail to give correct answers</td>
<td>Principle 11</td>
</tr>
<tr>
<td>23 Students who talk a lot are problematic</td>
<td>Principle 3</td>
</tr>
<tr>
<td>29 Criticising is a good way to motivate the students</td>
<td>Principle 11</td>
</tr>
</tbody>
</table>

Based on the table above, four items were associated with experience processing and another four items were from the relaxed alertness element. Out of four items in experience processing, two items, item 30 and item 33, came from principle 12 (Each brain is uniquely organised). Another two items came from two different principles: item 7 came from principle 9 (There are at least two approaches to memory: Archiving isolated facts and skills or making sense of experience), which describes two types of memory in learning, and item 24 came from principle 8 (Learning is both conscious and unconscious).

The same pattern is illustrated in relaxed alertness element as two items, item 11 and item 29, came from principle 11 (Complex learning is enhanced by challenge and inhibited by threat associated with helplessness), which describes how challenge and threat affects learning. Item 6 is related to principle 2 (The mind/brain process parts and wholes
simultaneously) and item 23 is associated with principle 3 (the search for meaning is innate), which describes human beings as natural meaning-seekers.

As the above-mentioned principles were regarded as important, which affects teachers’ pedagogical beliefs about a BCC, it was discovered that items related to principle 12 and principle 11 dominated the TTA dimension. This indicates that the issues of acknowledging the differences among the students and challenging and threatening students are still dominating teachers’ beliefs and practices. In reference to the score of the mean responses towards the dimension, it was revealed that teachers have demonstrated complex responses in the issues of acknowledging commonalities as well as unique difference among the students. Moreover, complex responses have also been revealed in the areas of challenging and threatening the students. Above all, this indicates how certain TTA are still dominating teachers’ beliefs.

In reference to the current education situation in Malaysia, the inclination of relying on the use of textbooks in classroom instruction among science teachers (Mullis et al., 2008) may support the result. As teachers are predominantly utilising one single method in delivering the lesson, students’ preferred way of learning might have been trivialised. Consequently, teachers fail to acknowledge unique differences among the students (Caine & Caine, 2005), who display a variety of interests and preferences.

The use of textbooks can also be related to a boring situation that might have been experienced by the students. This has mentioned by Kegan’s (1996) model of learning (see Figure 2.1), which clearly demonstrates an association between balance and support, which affects learning. Consequently, teachers have been regarded as providing insufficient challenges for optimal learning to take place.
5.3.3 Summary.

The two dimensions (dimension 1: AESL, dimension 2: TTA) derived from factor analysis were analysed according to the fundamental elements of the brain-based learning principles. It was revealed that teachers perceived fundamental elements such as enriched experience and relaxed alertness as more important in the AESL dimension. However, the experience processing element, which is related to reflecting what is learnt, was regarded as more important in the TTA dimension.

As the teachers in this study showed complex pedagogical beliefs towards this dimension, three items from the teacher survey were selected for further investigation and are discussed below.

5.4 Feedback from the Interviews

Based on the results of the teacher survey, three questions were developed from each of the selected items (item 30, item 11 and item 29) for email interviews with eight participants (see section 4.13, which demonstrates the results of the email interviews). The following sections contain a discussion of how those participants viewed the three items, which described their pedagogical beliefs.

5.4.1 Reflection on the responses: Item 11.

Based on item 11, the following question was asked to the participants in the email interviews: ‘Most teachers disagree with punishing students if they fail to give correct answers. Why do you think this is so?’ In the teachers’ feedback in section 4.13.1, they have suggested their role as a guide as opposed to punishing the students in classroom. Moreover, they clearly demonstrated their disbelief in punishment by outlining its negative effect on the students. Themes and examples of responses for question 1 are presented in Table 5.5.
Table 5.5

*Examples of Responses According to Themes for Question 1*

<table>
<thead>
<tr>
<th>Theme</th>
<th>Teacher as a Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If they make mistakes, correct them there and then, so they realise their mistakes, relate to the correct answers and they will remember the correct answer as well (Female B aged more than 50)</td>
</tr>
<tr>
<td></td>
<td>I like a relevant response from the students even if it doesn’t really follow the answer scheme set by the teacher. It shows the students are thinking about the questions (Female A aged 41 to 50)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theme</th>
<th>Fear of Making Mistakes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students who were punished will probably not answer more questions for fear that they would make another mistake and be punished again (Female C aged 31 to 40)</td>
</tr>
<tr>
<td></td>
<td>Punishment creates unnecessary fear in the students (fear of saying something/fear of trying to answer any more questions (Male aged 41 to 50)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theme</th>
<th>Embarrassment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students’ lack of confidence due to chance or opportunity not given (Male aged more than 41 to 50)</td>
</tr>
<tr>
<td></td>
<td>Students who were punished will probably not answer any more questions due to embarrassment (Female C aged 31 to 40)</td>
</tr>
</tbody>
</table>

While the majority of teachers would prefer ‘guiding’ rather than ‘punishing’ their students, they specify the role of a teacher as guiding students to get the right answer rather than focusing on finding ways to think about how to solve the problem and find the answer. Their responses also provided evidence that they were aware of the consequences of punishment and the effects it could have on the students’ progress. Without having any formal introduction to the relationship of emotion and learning, this group of teachers were sensitive to the negative effect of punishment. As a group, they argued against responding to students in this way. Seen in this light, the participants have depicted explicitly how they are trying to step away from their authoritative role in classroom to be more approachable educators who see themselves as a guide with the right to advise students.
rather than punishing them. This was why the majority of the participants justified their disagreement with the statement and are compatible with being brain-friendly.

Further, the participants highlighted two types of guidance: 1) guiding the students to get the right answer and 2) guiding them to think about the answer. This discloses further what was meant by those teachers about their role in the classroom. While guiding to get the right answer is an approach that is more aligned with being teacher-centred, guiding students to think about the answer suggests the application of student-centred classroom instruction as it initiates an inspiring two-way communication between teacher and students (Shor, 1992). Initially, the importance of social communication in the classroom is acknowledged by Caine et al. (2005, p. 3) in principle 2 of the brain-based learning that states: ‘the brain/mind is social’. Supporting the results of the survey, social communication is also highlighted as among the important aspects perceived by the teachers in the AESL dimension (see section 5.3.1).

In describing their role as a guide, those teachers were also concerned about students’ emotions and feelings that were essentially related to fear, embarrassment and lowering their confidence levels. The participants in their feedback acknowledge their disagreement with the statement deliberately expressing the word ‘embarrassment’, fear and lack of confidence. This suggests that they are aware of the effect of punishment on the students’ emotion and understand how demotivating it can be to a student trying to find the right answer. The negative effects of punishment are mentioned by Caine et al. (2005, p. 3) in principle 11—while challenge initiates learning, punishment triggers a threat that affects students’ emotions, threatens their feelings and impairs the learning process. As well as feeling threatened, punishment triggers a stressful situation among the students (Caine et al., 2005). Sapolsky (1998) argues that while moderate amounts of stress will release a hormone to help in the learning process, a stressful situation will result in too
much hormone being released continuously and this negatively affects the brain, body and immune system. Thus, emotional instability as a result of punishment will lead to excessive stress, which contributes to learning impairment among the students.

As mentioned previously in the principles of brain-based learning, Caine et al. (2005) claim ‘emotions are critical to patterning’ (p. 3) and patterning is their term for ‘making meaning.’ Thus, negative emotions can be considered distracting students’ minds from making meaning from what is learnt and leading to students who are emotionally disengaged from the learning environment. Above all, teachers showed that they were trying to relate challenge and threat in learning to the social and emotional aspect of learning, and these were also among the main concerns in the AESL dimension.

Put differently, Lewis, Romi, Qui, and Katz (2008) have reported that students saw more punishment carried out than what the teachers believed had occurred. It shows that what the teachers thought of as a non-punishment act could be translated as punishment by the students. Moreover, Lewis, Romi, and Roache (2011) stressed the higher the expected number of misbehaving students perceived by the teachers, the higher the chances punishment-related actions will occur. Even if the sort of punishment that has been reported by Lewis et al. (2008) is specifically applied to classroom management and not related to pedagogical aspects specified in this study, the complexity of the classroom environment (Duffy & Anderson, 1984) and teachers’ coping strategies for students’ misbehaviour (Lewis et al., 2011) may trigger the punishing act to happen regardless of the situation.

Despite the fact that the notion of teacher-centred approaches are still dominant in school settings, these teachers’ disagreement with the punishment specified in this study and their claim to be guides who help students think provides significant evidence of their beliefs about using approaches that are aligned with a BCC.
5.4.2 Reflection on the responses: Item 30.

The participants in the email interview were asked the following question for item 30: ‘The majority of teachers thought that teachers should choose a teaching strategy that is comfortable for them. What is your opinion about this from your own and the students’ perspectives?’

Based on the question asked, the participants expressed a range of responses to the issue of choosing teaching strategies, with many claiming that a critical issue in this selection was the students’ acceptance (see section 4.13.2). This was clearly opposite to the teachers’ responses in the survey, where they believed they needed to teach according to their comfortable teaching strategy. Research by Caine et al. (2005), as presented in Chapter 2, argues that the teachers need to forget their own needs when selecting appropriate strategies, but consider what sorts of learning experiences will be best for the topic and for the students’ academic and social levels. In this question, it was interesting to note that the teachers considered the students’ preferences as most important, in contrast with what they reported in the teacher survey.

However, even with the term ‘students’ preferences’, it is not clear to what extent the teaching process follows the students’ inclination since each individual student is unique and different. In fact, each of us has our own preferences. Thus, in order to acknowledge the differences among the students, teachers should not stick to just one comfortable teaching strategy. Instead, they should explore all appropriate techniques available to enable learning to take place with whole-brain engagement, as discussed in section 2.4.3. It is possible that the focus on student acceptance of how they are taught hides the teachers’ own dislike of attempting new strategies, or teaching the students how to learn, although there has been not have enough evidence to make this claim. Examples of responses under each theme are outlined in Table 5.6.
Table 5.6

Examples of Responses According to Themes for Question 2

<table>
<thead>
<tr>
<th>Theme 1</th>
<th>Students’ Ability, Interest and Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teaching technique must be according to the students’ interests as they may have different understandings to the teachers (Female D aged 20 to 30)</td>
</tr>
<tr>
<td></td>
<td>Students would love to be involved in planning the lesson with the teacher, as they would feel close to the selected approach (Female F aged 41 to 50)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theme 2</th>
<th>Teaching Confidently and Effectively</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>It is very important that teachers should feel comfortable with their teaching strategies so that their teaching will be effective and genuine (Female G aged 41 to 50)</td>
</tr>
<tr>
<td></td>
<td>Teachers like to choose the most appropriate and easiest way of teaching in the classroom (Female A aged 41 to 50)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theme 3</th>
<th>Suitable Strategies for Teacher and Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A teacher cannot rely solely on their comfortable teaching technique. Students’ acceptance should be taken into consideration (Female B aged more than 50)</td>
</tr>
<tr>
<td></td>
<td>Teacher should not choose a teaching strategy that is suitable for them without taking students into consideration (Female F aged 31 to 40)</td>
</tr>
</tbody>
</table>

Comparing the results between the two forms of data, the survey and the email interviews, there are discrepancies in the responses regarding the important issue in choosing a comfortable teaching strategy. In the survey, teachers said they need to be comfortable, but in the interviews they claimed that students need to be comfortable. However, the brain theory argues that it is not comfort that is the main consideration in choosing a teaching strategy. What matters is a strategy that will engage all students regardless of their academic level and one that is appropriate to the topic. But here again, what is interesting is that it reveals that the survey responses about the belief regarding comfortable teaching strategy did not match with the claims in the email interviews.

Previous scholars have argued about the complexity of a classroom life as a contextual factor that influences teachers’ pedagogical beliefs, which results in a disconnection between teachers’ beliefs and their practices (see section 2.6.3). What was
written in the email interviews can be regarded as stated beliefs and there is no clear evidence of their practice. Thus, what other researchers have argued about the complexity of classroom life may have also affected what teachers said they believed in the survey. While teachers have demonstrated their stated pedagogical beliefs in the survey that they should teach according to their preferred teaching strategy, the inconsistency of what actually happens in the classroom may influence their beliefs. Further, this may also happen when they are given more opportunity to express what they had in their mind, as in the email interviews. Thus, teachers’ beliefs about comfortable teaching strategy as stated in the survey and the email interview did not match, probably due to the inconsistency and complexity of classroom life.

Another possibility is that the participants in the email interviews were provided with data from the survey and this may have influenced their responses by focusing their concern more towards students’ rather than teachers’ acceptance of the teaching strategy. However, even if part of the participants’ interview feedback deliberately probed their beliefs about teaching approaches aligned with a BCC, the overall feedback from the teacher survey demonstrates the complexity of their responses. This may well represent the beliefs of secondary school science teachers in the central region of Malaysia and their lack of familiarity with BCC instruction. Their limited responses to this question about teaching strategies may reflect a commonly held understanding of what teaching is about, a lack of knowledge about a wide range of possible teaching strategies and/or it may indicate that they have not been exposed to the idea of brain-compatible learning.

5.4.3 Reflection on the responses: Item 29.

Based on item 29, the participants were asked the following question in the interview: ‘Why do you think criticism is a useful way to motivate the students? (Why/ Why not?).’
Regarding the participants’ feedback from section 4.13.3, they demonstrated that
the type of criticism that they were keen on was constructive criticism that could be an
effective way of motivating students. From the feedback, it can be concluded that the
respondents held the belief that is common among secondary school science teachers that
teachers’ constructive criticism is valuable and can be another option for motivating the
students. This suggests why the mean of teachers’ responses that agreed with the statement
(item 29: ‘Criticising is a good way to motivate the students’) is slightly higher than those
who disputed it.

Like punishment, criticism is also regarded as a kind of threat that prevents
learning. It affects individual’s emotions as a result of embarrassment that lowers one’s
level of confidence. Conversely, criticism referred to by the participants was interpreted by
them as constructive criticism that is able to challenge the students to induce learning.
Examples of participants’ responses are demonstrated in Table 5.7.

Table 5.7
Examples of Responses According to Themes for Question 3

Using Constructive Criticism
Criticism can motivate the students if it means correcting mistakes step by step to achieve
the desired objective (Male aged 41 to 50)
Students will feel challenged and take an initiative to change to prove to the teachers that
they can perform better (Female C aged 31 to 40)

Using Destructive Criticism
Criticism can be bad if students cannot take it positively. This will lead to discouragement
(Female aged 31 to 40)
Destructive criticism can demoralise the students if language used is not appropriate in
pointing out their mistakes (Male aged 41 to 50)

Significantly, in delineating an effective way of utilising constructive criticism, the
participants took a stand in considering all the precautions to avoid inappropriate action or
behaviour that leads to destructive criticism. Moreover, those teachers expressed their
conscious feeling in differentiating between constructive and destructive criticism. Significantly, they expressed beliefs that are congruent with the argument about preventing classroom threat by using non-judgemental feedback.

However, careful consideration should be given to understanding to what extent feedback can be considered ‘constructive’ enough to motivate the students. This is important because sometimes what the teachers thought was constructive may be regarded as destructive from the students’ viewpoint. Moreover, there is no procedure in the Malaysian context to specify how such comments should be correctly articulated and thus it is a very subjective issue for every individual. This is especially relevant to students who are highly sensitive to criticism. Atlas, Taggart, and Goodell (2004) claim that teachers should be aware of students who may respond emotionally upon criticism and may withdraw from their classroom activities. Moreover, they further suggest the use of positive reinforcement instead of punishment. Coincidently, the idea of using constructive criticism from the participants’ feedback seems to be compatible with what has been suggested by Atlas et al. (2004).

The element of sensitivity should also be the main focus in criticising the students, especially with students in Malaysia. Malaysians are bound by Eastern culture, especially the Malay cultural background. People of Eastern culture are very sensitive to criticism, even if it is for the purpose of correcting mistakes (Park, 2010). In the feedback, the participants have indirectly hinted at the cultural factor by mentioning avoiding the use of harsh words in criticising the students. Above all, participants have suggested criticism should be constructive, as they indicate their awareness of the implications criticism has for the students and how it should be given according to the context in which the students are working; this is aligned with a BCC.
Overall, further investigation through email interviews revealed that even if the items were about the TTA, teachers’ feedback indicated beliefs aligned with a BCC. However, discrepancies were demonstrated with certain issues, especially related to teachers’ comfortable teaching strategy. Thus, these three issues should be investigated further in other research, as is discussed in the conclusion chapter.

5.4.4 Summary.

Analysis of the feedback of teachers’ email interviews revealed part of their beliefs were aligned with a BCC. Teachers saw themselves as a guide as opposed to punishing the students. They clearly suggested the implications of punishment on students’ emotions. In terms of criticism, the teachers had beliefs about constructive criticism. They distinguished between constructive and destructive criticism. In a comfortable teaching strategy, teachers demonstrated that they were focusing more on students’ preferences compared to teachers preferred way of teaching; this is non-aligned to what has been reported in the survey.

The following section describes the relationship between teachers’ pedagogical beliefs and practices from the context of a BCC.

5.5 Relationship Between Belief and Practice

Section 4.6 illustrated the results of correlation analysis between teachers’ pedagogical beliefs and practices for both dimensions. In focusing on the relationship between beliefs and practices towards the dimensions, it was discovered that secondary school science teachers’ pedagogical beliefs about the BCC dimensions were strongly correlated to their practices. By comparing the two dimensions, the TTA dimension demonstrated a higher and stronger relationship between teachers’ pedagogical beliefs and practices, followed by the AESL dimension. Essentially, while acknowledging the importance of approaches that engaged students in learning, this finding clearly indicates
that certain traditional teacher-centred approaches are still influencing teachers’ pedagogical beliefs that significantly affect their classroom practice.

The relationship between teachers’ beliefs and practices have been mentioned in another study by Gunningham (2006), which focused on the role of a mathematics teacher in the classroom. It was reported that the overall responses from the questionnaire showed little difference between the teachers’ beliefs and their matched practices. Thus, the result shows evidence of the teachers’ beliefs that had been applied in their classroom practices. However, after the data of the two schools were viewed separately, surprisingly, a difference was discovered between the teachers’ beliefs and their actual classroom practice. The findings of the study ultimately revealed that teachers are aware of the important factors for effective teaching and learning but do not translate them into their own classroom practice due to certain factors. However, what needs to be stressed here is that Gunningham made a case study with only six teachers from two different schools and the questionnaires employed in the study only reflect the feedback from those teachers. Further, the result of Gunningham’s study was solely based on the description at the item level and no other statistical analysis was undertaken to ascertain the result. Thus, according to Cohen (2007), the result was not considered generalisable as it did not meet the typicality of the situation such as participants and settings.

The results from Gunningham (2006) and the current study support the complexity of the relationship between teachers’ beliefs and their practices, which varies between very consistent to very inconsistent, and this has been mentioned by Readence et al. (1991) in Chapter 2. Even though the current study demonstrates a strong relationship between teachers’ beliefs and practices, certain factors were thought to have influenced the result of the study. Among these, the technique that was used to collect the data may have influenced the relationship between belief and practice. In this study, the relationship
between teachers’ beliefs and whether or not their beliefs had been translated into their practices was investigated by using a single method, a teacher survey. Thus, the result of the study, which demonstrates a strong correlation, was only regarded as between teachers’ stated beliefs and self-reported practices in regards to a BCC, confined to the study.

Also related to the current findings, Klinek (2009), who made a survey to discover participants’ knowledge, beliefs and practices about brain-based learning, reported a significant, strong positive relationship between teachers’ knowledge and beliefs and teachers’ knowledge and practice among educators. Both the current study and Klinek’s findings demonstrate a strong positive relationship regarding teachers’ beliefs and their practices in relation to classroom instruction. Klinek (2009) concludes his research by suggesting that by being given substantial knowledge about BCC theory, teachers would have proved a positive strong relationship between the knowledge and the belief as well as the knowledge and the practice in the theory. However, in the current study, teacher belief has been regarded as more important compared to knowledge, which influences the respondents’ classroom instruction (Kagan, 1992; Pajeras, 1992; Tobin et al., 1994). Thus, it has been affirmed that, being given an appropriate and sufficient exposure of BCC approaches to the science teachers, they may have expressed positive beliefs upon the approaches and utilised the beliefs in classroom practice. Thus, Klinek (2009) argues that while the participants demonstrated that only part of their beliefs were related to brain-based learning, the relationship between the belief and the practice was indicated to be strong. From the current study, a very strong relationship between belief and practice of the TTA dimension shows that the beliefs about TTA among secondary school science teachers had strongly influenced their classroom instruction.

The following section describes the demographic factors that influenced teachers’ pedagogical beliefs and practices in relation to BCC.
5.6 Factors Influencing Beliefs and Practices

As mentioned in section 4.2, only teaching experience and age groups were taken into consideration to discover the difference in teachers’ pedagogical beliefs and practices in regards to a BCC. In reference to the feedback from participants in this study, examining the two dimensions in detail, different pattern of responses from the respondents indicate different levels of pedagogical beliefs and practices among the science teachers. Higher and very positive responses were reported from the respondents, especially the senior science teachers aged more than 40 years, regarding their beliefs and practices towards the AESL dimension. The responses indicate those teachers’ pedagogical beliefs and practices upon the researched approaches were highly aligned with the BCC specified in this study. This finding again supports what has been reported by Krummick (2009) about the evidence of certain brain-based techniques being employed in the classroom even if there was no evidence of those approaches being taught in the teachers’ professional development.

The result of the current study could also be associated with what has been suggested by Morris (2010) about an intuitive practice of brain-based strategies during classroom instruction. Even though Morris reported that elementary teachers applied more of the surveyed brain-based practices than the middle and high school teachers, regardless of teachers’ teaching level, there was still evidence of the brain-based approach being utilised in the classroom; this supports the current findings of this study. The scenario presumed for the current study and the study undertaken by Krummick was that those teachers may not know about the theoretical aspects of BCC but may have espoused the beliefs about the application of the theory intuitively and realised them in their classroom practice. Thus, the findings may add to the justification that teachers may have applied the
classroom instructions that they thought work effectively without a clear rationale of their actions by practicing them intuitively (Thomas, 2008).

Regarding the TTA dimension, surprisingly, higher responses were also demonstrated by the same group of senior science teachers compared to their junior counterparts. Even though the responses by those teachers is not as high as with the other dimension, this has given more than enough indication that the same group of senior teachers also expressed their positive beliefs towards the TTA dimension. Moreover, the result also indicates that those teachers had realised the beliefs in their classroom practices. This finding is again aligned with the research of Krummick (2009), who reported that science teachers were among the subject teachers who least applied the brain-based approach in the classroom. Even if those teachers may have adopted other techniques in their science teaching rather than brain-based learning, in that study, Krummick assumed that those teachers had been using TTA more in their teaching. This was supported by Klinek (2009), who discovered a below average use of brain-based learning application in classroom teaching by referring to the scores reported by college educators, although the result was not specific to science educators. Even if the feedback from the email interviews reflects different (criticism was regarded as constructive criticism and the teacher as a guide as opposed to punishing the students), that applies to the two items specific for the interviews only.

There has been a complexity in the results of the study, which demonstrates how senior teachers expressed positive beliefs in both sets of approaches, which were both aligned and non-aligned with the BCC instructions specified in this study. However, this indicates that they may have strong positive beliefs about certain strategies that reflect BCC approaches and at the same time espouse beliefs about part of TTA. This further explains that those senior teachers may have beliefs about certain approaches that they think works
effectively for their students based on their long experience as a teacher. At the same time, even if they know about new approaches, they may still want to employ certain teaching techniques that they are comfortable with and that they think could help the students in the classroom, even if it means utilising TTA.

Conversely, the results also indicate the negative beliefs and practices towards the TTA dimension by junior teachers. Slightly lower than the senior teachers’ mean score, the junior teachers also demonstrated their positive beliefs and practices in AESL. This finding indicates that young teachers, especially from the schools in the most developed regions in Malaysia, may have been exposed to different kind of sources, including the use of ICT, and thus challenge themselves to employ different kinds of teaching approaches. This could be among the reasons, as Lau and Sim (2008) have reported that young science and mathematics teachers in Malaysia have higher competency in ICT compared to their senior counterparts. This was further supported by Smerdon et al. (2000) from the United States National Centre for Education Statistics, who declared that young teachers who have greater exposure to the use of computers and the internet indirectly upgrade their skills, especially in pedagogical aspects.

By looking at other demographic factors, apart from the teachers’ age groups, experienced teachers who had been teaching for more than 10 years also expressed their positive beliefs towards the TTA dimension, but there was no significant evidence of practicing the beliefs in the classroom. Thus, the influence of teachers’ teaching experience towards the belief and practice of the BCC dimensions was not clearly expressed by the science teachers when compared to teachers’ ages. Based on the previous studies by Klinek (2009) and Krummick (2009), there was no significant relationship between brain-based learning application in the classroom and teacher’s demographic factors such as teaching experience; these support the result of the current study.
Above all, while the science teachers in this study were assumed to not have been exposed to BCC theory, this study provided complexity in the result, especially with regard to the senior science teachers. They indicated positive pedagogical beliefs about instructions that were aligned and not aligned with a BCC and realised the beliefs into their classroom practice. This substantiates that this group of teachers had beliefs about certain approaches that were related to a BCC. At the same time, certain traditional teacher-centred techniques were still dominant as their pedagogical beliefs and practices. This study also demonstrates a strong and positive relationship between the belief and the practice of TTA specific in this study.

5.7 Reflection on the Results

The analyses show that secondary school science teachers from the central region of Malaysia demonstrated two kinds of dimensions that influenced their pedagogical beliefs and practices regarding the BCC specified in this study. The first dimension describes AESL and the second is related to TTA. By comparing the two dimensions with the three initial elements in the brain-based learning theory (relaxed alertness, enriched experience and experience processing), it is clearly demonstrated that what the science teachers perceived about a BCC is distinct from what has been stated in the theory. In fact, they have created two different dimensions that carry two different sets of classroom instruction. Even if the AESL dimension reflects BCC instructions, the TTA dimension clearly suggests the opposite concept of brain-based learning theory.

The result of the current study is aligned with the findings obtained by Klinek (2009), who contends that educators in the study had insufficient knowledge, especially of the theory and concepts about brain-based learning. The current findings also support the suggestions made by Morris (2010) that those teachers may not have been trained in this approach and, therefore, are not familiar with the classroom instruction associated with the
concept or theory of BCC. Thus, this justifies the way they perceive the items in the questionnaire, which is distinct from what has been illustrated in the theory. In fact, the two dimensions derived from the teachers’ perspectives can be described as located in two different continua: AESL contains items that portray BCC instruction, whereas TTA comprises a list of items that mirror TTA and are clearly non-aligned with the theory.

Among other factors that contribute to the findings were those related to the contextual issue, which includes culture and religion. The theory has been developed in the United States and most of the research undertaken in testing the theory involved teachers or participants from that country. While all the techniques in the brain-compatible approach may be well accepted in Western countries, it could be a different story for the Asian people who have different cultural backgrounds and religions, for example, Islam, as their way of life. Thus, certain techniques that were labelled as non-aligned with a BCC may work effectively among the teachers and students who adopt the Eastern culture in their classroom instruction. One example is memorising in learning. The science teachers in this study demonstrated a high mean score ($M = 4.00$) for the item that described the importance of memorising (item 7), which indicates their strong beliefs towards memorisation in learning. While memorisation is always associated with rote learning, in Islamic education, memorisation of the Qur’an is regarded as the first step in understanding (Boyle, 2006). The justification is that memorisation can lead to understanding (Bouzoubaa, 1998).

Even though the national schools in Malaysia follow the secular Malaysian educational system, they only offer Islamic education as one of the subjects taught in schools and the influence of its teaching approach may well change the way teachers teach in the classroom. While much of the criticism about traditional Islamic education focuses on its emphasis on memorisation, the effectiveness of this technique in Qur’an learning has
probably been seen as applicable to learning other subjects beyond the religious. Boyle (2006) gives an example of how parents, teachers and students in Yemen believe that memorising the Qur’an helped students to do well in Arabic language. In fact, recently, due to high demand from parents, a higher number of Islamic schools have been established in Malaysia offering a range of Islamic subjects with other core subjects in the curriculum standard outlined by the government. The same scenario occurs with Chinese people in Malaysia in demonstrating their beliefs about the effectiveness of memorising in learning mathematics (Sam, 2002). Thus, memorising in learning probably works effectively in classroom teaching and learning for certain cultures, such as among teachers in Malaysia.

Experience processing, which indicates reflection of the content material learnt in classroom, is not considered important, which influences the Malaysian science teachers’ pedagogical beliefs. This is evident through the pattern shown by the fundamental elements that consist in both dimensions. In this sense, the system has influenced Malaysian teaching towards examination-oriented approaches (ASM, 2012), and not giving enough time for the students for reflection supports the pattern. While a variety of activities and challenges as well as a conducive learning environment are important, sufficient time for the students to process the learning materials learnt is crucial for whole-brain learning.

The overall results of the current study are illustrated in Figure 5.1. Based on the diagram, the shaded area between the TTA and AESL dimensions refers to the senior teachers’ pedagogical beliefs and practices in regards to a BCC in this study. The relationship between science teachers’ pedagogical beliefs and practices of the dimensions is highlighted with a brown arrow.
Figure 5.1: A brain-compatible classroom: Teachers’ pedagogical beliefs and practices.

The two-dimension model of a BCC in this study could be applied to other contexts with similar characteristics of the study, albeit partly aligned with brain-based learning principles suggested by Caine et al. (1991) and Caine and Caine (2005). The model represents what the secondary school science teachers in the central region of Malaysia perceived within their limited knowledge about a BCC. This may also give a general picture of how secondary school science teachers in the central region of Malaysia classified their classroom instruction. Experiencing various techniques and approaches that have been exposed before and during their teaching services, they would likely generalise the teaching techniques into two different continuums—that is, the traditional and the non-traditional teacher-centred approach—based on their understanding. Therefore, even though the current research was conducted in Malaysia, the model identified in this study could be applied to other research contexts where the participants share the same level of knowledge about a BCC.
Based on the overall findings, besides a positive indication of teachers’ beliefs and practices about BCC approaches, TTA was also the centre of their beliefs and applied by those teachers (Hassan & Heywood, 2012). These complex findings demonstrate their insufficient knowledge about a BCC that influenced their beliefs and practices. However, regardless of the knowledge about brain-based learning principles, those teachers were probably utilising the techniques they thought worked better for effective classroom teaching without realising that those techniques were aligned with a BCC. In other words, the compatibility of the teachers’ pedagogical beliefs with a BCC would likely be due to the reason of what works effectively based on their experience, without a clear understanding of the theoretical aspect that lies as the foundation of this approach.

In an effort to influence teachers’ pedagogical beliefs according to a BCC, it would be supportive if teachers were exposed to an adequate amount of knowledge about the human brain and its functions. But here again, an issue could be raised: Is it important for the teacher to know all about brain functions in order for them to teach effectively? Combining what has been mentioned by Caine and Caine (2005) and Jensen (2008), it has been acknowledged that as a natural seeker, humans seek patterns and meaning in what we are doing. The reason is not just to know why we do what we do, because what teachers do in a classroom is more than knowing. It is about being able to understand deliberately the reason of what they are doing in their classroom practice. It is also about getting the whole picture of what it takes for effective learning. Seen in this light, teachers’ acceptance regarding the brain-based learning principles would be easier, as it reasons out their classroom instructions from the theoretical aspect. It would also be more interesting to learn about the theory because it is related to instructions that have been utilised intuitively in classrooms. Moreover, if that is considered interesting, the teachers may express a strong desire to practice the approach, as they can associate what they are doing with the
knowledge underpinning the approach. At the same time, other BCC approaches that are considered uncommon in their classroom practice could also be integrated during in-service teacher training or professional development. As a result, there would be no more complaints that teachers are too busy to think of another so-called ‘new teaching technique’, because all what we have here is not extra at all. It is the truly engaging and effective way of teaching and learning, derived from how the brain is naturally designed to learn (Jensen, 2006, 2007).

In associating the BCC with teacher beliefs and practice, Freeman and Freeman (2001) claim that if teachers’ beliefs about learning change, they will change the way they teach. Ultimately, Nespor (1987) and Pajares (1992) indicate that beliefs can change. Nespor (1987) further contends that it is not argument or reason that changes the beliefs but rather a conversion process or Gestalt shift. Thus, the existing beliefs need to be challenged, or if the individuals are dissatisfied with their existing beliefs, then the beliefs are prone to be changed (Posner et al., 1982). In this context, if we are able to change teachers’ pedagogical beliefs about classroom instruction according to brain-based learning principles, they are highly likely to change the way they teach the students. This has been further supported by Prawat (1992), who argues that teachers are the most powerful agents in revising classroom practices. Thus, in order to be successful in changing teacher beliefs through a professional teacher development programme, Kagan (1992) deploys the argument that:

It must require them to make their pre-existing personal beliefs explicit; it must challenge the adequacy of those beliefs; and it must give novices extended opportunities to examine, elaborate, and integrate new information into their existing belief systems. (p.77)
In reference to the current study, the main objective is to elucidate teachers’ preexisting personal pedagogical beliefs of a BCC and to ascertain whether or not their beliefs have been realised into their classroom practice. Even though the efforts in changing teachers’ beliefs are not included as the objectives of the current research, it is believed that the statement proposed by Kagan (1992) will be useful later for further research, regardless of the outcome of this study.

In reference to the 2013 to 2025 Malaysian Education Blueprint, it has been the government’s aspiration to focus on higher-order thinking skills among students, especially in science education. Seen in this light, a BCC can be used as one of the mechanisms to promote these skills. Nonetheless, considering the appropriateness and suitability to the local context, the objective is not solely a BCC. What is more important is a transformation of classroom instruction from a conventional, rigid and narrow scope of teaching to a more open, engaging and challenging classroom environment.

5.8 Summary

This chapter discussed the results of the study that derived from the teacher survey and email interviews among secondary school science teachers from the central region of Malaysia. Based on the findings, teachers demonstrated complex pedagogical beliefs in regards to AESL and TTA. Teachers demonstrated stronger beliefs towards certain approaches that are aligned with a BCC. However, they are still adopting certain techniques related to TTA and this has been influenced by other factors, such as contextual factors. Since the association between belief and practice is very strong among the teachers in this study, it is believed that the knowledge-based beliefs adopted by these teachers could be changed by exposure to BCC concepts for a truly engaging classroom environment.

The conclusion of this study is presented in Chapter 6.
Chapter 6

Conclusion and Implications

6.1 Summary

This research was conducted with the main purpose of investigating pedagogical beliefs and practices in regards to a BCC among secondary school science teachers in the central region of Malaysia. The drive to focus on this scope of research arose because the teacher-centred approach in classroom teaching is dominantly utilised by secondary school science teachers in Malaysia. Indirectly, this affects students’ interest and achievement in science subjects. Established from neuroscientific findings, brain-based learning has been identified as an effective approach that is different from traditional teacher-centred classroom instruction. Most of the empirical studies in classroom settings that test the approach have shown positive effects in terms of motivation and students’ achievement, and this includes students from Malaysia. Thus, in order to train these teachers effectively in the future, it was essential to determine their current pedagogical beliefs that might be compatible with the approaches, and to ascertain how far they had realised their beliefs in their classroom practice.

Impressed by the natural whole-brain engagement in classroom instruction from brain-based learning, the 12 Brain and Mind Learning Principles suggested by Caine and Caine (1991) were included in the conceptual framework of this study. This study was designed mainly to obtain general feedback from secondary school science teachers in the central region of Malaysia in terms of their stated pedagogical beliefs and self-reported practice in regards to a BCC. The term BCC was applied throughout the study because it was concerned with the application of brain-based learning approaches in classroom settings.
A mixed methods research with sequential explanatory design was adopted in this study, consisting of quantitative (teacher survey) and qualitative (email interviews) methods in generating the data. A survey was conducted with 153 secondary school science teachers in the central region of Malaysia to receive general feedback according to the research questions. The questionnaire was designed according to the brain-based learning principles suggested by Caine and Caine (1991) and Caine et al. (2005) and was also adapted from other questionnaires such as Klinek (2009) and Morris (2010) in previous research. Then, email interviews with eight participants were conducted as a follow-up to elucidate detailed explanations of three issues based on the results of the teacher survey.

From the survey data, teachers’ beliefs components were derived by conducting a series of multi-phased factor analyses together with an expert validation process. Moreover, reliability and validity tests were established in this method. Based on the analysis, two components were identified as dimensions of teachers’ stated pedagogical beliefs according to BCC instructions confined to the surveyed items in the study. The dimension concerned with approaches that encourage students’ learning in classroom were labelled AESL. The second dimension focusing more towards traditional teacher-centred approaches was classified as TTA. In reference to the brain-based learning principles, these two dimensions were distinct from what has been outlined in the principles, especially the TTA dimension. However, these two dimensions were regarded as important because they represent the perceived BCC instruction among secondary school science teachers in the central region of Malaysia. The elements of patterning, emotions and social interaction were regarded as more important from an AESL dimension, whereas those from the TTA dimension revealed complex responses, especially in the issue of challenging and threatening students and acknowledging a unique difference among individuals.
The analyses illuminated complex findings when it was revealed that senior teachers aged over 40 showed higher, more positive beliefs and practices towards both dimensions compared to their junior counterparts. Conversely, the junior teachers deliberately expressed their negative beliefs and practices in regards to the TTA dimension and had positive beliefs about the AESL dimension. Further analysis revealed that there was a very strong and positive relationship between teachers’ pedagogical beliefs and their practices towards TTA, followed by AESL. Among demographic factors such as age group and teaching experience, teachers’ pedagogical beliefs and practices regarding a BCC were clearly influenced only by the age group. Above all, senior teachers held stronger positive beliefs towards TTA and AESL components compared to their junior counterparts.

Based on the results of the teacher survey, the TTA dimension was chosen for further investigation through email interviews. Eight teachers were chosen as the participants for the email interviews. Three questions were designed as an interview protocol for the interview based on the findings at the item level of the dimension. Since the majority of the teachers disagree with punishing students if they failed to give correct answers, the selected teachers were asked about their opinions. According to their feedback, it was revealed that the majority thought that the teacher should act as a guide. They specified the teacher’s role further as either guiding students to acquire a correct answer or guiding them on thinking about how to achieve the right answer. Moreover, the respondents claimed that punishing the students meant students would never try to answer any more questions, because the students would be scared of making more mistakes. The teachers implied that punishment would make the students feel embarrassed and thus lower their level of confidence. In conclusion, the participants believed that teachers should consider themselves as a guide rather than punish the students for not getting the
right answer. The teachers were also aware of the effect of punishment upon students’ emotions and feelings.

The second question was about choosing a comfortable teaching strategy. As the majority of the respondents in the survey believed that teachers should choose a teaching strategy that is comfortable for them, the participants in the interview were asked about their opinions. From the students’ perspective, the participants suggested that teachers should be aware of students’ ability and interest and should acknowledge the differences among students. From the teachers’ perspective, the participants implied that by choosing a comfortable teaching strategy, teachers could teach confidently and effectively. There were also participants who valued both teacher-student acceptances in choosing the teaching strategy. However, from the feedback in the interviews, those teachers were placing more stress on students’ acceptance than upon the teachers’ preferred teaching strategy. This was clearly different to what they reported in the survey, where they placed more emphasis on their own comfortable teaching strategy. Thus, in choosing a comfortable teaching strategy, a complex range of ideas was obtained from the participants from the secondary school science teachers in the central region of Malaysia.

Another issue raised in the email interview related to the use of criticism in motivating students. While criticism carries a broad meaning, from the participants’ point of view they were focusing on constructive criticism that is related to evaluation or appraisal in motivating the students. Significantly, it clarified that what was meant by those teachers was the application of positive types of criticism, which they believed was capable of motivating the students.

In brief, this thesis conducted an investigation of the compatibility of pedagogical beliefs and practices in regards to a BCC among secondary school science teachers in the central region of Malaysia. The results identified two dimensions of aBCC from the
teachers’ perspective. Teachers’ pedagogical beliefs and practices relating to the dimensions regarding age and teaching experience were investigated. The relationship between the beliefs and practices of the dimensions were also ascertained. Teachers’ views of some of their beliefs were also demonstrated. Overall, while the proposed dimensions were distinct from the theory, the findings of the study demonstrated that part of their beliefs were compatible with a BCC.

6.2 Theoretical Contributions

The first theoretical contribution relates to the relationship between teachers’ pedagogical beliefs and practices in relation to a BCC. Since the findings indicated a high consistency between a belief and its practice, this shows that if teachers had a belief about brain-based learning, the intention of them practicing their belief is very high, as they had been practicing the approaches intuitively.

The second aspect relates to the compatibility of the principles to the teacher. Regardless of their level of knowledge about the theoretical aspect, the way the principles were designed may not be fully compatible with the Asian teacher-student context. While teachers indicated that they held positive beliefs about a BCC intuitively, the application of a belief may possibly depend on other factors such as culture and education system. Even if the principles were regarded as helpful for teachers and students for classroom engagement, under the influence of cultural factors teachers may demonstrate their own way of how best to engage students in a classroom.

6.3 Methodological Implications

The findings of this study were based on a mixed methods approach using a teacher survey and email interviews to reveal teachers’ pedagogical beliefs and practices in regards to a BCC. The survey technique was the main method of gathering the data and the teachers’ feedback was based on the items in the questionnaire, so the beliefs in the
context of this study were regarded as stated pedagogical beliefs and the practices were referred to as self-reported pedagogical practices.

From the survey, teachers’ pedagogical beliefs and practices in regards to a BCC can be generalised to secondary school science teachers from the central region of Malaysia. If the same set of questions were to be tested in the same context but in different part of the world—for example, in Asian countries—it would likely reveal the same kind of result. However, the beliefs regarding the dimensions derived from this study were specifically based on the classroom techniques outlined in the questionnaire only. Testing with other classroom techniques may produce different kinds of results.

Another methodological implication relates to the utilisation of email interviews as another way of gathering the data. The feedback was based on the interview protocol that consists of only three questions and was answered by the participants through email. As there was no other follow-up email from the researcher, the data were solely based on the replies of the participants through email. This was again considered stated pedagogical beliefs because the data were in written form.

Next, the survey focused on secondary school science teachers from the central region of Malaysia. Thus, the result is generalisable to science teachers from the central region of Malaysia only and not to other regions. If the research was extended to other regions or other subject teachers in secondary schools, a different set of findings may be discovered. Further, the results may be different if those participants are further grouped according to the specific science subjects taught, such as additional science, biology, chemistry, physics and science for lower secondary and science for upper secondary.

6.4 Pedagogical Suggestions

The teachers in the current study intuitively indicated that they held positive beliefs towards parts of BCC approaches, indicating that they should be exposed to the theoretical
aspects of the brain-based learning principles. In-service teacher training or teachers’ professional development can be a medium of training science teachers in a BCC (Geake, 2011). Even if they have been utilising part of the application of brain-based learning in their classroom instruction, it will be more comprehensive if they have the knowledge about what they are doing from the theoretical perspective. The training can be extended to all levels of teachers and includes the pre-service teachers at the teacher-training institute. This suggests that teachers are expected to become literate in knowledge about a BCC (Wolfe, 2003) and they will embrace the knowledge, especially in relation to how the brain functions in learning, because they have been applying those techniques intuitively (Fogarty, 2009; Wolfe, 2003). Even though brain-based learning has been used intuitively in the classroom, not all techniques follow the brain-based guidelines (Jackson, 1999).

Since the findings of this study also demonstrated that teachers valued certain teaching techniques beyond aBCC, this shows that their knowledge about brain-based learning is still insufficient. However, cautious steps have to be taken so as not to simply apply the entire brain-based approach without considering the context of the students. This has been acknowledged by certain researchers who question the direct application of brain research to the field of education (Goswami, 2008; OECD, 2001). Thus, some approaches from other fields can be integrated with the findings from neuroscience for better outcomes (Sikes, 2009).

Another suggestion would be to allow teachers to have more choices to implement various teaching techniques. This includes continuing to provide more teaching materials and resources, as had been done during the implementation of ETeMS (MOE, 2008). Aligned with the government’s concern to improve the quality of science education in Malaysia, the allocation of funding for teacher training and up-skilling has been outlined in the reviewed Malaysia Education Blueprint 2013 to 2025 (MOE, 2012). Hence, teachers
should be encouraged to take this opportunity to utilise and expand their creativity by integrating their knowledge from different pedagogical aspects. This will hopefully result in various teaching techniques for whole-brain learning and optimal classroom engagement (Dryden & Vos, 2001).

It is also suggested that it would be appropriate if teachers focus more on emotional aspects in classroom teaching in a broader scope, as this would encourage them to create a safe and engaging classroom. This is expected to be supported by the school administrator and supervised at the district and state level of the education department by providing teachers with sufficient knowledge and values. This is to make sure that what has been outlined in the Malaysian science curriculum specifications, to inculcate ‘scientific attitudes and noble values’ in teaching approaches, can be realised (MOE, 2002a).

The suggested pedagogical steps are intended to improve the TIMSS performance and to increase the ratio of the targeted 60:40 (60 per cent represents students in science and technology and 40 per cent in arts) proposed by MOE (2004). Further, it is also aimed at raising the quality of science education in Malaysia in order to achieve a developed nation by 2020.

6.5 Limitations

Throughout the study, there were a number of limitations applied to ensure the research could be conducted within the researcher’s capability. The first limitation related to the use of email interview sessions as another way of gathering the data. While the initial plan was to conduct face-to-face interviews with the participants who were willing to take part in the interview sessions, due to the time constraints the mode of the interview had to be changed to email.

The second limitation related to the number of participants involved in the interview sessions. Even though the number of the participants willing to take part in the
sessions exceeded eight, it was decided to choose only eight because this number was considered manageable for the researcher. Moreover, due to the teachers’ workloads, the interview was set to a one-off session between the researcher and the participants.

Third, the interview protocol was developed based on the item level of the AESL dimension. As mentioned before (see section 4.10), in relation to adopting a sequential explanatory design, both dimensions (AESL and TTA) should be considered for further investigation. However, for the purpose of this study, it was decided to choose items only from the dimension that describes approaches to encourage students in learning. Further, instead of investigating the dimension level, it was decided to focus on the item level by selecting only three out of eight items for the follow-up, even though other items in the dimension were also considered important. This was again related to the manageability of the researcher in getting sufficient amounts of data in a specific period. All the limitations in conducting the research related to aspects of manageability and accessibility.

6.6 Suggestions for Future Research

For future research, if a questionnaire is going to be used, it is suggested that the items are designed to cover more comprehensive techniques that were not covered in the current study. Examples of other techniques in brain-based learning are the use of music, smells and movement during the teaching and learning process. Further, if the questionnaire in the current study is to be adopted or adapted, it should be revised. The negative items need to be removed or replaced with positive ones as the negative items may confuse the respondents (Sauro & Lewis, 2011). Further, if a sequential mixed methods approach using a survey followed by email interviews is to be conducted, it is also better if each respondent of the survey can be traced back for the purpose of finding the closest possible respondent regarding the follow-up issue for the interview session.
Furtherspecific research can be undertaken by focusing on teachers who teach different level of students such as pre-school, elementary and secondary school. Further, a study can also be conducted between teachers who teach different science subjects or subjects other than science. As the current study in the central region of Malaysia was focusing on teachers from urban and suburban areas, another study can be extended to teachers from rural areas, then a comparison could be made between teachers from rural and urban areas.

The area of research can also be extended to other regions in Malaysia, such as the northern, southern and eastern part of the Malaysian Peninsula as well as East Malaysia, which is part of Borneo. Even though Malaysia’s education system is centralised under the Ministry of Education at the national level (MOE, 2008), different regions of Malaysia may demonstrate different levels of teachers’ pedagogical beliefs and practices. This may be influenced by teachers’ levels of exposure to the latest information using ICT about pedagogical aspects and teachers’ professional development provided by the state education department.

As the current study focused on stated pedagogical beliefs and self-reported pedagogical practices, it would be useful if a series of face-to-face interviews could be undertaken with small groups of teachers from two different age ranges: junior and senior teachers. This is to discover their pedagogical beliefs about a BCC through instant feedback and close to their context (Darlaston-Jones, 2007). Then, a follow-up could be undertaken with classroom observations to find out if pedagogical practices are aligned with what had been claimed as pedagogical beliefs.

Apart from having the teachers as the respondents, other research can also take students into consideration and a case study can be undertaken with a group of students. Those students can be interviewed about how they would imagine a very interesting
classroom. Then, a comparison could be made between what the students claim and what has been outlined according to brain-based learning principles. The teacher may provide a classroom situation that is aligned with what has been outlined in the brain-based learning principles. After that, the same students may be interviewed again to receive feedback about the BCC that they have experienced. This may give a picture as to whether the BCC can be regarded as among the types of classrooms that students enjoy. This is important as students’ beliefs about a BCC could be discovered.

Further suggestions are follow-up studies regarding the items that were investigated in the interview sessions (mentioned in section 5.4.3) and other items in the TTA dimension. More research can be conducted on issues like memorisation, punishment, comfortable teaching strategy and other traditional teacher-centred items outlined in this study. This is to clarify further the TTA that they consider important and also their beliefs as well as classroom practice. Then, a comparison can be made between those techniques and the approaches outlined in the brain-based learning principles and how far those approaches can be integrated for the best pedagogical output.

6.7 Conclusion

This study investigated pedagogical beliefs and practices in regards to a BCC among secondary school science teachers from the central region of Malaysia. The study adopted a sequential mixed methods research design, conducting a teacher survey followed by email interviews. The findings revealed two dimensions of teachers’ pedagogical beliefs that explain how they perceive their classroom teachings from both the brain-based learning and the traditional teacher-centred approaches.

Higher pedagogical beliefs and practices for both dimensions were discovered, especially among the senior teachers aged above 40. This indicated their insufficient knowledge about brain-based learning, which affects their pedagogical beliefs and
practices. However, the findings also demonstrated that they have been practising some BCC approaches intuitively and a high consistency was discovered between teachers’ beliefs and practices for both dimensions. Thus, it should be possible for those teachers with insufficient knowledge about the brain and learning to be identified and to expose the knowledge through in-service teacher training.

However, over emphasising brain-based techniques needs to be cautioned as other factors such as cultural and religious contexts should be considered when utilising those techniques. Incorporating a BCC instruction in classroom teaching and learning may lead to whole-brain learning and integrating the approach with other techniques will create a better outcome for optimal classroom engagement.

6.8 Summary

This chapter concluded the research and outlined the implications of the study based on the research findings. Two types of data gathered in this study (stated pedagogical beliefs and self-reported pedagogical practices) contributed part of the methodological implications. A strong relationship between teacher’ pedagogical beliefs and practices in relation to a BCC in the context of this study is among the outlined theoretical contributions. Thus, adequate exposure of a BCC to the science teachers, relevant to the local context, is proposed as one of the pedagogical suggestions. While the objective was to answer all the research questions, a number of limitations were taken into consideration to make sure the research could be conducted within the researchers’ capability. In order to find more answers to questions that arose during the research, some suggestions for future research have been outlined.
References


Howard, P. J. (2000). The owner’s manual for the brain: Everyday applications from mind-brain research. ERIC.


doi:10.1177/002248719104200406


http://proquest.umi.com/pqdweb?did=736613361&Fmt=7&clientId=20828&RQT=309&VName=PQD


Tin, D. T. (2012). *Learner autonomy perception and performance: A study on vietnamese students in online and offline learning environments* (Faculty of Education, La Trobe University, Victoria, Australia).


## Appendix 3-1

### Items Designed Under Each Brain-Based Learning Principle

<table>
<thead>
<tr>
<th>Principle</th>
<th>Items</th>
<th>Items for PART 1: BBL BELIEFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td><strong>All Learning is Physiological (EE)</strong></td>
</tr>
<tr>
<td></td>
<td>K01</td>
<td>Learning activities are best when they involve the students’ senses</td>
</tr>
<tr>
<td></td>
<td>K20</td>
<td>*The ‘chalk and talk’ technique is an effective way of teaching</td>
</tr>
<tr>
<td></td>
<td>K35</td>
<td>New classroom experiences should be provided for the students</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td><strong>The Brain/Mind is Social (RA)</strong></td>
</tr>
<tr>
<td></td>
<td>K04</td>
<td>Teachers should encourage students to share their ideas</td>
</tr>
<tr>
<td></td>
<td>K09</td>
<td>Students’ interaction need to be encouraged in the classroom</td>
</tr>
<tr>
<td></td>
<td>K06</td>
<td>*It is important for students to keep their work confidential</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td><strong>The Search for Meaning is Innate (RA)</strong></td>
</tr>
<tr>
<td></td>
<td>K23</td>
<td>*Students who talk a lot are problematic</td>
</tr>
<tr>
<td></td>
<td>K05</td>
<td>It is a good idea to involve students in making decisions about their learning</td>
</tr>
<tr>
<td></td>
<td>K14</td>
<td>*Students are not capable of making decisions in the classroom</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td><strong>The Search for Meaning Occurs through Patterning (EE)</strong></td>
</tr>
<tr>
<td></td>
<td>K10</td>
<td>The teacher needs to guide the students to deepen their understanding of the concepts being taught</td>
</tr>
<tr>
<td></td>
<td>K32</td>
<td>A useful way of explaining new knowledge is to use analogies</td>
</tr>
<tr>
<td></td>
<td>K12</td>
<td>Teachers need to help students to understand a concept by using meaningful themes</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td><strong>Emotions are Critical to Patterning (RA)</strong></td>
</tr>
<tr>
<td></td>
<td>K13</td>
<td>Teachers need to pay attention to students’ emotions in classroom</td>
</tr>
<tr>
<td></td>
<td>K31</td>
<td>Students need to be encouraged to have positive attitudes</td>
</tr>
<tr>
<td></td>
<td>K17</td>
<td>Teachers need to relate the lessons to students’ life experiences</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td><strong>The Brain/Mind Processes Parts and Wholes Simultaneously (EE)</strong></td>
</tr>
<tr>
<td></td>
<td>K16</td>
<td>A new topic is best taught in small segments</td>
</tr>
<tr>
<td></td>
<td>K26</td>
<td>*Using stories to teach new topics is a waste of time</td>
</tr>
<tr>
<td></td>
<td>K18</td>
<td>Group projects are good in teaching</td>
</tr>
<tr>
<td>Principle</td>
<td>Items</td>
<td>Items for PART 1: BBL BELIEFS</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------------------------</td>
</tr>
</tbody>
</table>
| 7         | Learning Involves both Focused Attention and Peripheral Perception (EP) | K19 Novelty in classroom promotes learning  
K02 *Students decorating the classroom is a waste of time  
K21 The teachers’ attitude is an important influence on students’ learning |
| 8         | Learning is both conscious and unconscious (EP) | K22 Students need to be given opportunities to reflect on what they have learnt  
K36 *Encouraging students to work in groups much of the time is important  
K24 *Art has little relevance to teaching science |
| 9         | There at Least Two Approaches to Memory: Archiving Isolated Facts and Skills or Making Sense of Experience (EP) | K07 *It is important for students to memorize what they have learnt  
K03 It is difficult for the students to remember things that have no meaning to them  
K27 Imagination is a tool to increase understanding |
| 10        | Learning is Developmental (EE) | K28 Students should be given choices in the activities they will be doing  
K34 Students need to be taught according to their capabilities  
K15 It is best to give students opportunities to work alone, in pairs or in group as needed |
| 11        | Complex Learning is Enhanced by Challenge and Inhibited by Threat Associated with Helplessness (RA) | K25 *Teachers need to be serious when teaching  
K29 *Criticising is a good way to motivate the students  
K11 *Students need to be punished when they fail to give correct answers |
| 12        | Each Brain is Uniquely Organized (EP) | K30 *Teachers should choose a teaching strategy which is comfortable for them  
K08 Students’ potential can be increased by exposing them to a variety of experiences |
<table>
<thead>
<tr>
<th>Principle</th>
<th>Items</th>
<th>Items for PART 1: BBL BELIEFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>K33</td>
<td>*The teacher should provide the same activity for all groups of students</td>
<td></td>
</tr>
</tbody>
</table>

*Note. EE: Enriched experienced; EP: Experienced processing; RA: Relaxed alertness; *: Negative items.*
Appendix 3-2

The Questionnaire for Teacher Survey

ETHICS APPROVAL NO:R050/10

TEACHING SURVEY QUESTIONNAIRE

This survey is part of a doctoral research project on teachers’ thinking about learning. Your views on the following questions are highly appreciated. Your identity and all the information in this survey will be kept strictly confidential and will be used for research purposes only. Thank you very much for your time.

PART 1: KNOWLEDGE ABOUT LEARNING

Please tick (✓) the statements below based on the following scale:

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>STRONGLY DISAGREE</th>
<th>DISAGREE</th>
<th>NEUTRAL</th>
<th>AGREE</th>
<th>STRONGLY AGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Learning activities are best when they involve the students’ senses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Students decorating the classroom is a waste of time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 It’s difficult for students to remember things that have no meaning to them</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Teachers should encourage students to share their ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 It is a good idea to involve students in making decisions about their learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 It is important for students to keep their work confidential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 It is important for students to memorize what they have learnt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Students’ potential can be increased by exposing them to a variety of experiences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Students’ interactions need to be encouraged in the classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 The teacher needs to guide the students to deepen their understanding of the concepts being taught.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Students need to be punished when they fail to give correct answers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITEMS</td>
<td>STRONGLY DISAGREE</td>
<td>DISAGREE</td>
<td>NEUTRAL</td>
<td>AGREE</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>12</td>
<td>Teachers need to help students to understand a concept by using meaningful themes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Teachers need to pay attention to students’ emotions in classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Students are not capable of making decisions in the classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>It is best to give students opportunities to work alone, in pairs, or in group as needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>A new topic is best taught in small segments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Teachers need to relate the lessons to the students’ life experiences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Group projects are good in teaching</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Novelty in the classroom promotes learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>The “chalk and talk” technique is an effective way of teaching</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>The teacher’s attitude is an important influence on students’ learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Students need to be given opportunities to reflect on what they have learnt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Students who talk a lot are problematic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Art has little relevance to teaching science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Teachers need to be serious when teaching</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Using stories to teach new topics is a waste of time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Imagination is a tool to increase understanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Students should be given choices in the activities they will be doing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Criticising is a good way to motivate the students</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Teachers should choose a teaching strategy which is comfortable for them</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Students need to be encouraged to have positive attitudes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>A useful way of explaining new knowledge is to use analogies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>The teacher should provide the same activity for all groups of students</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Students need to be taught according to their capabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>New classroom experiences should be provided for the students</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Encouraging students to work in groups much of the time is important</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART 2: DEMOGRAPHICS

Please read the questions carefully and write down the answers at the space provided. For questions 2, 3 and 5, please tick (✓) at the appropriate box.

1. Age group:
   - [ ] 20–30
   - [ ] 31–40
   - [ ] 41–50
   - [ ] >51

2. Gender:
   - [ ] Male
   - [ ] Female

3. Cultural background:
   - [ ] Malay
   - [ ] Chinese
   - [ ] Indian
   - [ ] Other
   (Please specify)

4. Highest qualification:

5. Teaching experience:
   - [ ] 0–10 years
   - [ ] 11–20 years
   - [ ] >20 years
<table>
<thead>
<tr>
<th>ITEMS</th>
<th>NEVER</th>
<th>SOMETIMES</th>
<th>OFTEN</th>
<th>ALWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I involve the students’ senses in learning activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 I discourage students from decorating the classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I encourage my students to create meaning for themselves from what they have learnt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 I like students to share their ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 I involve my students in making decisions about their learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 I encourage students to keep their work confidential</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 I encourage my students to memorize what they have learnt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 I expose the students to a variety of experiences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 I encourage students’ interactions in the classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 I guide the students to deepen their understanding of the concepts being taught</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 I punish students when they fail to give correct answers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 I help my students to understand a concept by using meaningful themes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 I pay attention to students’ emotions in classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 I make all the decisions in the classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 I give students opportunities to work alone, in pairs, or in group as needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 I teach new topics in small segments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 I relate the lessons to the students’ life experiences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITEMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>I use group projects in my teaching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>I introduce novelty in the classroom to promote learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>I use the “chalk and talk” technique in my teaching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>I am aware of my attitude in the classroom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>I give students opportunities to reflect on what they have learnt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>I consider students who talk a lot to be problematic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>I do not include art in my science teaching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>I am serious when I am teaching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>I avoid using stories to introduce new topics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>I use imagination to increase students’ understanding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>I give the students choices in the activities they will be doing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>I criticize students to motivate them</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>I choose a teaching strategy which is comfortable for me</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>I encourage students to have positive attitudes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>I use analogies to explain new knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>I provide the same activity for all groups of students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>I teach students according to their capabilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>I provide new classroom experiences in my teaching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>I encourage students to work in groups much of the time</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As part of this research, I plan to interview some teachers. If you are willing to be interviewed, please write down your contact number: _______________________

I will contact you for the interview arrangement.

Your cooperation is greatly appreciated. Thank you.

Wan Rosmini HASSAN
FACULTY OF EDUCATION
LA TROBE UNIVERSITY
MELBOURNE, AUSTRALIA
Appendix 3-3

The Interview Protocol

Written Document Schedules

Opening Statement: Dear teacher, to help clarify some of my results and to provide more detail, I will be most grateful if you can respond to the following questions:

1. Most teachers disagree with punishing students if they fail to give correct answers. Why do you think this is so?

2. The majority of teachers thought that teachers should choose a teaching strategy which is comfortable for them. What is your opinion?

3. Do you think criticism is a useful way to motivate students? (Why/Why not?)

Thank you for your co-operation and great effort to answer the questions.
Appendix 3-4

Ethics Approvals

Appendix 3–1

La Trobe University

30th May 2012

War Rawanni Hassan

1 Library Place

Thornbury Vic 3074

Dear Won

Project/Activity Title: An investigation into baseline knowledge and application of brain-based learning theory

Thank you for submitting your application to the Education Faculty Human Ethics Committee seeking ethical approval to carry out your project.

The Chair of the Education HREC has reviewed your application and has approved your request to:

Extend the approval period to the 31 December 2012 and slightly amend the data collection method.

The following standard conditions apply to your project:

• Complaints - If any complaints are received or ethical issues arise during the course of the project, researchers should contact the Director of the Education HREC.

• Limit of Approval - Approval is limited solely to the research proposal as submitted in your application while taking into account the conditions and approval dates outlined by the HREC.

• Validation on Approval - As a consequence of the previous condition, any subsequent versions of the research you wish to make to your project must be certified formally by the HREC. This can be done using the Application for Approval of Modifications to Research Project which is available at http://www.latrobe.edu.au/education-research/educationhec/applications.htm

• A condition of approval is that you submit a Progress Report to the Committee annually throughout the approval period, of course activities of the previous calendar year. Reports are due on 12 February. Failure to submit a progress report may result in the withdrawal of Human Ethics approval. The form is available from http://www.latrobe.edu.au/education-research/educationhec/applications.htm.

On behalf of the Committee, best wishes with the success of your project.

Yours sincerely,

[Signature]

[Name]

Executive Secretary, Education Faculty Human Ethics Committee

[Signature]

[Name]

[Role or Title]
Appendix 3-5

Permission to Conduct Research in Malaysia

Application to Conduct Research in Malaysia

With reference to your application, I am pleased to inform you that your application to conduct research in Malaysia has been approved by the Research Promotion and Coordinating Committee, Economic Planning Unit, Prime Minister's Department. The details of this approval are as follows:

Researcher's Name: WAN ROSMINI BINTI HAASSAN
Passport No. & C. No.: 7067186626A
Nationality: MALAYSIAN
Title of Research: "AN INVESTIGATION INTO TEACHERS' KNOWLEDGE AND APPLICATION OF BRAIN-BASED LEARNING THEORY"

Period of Research Approval: 4 YEARS

2. Please collect your Research Pass in person from the Economic Planning Unit, Prime Minister's Department, Pavilion B, Level 1, Block 88, Federal Government Administrative Centre, 50490, Putrajaya and bring along your passport size photographs. You are also required to comply with the laws and regulations applicable from time to time by the agencies with which you have dealings in the conduct of your research.
Appendix 3-6

Letter to the Principal

September 28th 2010

To the Principal,
Dear Sir/Madam,

RESEARCH FIELD WORK ON ‘KNOWLEDGE AND PRACTICE IN TEACHING AND LEARNING IN MALAYSIA SECONDARY SCHOOLS’

The above matter referred.

I am writing this letter to seek your permission to meet with science teachers in your school and to invite them to participate in a study I am undertaking for my PhD. My study involves an investigation into the pedagogical practices of science teachers. I hope I will identify practices that promote deep learning in students and hope to develop more understanding of current research into learning.

I would really appreciate if you could allow me to meet the science teachers to answer the questionnaire and to contact any teacher who is willing to take part in the interview. However, I am pleased to tell you that taking part in this study is completely voluntary. In fact, any information provided will be treated in the strictest confidence and neither participant nor schools will be individually identifiable in the resulting thesis, report or other publications and conferences. The research is done after the permission has been granted from the La Trobe University Education Faculty Human Ethics Committee (Education FHEC) and the Ministry of Education Malaysia.

If you have any questions regarding this study you may contact my supervisors: Dr. Peta Heywood, Lecturer in Education, Faculty of Education, La Trobe University, Victoria, Australia 3086. Telephone number: +61 (0)3 9479 2641 or E-mail: p.heywood@latrobe.edu.au Or Dr. Glyn Thomas, Faculty of Education, La Trobe University, Bendigo, Australia 3552. Telephone: +61 (0)3 5444 7480 or E-mail: g.thomas@latrobe.edu.au

Your kind consideration in allowing me to do my research field work in your school is very much appreciated. Thank you.

Sincerely,

(WAN ROSMINI HASSAN)
Appendix 3-7

Participant Information Statement

ETHICS APPROVAL NO: R050/10

Research Title:

Knowledge and Practice in Teaching and Learning in Malaysia Secondary Schools

Researcher:

Wan Rosmini HASSAN, PhD student, La Trobe University, Australia.

Supervisor(s):

1. Dr. Peta Heywood, La Trobe University, Australia
2. Dr. Patricia McCann, La Trobe University, Australia

Dear Teachers,

Thank you for showing interest in participating as study participants in my research entitled Knowledge and Practice in Teaching and Learning in Malaysia Secondary Schools. Please read this Participant Information Statement carefully and ask any questions you may have before agreeing to take part in the study.

My name is Wan Rosmini HASSAN, and I am PhD student at La Trobe University, Australia. This study is part of my PhD research. The purpose of this research is to study the teachers’ knowledge and practice in teaching and learning in secondary schools in Malaysia. This research is being funded by the Ministry of Education.

The research questions will be answered by analyzing data collected from questionnaires and written documents. I am doing this research only after I have received permission from the La Trobe University Education Faculty Human Ethics Committee (Education FHEC) and Ministry of Education, Malaysia.

Part I: The Questionnaire

You are being invited to participate in this research by answering a questionnaire. The questionnaire is divided into three parts. It will take approximately 15-20 minutes to answer the questions. It will be assured that any information provided be treated in the strictest confidence and neither participant nor schools will be individually identifiable in the resulting thesis, report or other publications. Participants are, of course, entirely free to discontinue their participation at any time or to decline to answer particular questions in the study. Since participation is purely voluntary, non-participation will not affect your career and teaching in any way. I am not evaluating or assessing your teaching approach.
Part II: Written Document

In this project, I intend to send an email to get your opinions regarding emerging questions from the findings of the survey. If you are willing to take part in this written document, please write your contact details and email address and I will contact you through email. Therefore, I will seek the consent to use the written document in preparing the thesis, report or other publications, on condition that names or identities are not revealed. The questions will be asked in English but you can choose your preferred language, i.e. Malay language. I will save the document in Microsoft Words files onto my computer with password protection. I will then delete the original document from my email data. I will also check with you the accuracy of your written material that is quoted anonymously in my thesis or other publication. At the time of checking, you will still be able to remove any quotes you do not want to be included in my academic writing. Taking part in this study is completely voluntary. For instance, you may skip any questions that you do not want to answer in the written document. If you decide not to take part or to skip some of the questions, it will not affect your current or future career at your school.

You have the right to withdraw from active participation in this project at anytime and, further, to demand that data arising from your participation are not used in the research project provided that this right is exercised within four weeks of the completion of your participation in the project. You are asked to complete the “Withdrawal of Consent Form” or to notify the investigator by e-mail or telephone that you wish to withdraw your consent for your data to be used in this research project.

The records of this study will be kept private. Information from written documents and questionnaires information will be anonymous and confidential. Research files will be kept in a lockable storage; only the researcher will have access to the files. Data from this research will be used in my doctoral thesis and possibly in later publications and conferences. Your anonymity and confidentiality will be assured.

If you have any questions regarding this study you may contact to Ms. Wan Rosmini HASSAN, Faculty of Education, La Trobe University, Bundoora 3086 Melbourne Australia on the telephone number +614 2588 8700 or E-mail wrosmini@students.latrobe.edu.au. You also may contact her supervisors: Dr. Peta Heywood, Lecturer in Education, Faculty of Education, La Trobe University, Victoria, Australia 3086. Telephone number: +61 (0)3 9479 2641 or E-mail: p.heywood@latrobe.edu.au Or Dr. Patricia McCann, Faculty of Education, La Trobe University, Victoria, Australia 3086. Telephone: +61 (0)3 9479 2638 or E-mail: p.mccann@latrobe.edu.au

If you have any complaints or queries that the researcher has not been able to answer to your satisfaction, you may contact the Secretary, Faculty Human Ethics Committee, Faculty of Education, La Trobe University, Victoria 3086, Tel: +61 (0)3 9479 1443, Email: humanethics@latrobe.edu.au

Name of Participant (Block Letters): __________________________________________

(Teacher’s Name/ Signature)

Participant’s signature: ____________________________ Date: __________________

Name of Investigator (Block Letters): WAN ROSMINI HASSAN

Investigator’s signature: ____________________________ Date: __________________
Appendix 3-8

Consent Form

ETHICS APPROVAL NO: R050/10

Research Title:

Knowledge and Practice in Teaching and Learning in Malaysia Secondary Schools

In order to participate in this study, this Consent Form must be signed by participant.

I ________________________________________ have read and understood the Participation Information Sheet and consent form, and any questions I have asked have been answered to my satisfaction. I agree to participate in this project by answering survey questions. I agree that research data provided by me or with my permission during the project may be included in a thesis, presented at conferences and published in journals on the condition that neither my name nor any other identifying information is used.

If you have any questions regarding this study you may contact to Ms. Wan Rosmini HASSAN, Faculty of Education, La Trobe University, Bundoora 3086 Melbourne Australia on the telephone number +614 2588 8700 or E-mail wnrosmini@students.latrobe.edu.au. You also may contact her supervisors: Dr. Peta Heywood, Lecturer in Education, Faculty of Education, La Trobe University, Victoria, Australia 3086. Telephone number: +61 (0)3 9479 2641 or E-mail: p.heywood@latrobe.edu.au Or Dr. Glyn Thomas, Faculty of Education, La Trobe University, Bendigo, Australia 3552. Telephone: +61 (0)3 5444 7480 or E-mail: g.thomas@latrobe.edu.au

If you have any complaints or queries that the researcher has not been able to answer to your satisfaction, you may contact the Secretary, Faculty Human Ethics Committee, Faculty of Education, La Trobe University, Victoria 3086, Tel: +61 (0)3 9479 1443, Email: humanethics@latrobe.edu.au

Name of Participant (Block Letters): ___________________________________________

(Teacher’s Name/ Signature)

Participant’s signature: ____________________________ Date: ___________________

Name of Investigator (Block Letters): WAN ROSMINI HASSAN

Investigator’s signature: ____________________________ Date: ___________________
Appendix 3-9

Withdrawal of Consent for Use of Data Form

ETHICS APPROVAL NO: R050/10

Research Title:

Knowledge and Practice in Teaching and Learning in Malaysia Secondary Schools

“I, ___________________________(the participant), wish to WITHDRAW my consent to the use of data arising from my participation in the above named project. Data arising from my participation must NOT be used in this research project as described in the Participation Information Sheet and Consent Form.

I understand that data arising from my participation will be destroyed provided this request is received within four weeks of the completion of my participation in this project. I understand that this notification will be retained together with my consent form as evidence of the withdrawal of my consent to use the data I have provided specifically for this research project.”

Participant’s name (Block Letters): ____________________________ Signature: ____________________________

Date: ____________________________

Please forward to:

Wan Rosmini HASSAN

Faculty of Education

La Trobe University

Victoria 3086, Australia.

OR Email to:

wrhassan@students.latrobe.edu.au
### Appendix 4-1

**Total Variance Explained: 11 Items**

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
</tr>
<tr>
<td>1</td>
<td>7.27</td>
<td>20.20</td>
</tr>
<tr>
<td>2</td>
<td>3.10</td>
<td>8.62</td>
</tr>
<tr>
<td>3</td>
<td>1.86</td>
<td>5.18</td>
</tr>
<tr>
<td>4</td>
<td>1.74</td>
<td>4.85</td>
</tr>
<tr>
<td>5</td>
<td>1.56</td>
<td>4.33</td>
</tr>
<tr>
<td>6</td>
<td>1.27</td>
<td>3.54</td>
</tr>
<tr>
<td>7</td>
<td>1.24</td>
<td>3.44</td>
</tr>
<tr>
<td>8</td>
<td>1.23</td>
<td>3.43</td>
</tr>
<tr>
<td>9</td>
<td>1.17</td>
<td>3.22</td>
</tr>
<tr>
<td>10</td>
<td>1.16</td>
<td>2.99</td>
</tr>
<tr>
<td>11</td>
<td>1.08</td>
<td>2.65</td>
</tr>
</tbody>
</table>
### Appendix 4-2

**Pattern Matrix (Items With Factor Loadings Smaller Than .40)**

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>K08 Students’ potential can be increased by exposing them to variety of experience</td>
<td></td>
<td></td>
<td></td>
<td>.847</td>
</tr>
<tr>
<td>K17 Teachers need to relate the lessons to the students’ life experiences</td>
<td></td>
<td></td>
<td></td>
<td>.741</td>
</tr>
<tr>
<td>K04 Teachers should encourage students to share their ideas</td>
<td></td>
<td></td>
<td></td>
<td>.735</td>
</tr>
<tr>
<td>K21 The teachers’ attitude is an important influence on students’ learning</td>
<td></td>
<td></td>
<td></td>
<td>.656</td>
</tr>
<tr>
<td>K22 Students need to be given opportunities to reflect on what they have learnt</td>
<td></td>
<td></td>
<td></td>
<td>.653</td>
</tr>
<tr>
<td>K31 Students need to be encouraged to have positive attitudes</td>
<td></td>
<td></td>
<td></td>
<td>.637</td>
</tr>
<tr>
<td>K09 Students’ interactions need to be encouraged in the classroom</td>
<td></td>
<td></td>
<td></td>
<td>.620</td>
</tr>
<tr>
<td>K10 Teacher guide students to deepen their understanding of the concepts taught</td>
<td></td>
<td></td>
<td></td>
<td>.611</td>
</tr>
<tr>
<td>K26 Using stories to teach new topics is a waste of time</td>
<td></td>
<td></td>
<td></td>
<td>-.532</td>
</tr>
<tr>
<td>K13 Teachers need to pay attention to students’ emotions in classroom</td>
<td></td>
<td></td>
<td></td>
<td>.530</td>
</tr>
<tr>
<td>K12 Teachers help students understand a concept taught using meaningful themes</td>
<td></td>
<td></td>
<td></td>
<td>.516</td>
</tr>
<tr>
<td>K01 Learning act are best when involve the students’ senses</td>
<td></td>
<td></td>
<td></td>
<td>.502</td>
</tr>
<tr>
<td>K34 Students need to be taught according to their capabilities</td>
<td></td>
<td></td>
<td></td>
<td>.473</td>
</tr>
<tr>
<td>K32 A useful way of explaining new knowledge is to use analogies</td>
<td></td>
<td></td>
<td></td>
<td>.428</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>K27 Imagination is a tool to increase understanding</td>
<td></td>
<td></td>
<td></td>
<td>.360</td>
</tr>
<tr>
<td>K05 Good to involve students in making decisions about their learning</td>
<td></td>
<td></td>
<td></td>
<td>.334</td>
</tr>
<tr>
<td>K16 A new topic is best taught in small segments</td>
<td></td>
<td></td>
<td></td>
<td>.332</td>
</tr>
</tbody>
</table>
### Component Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>K15 Best to give students opportunities to work alone, in pairs or in group as needed</td>
<td>.285</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K23 Students who talk a lot are problematic</td>
<td>.677</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K07 Important for students to memorize what they have learnt</td>
<td>.583</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K11 Students need to be punished when they fail to give correct answers</td>
<td>.555</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K06 Important for students to keep their work confidential</td>
<td>.547</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K24 Art has little relevance to science teaching</td>
<td>.535</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K33 Teacher should provide the same activity for all groups of students</td>
<td>.492</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K30 Teachers should choose a teaching strategy which is comfortable for them</td>
<td>.459</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K25 Teachers need to be serious when teaching</td>
<td>.375</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K02 Students decorating the classroom is a waste of time</td>
<td>.371</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K36 Encouraging students to work in groups much of the time is important</td>
<td>-.719</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K18 Group projects are good in teaching</td>
<td>-.654</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K19 Novelty in classroom promotes learning</td>
<td>-.474</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K29 Criticising is a good way to motivate the students</td>
<td>.414</td>
<td></td>
<td>-.470</td>
<td></td>
</tr>
<tr>
<td>K35 New classroom experience should be provided for all the students</td>
<td>-.373</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K28 Students should be given choices in the activities they will be doing</td>
<td></td>
<td></td>
<td></td>
<td>-.667</td>
</tr>
<tr>
<td>K14 Students are not capable of making decisions in classroom</td>
<td></td>
<td></td>
<td></td>
<td>.547</td>
</tr>
<tr>
<td>K03 Difficult for students to remember things that have no meaning to them</td>
<td></td>
<td></td>
<td></td>
<td>.502</td>
</tr>
<tr>
<td>K20 The &quot;chalk and talk&quot; technique is an effective way of teaching</td>
<td></td>
<td></td>
<td></td>
<td>-.282</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 16 iterations.
## Appendix 4-3

**Total Variance Explained (Forced Four-Factor Solutions: 28 Items)**

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total % of Variance</td>
<td>Cumulative %</td>
<td>Total % of Variance</td>
</tr>
<tr>
<td>1</td>
<td>6.620</td>
<td>23.642</td>
<td>6.620</td>
</tr>
<tr>
<td>2</td>
<td>2.786</td>
<td>9.951</td>
<td>2.786</td>
</tr>
<tr>
<td>3</td>
<td>1.768</td>
<td>6.313</td>
<td>1.768</td>
</tr>
<tr>
<td>4</td>
<td>1.615</td>
<td>5.767</td>
<td>1.615</td>
</tr>
<tr>
<td>5</td>
<td>1.237</td>
<td>4.418</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.135</td>
<td>4.054</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1.117</td>
<td>3.991</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 4-4

**Pattern Matrix: Items Moved (Item 29) and Removed**

*(Items 19, 3)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>K08 Students’ potential can be increased by exposing them to variety of experience</td>
<td>.847</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K17 Teachers need to relate the lessons to the students’ life experiences</td>
<td>.741</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K04 Teachers should encourage students to share their ideas</td>
<td>.735</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K21 The teachers’ attitude is an important influence on students’ learning</td>
<td>.656</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K22 Students need to be given opportunities to reflect on what they have learnt</td>
<td>.653</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K31 Students need to be encouraged to have positive attitudes</td>
<td>.637</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K09 Students’ interactions need to be encouraged in the classroom</td>
<td>.620</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K10 Teacher guide students to deepen their understanding of the concepts taught</td>
<td>.611</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K26 Using stories to teach new topics is a waste of time</td>
<td>-.532</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K13 Teachers need to pay attention to students’ emotions in classroom</td>
<td>.530</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K12 Teachers help students understand a concept taught using meaningful themes</td>
<td>.516</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K01 Learning act are best when involve the students’ senses</td>
<td>.502</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K34 Students need to be taught according to their capabilities</td>
<td>.473</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K32 A useful way of explaining new knowledge is to use analogies</td>
<td>.428</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K23 Students who talk a lot are problematic</td>
<td></td>
<td></td>
<td>.677</td>
<td></td>
</tr>
<tr>
<td>K07 Important for students to memorize what they have learnt</td>
<td></td>
<td></td>
<td>.583</td>
<td></td>
</tr>
<tr>
<td>K11 Students need to be punished when they fail to give</td>
<td></td>
<td></td>
<td>.555</td>
<td></td>
</tr>
<tr>
<td>correct answers</td>
<td>Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>-----------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K06 Important for students to keep their work confidential</td>
<td>0.547</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K24 Art has little relevance to science teaching</td>
<td>0.535</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K33 Teacher should provide the same activity for all groups of students</td>
<td>0.492</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K30 Teachers should choose a teaching strategy which is comfortable for them</td>
<td>0.459</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K36 Encouraging students to work in groups much of the time is important</td>
<td>-0.719</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K18 Group projects are good in teaching</td>
<td>-0.654</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K19 Novelty in classroom promotes learning</td>
<td>-0.474</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K29 Criticising is a good way to motivate the students</td>
<td>0.414</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K28 Students should be given choices in the activities they will be doing</td>
<td>-0.667</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K14 Students are not capable of making decisions in classroom</td>
<td>0.439</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K03 Difficult for students to remember things that have no meaning to them</td>
<td>0.502</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
## Appendix 4-5

### Total Variance Explained ( Forced Four-Factor Solutions: 26 Items)

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>6.401</td>
<td>24.619</td>
<td>24.619</td>
</tr>
<tr>
<td>2</td>
<td>2.758</td>
<td>10.607</td>
<td>35.225</td>
</tr>
<tr>
<td>3</td>
<td>1.734</td>
<td>6.668</td>
<td>41.894</td>
</tr>
<tr>
<td>4</td>
<td>1.361</td>
<td>5.236</td>
<td>47.129</td>
</tr>
<tr>
<td>5</td>
<td>1.220</td>
<td>4.692</td>
<td>51.821</td>
</tr>
<tr>
<td>6</td>
<td>1.096</td>
<td>4.216</td>
<td>56.037</td>
</tr>
<tr>
<td>7</td>
<td>1.041</td>
<td>4.004</td>
<td>60.040</td>
</tr>
<tr>
<td>8</td>
<td>.959</td>
<td>3.690</td>
<td>63.731</td>
</tr>
<tr>
<td>9</td>
<td>.895</td>
<td>3.442</td>
<td>67.172</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rotation Sums of Squared Loadings are used for rotation purposes.
Appendix 4-6

Reliability Statistics and Item-Total Statistics (Factor 1)

Reliability Statistics (Factor 1)

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>Cronbach’s Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.881</td>
<td>.885</td>
<td>14</td>
</tr>
</tbody>
</table>

Item-Total Statistics (Factor 1)

<table>
<thead>
<tr>
<th>K08 Students’ potential can be increased by exposing them to a variety of experience</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.75</td>
<td>20.84</td>
<td>.68</td>
<td>.49</td>
<td>.87</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K17 Teachers need to relate the lessons to the students’ life experience</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.87</td>
<td>20.89</td>
<td>.65</td>
<td>.49</td>
<td>.87</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K04 Teachers should encourage students to share their ideas</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.82</td>
<td>21.15</td>
<td>.62</td>
<td>.46</td>
<td>.87</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K21 The teachers’ attitude is an important influence on students’ learning</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.99</td>
<td>20.88</td>
<td>.61</td>
<td>.47</td>
<td>.87</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K22 Students need to be given opportunities to reflect on what they have learnt</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.08</td>
<td>21.14</td>
<td>.60</td>
<td>.40</td>
<td>.87</td>
<td></td>
</tr>
</tbody>
</table>
K31 Students need to be encouraged to have positive attitudes
K09 Students’ interactions need to be encouraged in the classroom
K10 Teacher guide students to deepen their understanding of the concepts taught
RK26 Using stories to teach new topics is not a waste of time
K13 Teachers need to pay attention to students’ emotions in classroom
K12 Teachers need to help students to understand a concept by using meaningful themes
K01 Learning activities are best when involve the students’ senses
K34 Students need to be taught according to their capabilities
K32 A useful way of explaining new knowledge is to use analogies
## Appendix 4-7

### Reliability Statistics and Item-Total Statistics (Factor 2)

**Reliability Statistics (Factor 2)**

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>Cronbach’s Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.701</td>
<td>.701</td>
<td>8</td>
</tr>
</tbody>
</table>

**Item-Total Statistics (Factor 2)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>K06</td>
<td>21.31</td>
<td>14.098</td>
<td>.416</td>
<td>.211</td>
<td>.668</td>
</tr>
<tr>
<td>K07</td>
<td>20.41</td>
<td>15.572</td>
<td>.363</td>
<td>.166</td>
<td>.679</td>
</tr>
<tr>
<td>K11</td>
<td>22.24</td>
<td>14.405</td>
<td>.434</td>
<td>.250</td>
<td>.663</td>
</tr>
<tr>
<td>K23</td>
<td>21.71</td>
<td>14.998</td>
<td>.422</td>
<td>.286</td>
<td>.667</td>
</tr>
<tr>
<td>K24</td>
<td>21.50</td>
<td>14.791</td>
<td>.405</td>
<td>.215</td>
<td>.670</td>
</tr>
<tr>
<td>K29</td>
<td>21.34</td>
<td>15.015</td>
<td>.364</td>
<td>.227</td>
<td>.679</td>
</tr>
</tbody>
</table>
K30 Teachers should choose a teaching strategy which is comfortable for them.

K33 Teacher should provide the same activity for all groups of students.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.41</td>
<td>16.414</td>
<td>.304</td>
<td>.163</td>
<td>.690</td>
</tr>
</tbody>
</table>
Appendix 4-8

Reliability Statistics and Item-Total Statistics (Factor 3)

Reliability Statistics (Factor 3)

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>Cronbach’s Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.602</td>
<td>.605</td>
<td>2</td>
</tr>
</tbody>
</table>

Item-Total Statistics (Factor 3)

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>K18 Group projects are good in teaching</td>
<td>3.69</td>
<td>.533</td>
<td>.434</td>
<td>.188</td>
<td>-</td>
</tr>
<tr>
<td>K36 Encouraging students to work in groups much of the time is important</td>
<td>4.09</td>
<td>.426</td>
<td>.434</td>
<td>.188</td>
<td>-</td>
</tr>
</tbody>
</table>
### Appendix 4-9

#### Reliability Statistics and Item-Total Statistics (Factor 4)

**Reliability Statistics (Factor 4)**

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>Cronbach’s Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.393</td>
<td>.394</td>
<td>2</td>
</tr>
</tbody>
</table>

**Item-Total Statistics (Factor 4)**

<table>
<thead>
<tr>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>K28 Students should be given choices in the activities they will be doing</td>
<td>3.65 .662</td>
<td>.245</td>
<td>.060</td>
<td>-</td>
</tr>
<tr>
<td>RK14 Students are capable of making decisions in the classroom</td>
<td>3.65 .557</td>
<td>.245</td>
<td>.060</td>
<td>-</td>
</tr>
</tbody>
</table>
Appendix 4-10

Total Variance Explained (Forced Two-Factor Solution)

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>5.87</td>
<td>27.94</td>
<td>27.94</td>
</tr>
<tr>
<td>2</td>
<td>2.54</td>
<td>12.10</td>
<td>40.04</td>
</tr>
<tr>
<td>3</td>
<td>1.30</td>
<td>6.17</td>
<td>46.22</td>
</tr>
<tr>
<td>4</td>
<td>1.09</td>
<td>5.17</td>
<td>51.39</td>
</tr>
<tr>
<td>5</td>
<td>1.02</td>
<td>4.83</td>
<td>56.22</td>
</tr>
<tr>
<td>6</td>
<td>1.00</td>
<td>4.77</td>
<td>60.99</td>
</tr>
<tr>
<td>7</td>
<td>.86</td>
<td>4.08</td>
<td>65.08</td>
</tr>
<tr>
<td>8</td>
<td>.82</td>
<td>3.93</td>
<td>69.00</td>
</tr>
<tr>
<td>9</td>
<td>.79</td>
<td>3.77</td>
<td>72.77</td>
</tr>
<tr>
<td>10</td>
<td>.74</td>
<td>3.54</td>
<td>76.31</td>
</tr>
<tr>
<td>11</td>
<td>.69</td>
<td>3.27</td>
<td>79.57</td>
</tr>
<tr>
<td>12</td>
<td>.64</td>
<td>3.04</td>
<td>82.62</td>
</tr>
<tr>
<td>20</td>
<td>.31</td>
<td>1.46</td>
<td>98.74</td>
</tr>
<tr>
<td>21</td>
<td>.27</td>
<td>1.27</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.

<sup>a</sup> When components are correlated, sums of squared loadings cannot be added to obtain a total variance.
Appendix 4-11

Examples of Teachers’ Interview Feedback

Participant: Male, aged 41 to 50

Written Document Schedules

Opening Statement: Dear teacher, to help clarify some of my results and to provide more detail, I will be most grateful if you can respond to the following questions:

4. Most teachers disagree with punishing students if they fail to give correct answers. Why do you think this is so?
   i. This will create unnecessary fear in students (fear to say something different/fear to give a try to answer the question posed) whereas learning should be able to tap the potential of students and response because of their diverse background and levels of understanding. Making mistakes is also part of learning.
   ii. Lack of confidence in students due to the ‘chance/opportunity’ is not given; missing the nurturing aspect the education. Shouldn’t educator nurture students’ creative minds based on their ‘creative answers’? By punishing students for not giving correct answers, a signal is enforced: the culture of diverse thinking is not welcomed, but must follow the only answer provided. Should it be better just to ask them to make corrections to the mistakes done? Punishing for disciplinary matter is different.
   iii. I don’t think the objective of education will be achieved by carrying out that sort of punishment: what type of students that we are going to create? Just ‘waiting to receive the correct answer’ attitude is not what education is all about. We hope one day the students are able to think reasonable in facing challenges rather than be a ‘static robot’

5. The majority of teachers thought that teachers should choose a teaching strategy which is comfortable for them. What is your opinion?
   I believe that each one of us love to follow something close to them, something we have confidence in and have knowledge about it. With experience, a teacher can
formulate a teaching strategy which he/she thought will work to achieve the teaching objective. Different classes with different levels of students will make the teacher to think how best to deliver the lesson and its impact to the students— as can be seen from the students’ reactions, should be the positive one.

6. Do you think criticism is a useful way to motivate students?
(Why/Why not?)
Criticism can motivate the students if it means correcting mistakes step by step to achieve the desired objective. It is a sort of opening the mind and not chopping the ideas posed by the students right away. Teachers need to guide the student from not knowing to better understanding, from lack of confidence to more confidence in carrying out tasks. This is the sort of constructive criticism. Criticism (destructive) can demoralise students if language used is not appropriate in pointing out their mistakes/for not knowing.

Thank you for your co-operation and great effort to answer the questions.
Participant: Female E, aged more than 50

Written Document Schedules

Opening Statement: Dear teacher, to help clarify some of my results and to provide more detail, I will be most grateful if you can respond to the following questions:

1. Most teachers disagree with punishing students if they fail to give correct answers. Why do you think this is so?
   Firstly, I would like a clear picture with the term **Punishment**. Punishing is a severe form of action imposed on a student for a small mistake like failing to give a correct answer. I encourage students to answer questions using logic and prior knowledge and somehow if they make mistakes, correct them there and then, so as they realize their mistakes, relate to the correct answer and they will remember the correct answer well. Punishing students will distance the child from the teacher, build a negative perception by the students on the teacher and has negative impact on the learning process whereby the students fear to make another mistake, or afraid and feel embarrassed should they make mistake. I truly believe in learning through mistakes. Anyway, nobody is perfect! Forever making mistakes is not the case here because instruction does not happen here.

2. The majority of teachers thought that teachers should choose a teaching strategy which is comfortable for them. What is your opinion?
   In a way, yes. When I am comfortable with a teaching strategy, I guess I feel at ease, more confident with what I do. That doesn’t mean I only stick to one type of instruction method all the time. A teacher will be bored too with the same method all of the time. We become predictable. Got to change and create variety to avoid students feeling bored and these changes sort of creates an air of excitement in class.
3. Do you think criticism is a useful way to motivate students?
(Why/Why not?)
Yes, sometimes (or most of the time!). Students nowadays are able to accept criticism as a way of life as they frequently watch reality shows. It seems, this is a way of life now, and becoming a trend. Criticism should be done in a positive way. Facial expression and body language by teacher should not be harsh thus, students take it negatively. Criticism will actually train the students to be able to accept their wrongdoings/mistakes and rectify them willingly. This is good to prepare them to be a positive-minded individual.

Thank you for your co-operation and great effort to answer the questions.