

# **THE EFFECT OF THE PEDAGOGY ON THE CLASSROOM LEARNING OF SCIENCE**

By Stephen John Tynan.

G. Cert. (Theology), University of Newcastle, 2012.

G. Dip. (Secondary Science Education), University of Canberra, 2003.

M.B.A., Australian National University, 2000.

Ph.D., University of New South Wales, 1997.

B. App. Sc. (Medical Laboratory Science), 1989.

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Education at the University of New England.

## **Declaration of originality.**

I hereby declare that this submission is my own work and that to the best of my knowledge and belief, it contains no material previously published or written by another person nor material to which a substantial extent has been accepted for the award of any other degree or diploma of a university or other institute of higher learning, except where due acknowledgement is made in the text.

## Statement of authorship.

### University of New England Research Services

#### STATEMENT OF AUTHORSHIP

On each occasion that research is made public the forms 'Statement of Authorship' and 'Location of Data' must be filled out, signed and lodged with the Head of the Department of which the principal researcher is a member. If, for any reason, one or more co-authors are unavailable or otherwise unable to sign the statements, the Head of Department may sign on their behalf, noting the reason for their unavailability. Heads of Departments must keep copies of these statements in departmental files.

#### Definition of Authorship

*Authorship is defined as substantial participation, where all the following conditions are met:*

- (a) conception and design, or analysis and interpretation of data, and*
- (b) drafting the article or revising it critically for important intellectual content, and*
- (c) final approval of the version to be published.*

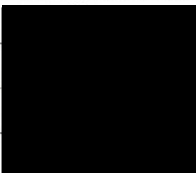
*An author's role in a research output must be sufficient for that person to take public responsibility for at least part of the output in that person's area of expertise. No person who is an author, consistent with this definition, must be excluded as an author without their permission in writing.*

Responsible or principal author(s): **Stephen John TYNAN**

School: **School of Education.**

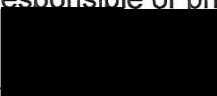
Institution: **University of New England.**

The author of the paper entitled: **'The Bios pedagogy: A causal comparative study in the translation and effect of cognitive neuroscience in the classroom learning of science'**, submitted to: **The University of New England** on 31<sup>st</sup> October, 2015, is the undersigned and there are no other authors.

NAME	SCHOOL/CENTRE	SIGNATURE
<b>Stephen John TYNAN</b>	Education	

Statement by the responsible or principal author:

I am the responsible or principal author.

SIGNED:  \_\_\_\_\_

DATE:  31-10-2015

**Abstract.**

Two different types of teaching practices were examined for their effects upon the student learning of high school science, being Bios practices and Conventional practices. Bios teaching practices were underpinned by five propositions founded upon the cognitive neuroscience of how the brain learns; as interpreted in the midst of a mixed gender classroom of 20-plus teenage (about 15 to 16 year old) students. These propositions were formulated in response to classroom observations which indicated that student attention, sociability and dialogue could be brought together to promote engagement with classroom learning. Critical to this was the teacher being the dialogical focal point upon which these variables were amalgamated. Consequently, the teacher had an active role in the formation of classroom memory as it is occurring. The conventional conception of the role of the teacher in learning is that one is a manager of classroom learning. This is also achieved by five teaching propositions but which do not give the teacher a critical role in the formation of classroom memory. Hence, one manages the behavioural climate of the classroom to ensure that student engagement with learning is optimal; it is the students' responsibility to muster their own cognitive resources (independent of the teacher) to become engaged with their classroom learning. The stimulus for this reinterpretation of the role of the classroom teacher in learning was that nothing I had learned during my scientific career was reflected in 'best teaching and student learning' practice.

The study was situated in a Catholic weekly boarding high school located in regional NSW, Australia. It covers the period from 2003 till 2010. Science classes were 50 minutes long and taught according to the propositions. From 2003 to 2006, all science classes received Conventional teaching practices. From 2008 to 2010, one group of science classes received Bios teaching practices whilst the others received Conventional teaching practices. Student learning outcomes of the Author's Conventional and Bios taught classes were compared to those of other Conventionally taught classes.

The study used Mahalanobis distance measures to match comparable classes. It then applied regression methods to statistically examine science test-retest scores and the contribution of cognitive test scores for probable differences in student learning processes (at the 95% confidence interval). The corrected effects of the Bios propositions upon classroom learning relative to the Conventional propositions thus include a medium partial correlation (.28) in the test-retest science score, with which reading was uniquely associated via a small partial correlation (.09) and a medium partial mediation (.11). These corrected effects were associated with improved student behaviour and greater classroom participation, as well as a sense of trust by the teacher that the class was doing its best as students and young adults.

The significance of the work is that desirable student learning outcomes did not occur in response to the five Conventional propositions; the dominant view of how best to promote student learning. This state reflects theoretical concerns associated with teaching practices that do not intertwine with the cognitive architecture of the learning mind. Alternatively, the five Bios propositions do seem to mesh and probably had their general effect on episodic memory via the extent and richness of the dialogue shared with the teacher. It is concluded that teachers need a greater understanding of the cognitive role that shared language has in the formation and application of memory if students are to more effectively develop their potential to learn. It is recommended that providers of teaching qualifications adjust their courses to ensure future teachers possess a working knowledge of the role of cognitive neuroscience in teaching. Finally, in terms of practice, it is recommended that instead of teachers talking to students, they talk with students. This would promote more favourable episodic memories of classroom experiences and thus, autobiographical knowledge construction processes in the student ZPD.

## **Acknowledgements.**

This has been an abnormally long and personally draining experience. I now look forward to having a normal life. One in which I can spend more time with my wife, Lizabeth, and my most adorable daughters, Maria (11 years) and Grace (9 years). No more getting up at 4 am to write for a few hours before going to work and being immersed in the world of learning children. So, to my wonderful family, thank you for the quiet times and thank you for the noisy times. I have finished and my time is now all yours.

I would also like to thank my mum and my aunt; just because.

## Table of Contents.

Declaration of originality.....	1
Statement of authorship.....	2
Abstract.....	3
Acknowledgements.....	5
Table of Contents.....	6
List of Figures.....	9
List of Tables.....	10
CHAPTER 1: The epistemological framework of classroom work and research.....	11
Pragmatic inquiry.....	14
The information and action schism.....	18
The difference between theoretical and practical research.....	26
The classroom workplace and education theory.....	33
The context.....	39
Understanding mapped backwards to information.....	41
CHAPTER 2: Introduction.....	44
Biology: the masked variable in the teacher professional practice.....	45
The brain's information processing architecture.....	55
The organisation of long term memory.....	56
Episodic thinking.....	58
Autobiographical memory.....	62
The multicomponent model of working memory.....	66
Working memory and problem solving.....	69
Representation of knowledge.....	70
Attention, affect and cognition.....	72
Processing language in the mind.....	75
The formation of cognitive structures in the classroom.....	76
Working memory and the classroom.....	80
Managing working memory in the classroom.....	82
Working memory training.....	86
The teacher, the classroom, language and cognitive development.....	87
The teacher's autobiographical self.....	90
Conventional (counterfactual) learning and teaching practices.....	99

The propositions of the Conventional classroom learning.....	100
Bios learning and teaching practices.....	101
The propositions of the Bios classroom learning.....	103
The five bios propositions as they are routinely enacted in the classroom. ....	105
The core neuroscience concepts that inform L&T practices.....	107
The professional and academic context. ....	109
Aim. ....	110
CHAPTER 3: Methodological framework. ....	111
Nature of the study.....	111
Justification for the statistical methods of the study. ....	115
Sequence of the study. ....	118
Correspondence criteria for assigning a causal effect.....	119
A summary of causal effects criteria.....	125
CHAPTER 4: Methods. ....	128
Demographic profile of school. ....	128
Classroom practice.....	129
Data entry.....	130
Exploratory plots.....	131
Matching of classes.....	131
Data grouping.....	131
Regression analysis.....	132
Mediation analysis. ....	133
Power analysis. ....	134
CHAPTER 5: Results. ....	135
Introduction.....	135
Is the data normal?.....	136
Is there a difference in the influence of different L&T practices upon student learning? .....	147
Is there a difference in the cognitive processes underpinning different L&T practices?.....	151
The mediated effect of reading upon exam achievement.....	159
The general effect of Conventional L&T practices upon student learning.....	161
Adjusted effect sizes of Bios L&T practices.....	165
Classroom observations and reflections of the Bios teacher.....	166
Summary. ....	167
CHAPTER 6: Discussion.....	169

Preamble. ....	169
The heuristic framework. ....	171
Learning in the counterfactual classroom. ....	173
How reliance on text stifles classroom learning. ....	175
Learning in the Bios classroom.....	182
Working memory and reading. ....	184
Working memory and writing. ....	186
Phonological processes and reading. ....	187
Sequestering LTM into working memory.....	190
Episodic memory, the attention and LTM. ....	193
“Everybody knows what attention is.” .....	200
The pedagogical model. ....	205
Limitations and future direction of the research. ....	209
CHAPTER 7: Exegesis.....	212
Pragmatic information and knowledge. ....	214
The lexical quality hypothesis and working memory. ....	215
Closing. ....	218
A request of the Examiners.....	231
Conclusion. ....	233
Appendix 1.....	234
Copyright compliance table. ....	235
Right of access to thesis. ....	236
Thesis presentation form.....	238
Location of data. ....	239
Ethics approval.....	240
REFERENCES. ....	241



## List of Figures

Figure 1. The information processing model of human memory. ....	55
Figure 2. The structure of long term memory. ....	56
Figure 3. The sociocultural mode of the development of autobiographical memory. ....	65
Figure 4. The multicomponent model of working memory. ....	66
Figure 5. Results criteria. ....	126
Figure 6. Scatter plots of yearly Trial and SC exam scores. ....	135
Figure 7. The Mahalanobis distance profiles of individual science classes.....	136
Figure 8. Exploratory scatterplots of grouped data. ....	137
Figure 9. Box plots of possible non-normal data. ....	139
Figure 10. Bivariate residuals. ....	140
Figure 11. Multivariate residuals. ....	142
Figure 12. Difference in mean Trial science exam scores of matched groups. ....	146
Figure 13. Difference in $r$ of bivariate models.....	147
Figure 14. Difference in multivariate means.....	150
Figure 15. Corrected Bios effect sizes. ....	164
Figure 16. The A-frame heuristic. ....	172
Figure 17. Models of single word processing. ....	188

## List of Tables

Table 1. Shapiro-Wilk statistics of regression data. ....	138
Table 2. The Durbin-Watson statistics of regressed data. ....	145
Table 3. Predictors of SC exam achievement. ....	151
Table 4. The contribution of growth in cognitive variables to SC exam achievement. ...	153
Table 5. The contribution of cognitive variables to SC exam achievement. ....	154
Table 6. The partial correlation of individual cognitive variables. ....	156
Table 7. The mediated effect of reading upon SC science exam achievement. ....	158
Table 8. The general effect of Conventional L&T practices upon student learning. ....	160
Table 9. Regression and multiple mediation models of whole school science exam achievement. ....	162
Table 10. NAPLAN (2009-2010) predictors of SC exam achievement. ....	233