THE SCIENCE OF LEARNING AND DEVELOPMENT IN EDUCATION

A Research-based Approach to Educational Practice

All teachers need to understand how children and adolescents learn and develop. Traditionally, teachers' understandings were informed by a mix of speculative theory and scientific evidence. However, recent scientific research has provided new insights into how children and adolescents learn and develop that are particularly relevant to teachers. *The Science of Learning and Development in Education* provides teachers with an exciting and comprehensive introduction to this new and emerging field.

This innovative text introduces readers to brain science and the science of complex, dynamic systems as applied to human development. It does not assume or require any prerequisite knowledge and it situates the scientific study of learning and development firmly within the academic discipline of education and its practice in schools and classrooms. Part 1 examines the science of learning and development in the twenty-first century; Part 2 explores the emotional, cultural, moral and empathetic brain; and Part 3 focuses on learning, wellbeing and the ecology of learning environments.

Each of the 11 chapters guides the reader through the subject matter and relevant concepts and terminology. Readers are encouraged to take a critical approach to their study and are provided with opportunities to reflect on key issues as they arise, via questions and prompts interspersed throughout the text.

Written in an engaging style by experts and generously illustrated with colour photographs and diagrams, *The Science of Learning and Development in Education* is an essential resource for pre-service teachers entering the profession, and a valuable aid for all teachers wishing to deepen their scientific understanding of learning and development.

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To the future …
For Diana, Markos, Laon and Dawon

FOREWORD

When the findings of projects from the Australian Values Education Program (AVEP) (2003–2010) became apparent, there was much talk of a 'surprise effect'. The surprise was that a program designed to enhance values-based education included such a strong academic achievement effect. From the very first project, the Values Education Study, along with the predictable outcomes of improved behaviour, enhanced relationships and a more settled environment, came evidence of greater student engagement and academic results, along with an allied strengthening of teachers' pedagogical practice. Six years later, analysis of all the findings in the evaluation study, loosely called The Testing and Measuring project, 'was guided by the conceptual framework established … between values education, school ambience and student academic diligence (Lovat & Dally, 2018, p. 7).' In time, the notion of 'surprise effect' was replaced with 'brain effect' or 'knowing effect' as neuroscientific and epistemological research helped to explain why the surprise was no surprise at all.

In somewhat similar ways, this 'project' by Minkang Kim and Derek Sankey will likely engender a surprise effect that should be no surprise at all. In introducing the 'brain effect' and 'knowing effect' in educational contexts, the authors show that concern for a scientific, evidence-based understanding of student academic achievement *necessarily* entails grappling with notions of value, emotion, empathy and the wellbeing of each and every individual student. Adopting a scientific approach to student learning and development in education *necessarily* involves interweaving the biological, sociocultural, relational and environmental factors involved.

In a sense, the wisdom that underpinned the AVEP effect, which is further evidenced in this book, is so deeply embedded in our knowledge tradition that the only real surprise was that we would have ignored or forgotten it. One of Socrates' pupils, Antisthenes (445–365 BCE), wrote that Pythagoras, a hundred years beforehand, had learned that the art of effective learning was in prioritising the wellbeing of the individual student and tailoring education to the individual student's needs. He wrote that Pythagoras regarded it as 'stupidity' itself that standardised expectations should be imposed on a diverse audience (Horky, 2013). Yet we live in times where educational systems inflict that very stupidity on generations of students. We also know through Pythagoras's biographers that he discovered – no doubt through trial and error – that his pupils excelled in mathematics (his prime concern) when immersed in multidisciplinary curricula (Stanley, 2010). Dance, theatre and music were especially important. Yet, we live in times where even kindergarten teachers are heard saying, 'we don't have time for play, for music.'

Similarly, the medieval Persian scholar, Abu al-Ghazali (1056–1111 CE), asserted that the most important element in any effective education is in instilling imaginativeness and eliciting wonder because these are the intellectual skills necessary to lifelong learning. The assertion is found in the context of his warning to teachers to avoid prescriptive and rote forms of learning because they dull the mind and kill off the desire to learn (Karim, 2003). Ghazali's warning fits well with updated findings from brain science (Narvaez, 2016; Gotlieb et al., 2016), which emphasise the indispensable interdependence of human emotion, sociality, morality and imagination in the business of learning. It also fits well with the ground-breaking work of Habermas (1972; see also Leydesdorff, 2000), whose 'ways of knowing' theory contains its own warning that the only true knowing comes when the cognitive interest to imagine is triggered. Yet we live in times that prioritise rote learning in schools

and universities to the point where their measurable products have come to define the success of the institution and the key performance indicators of teachers, lecturers and institution heads. And we seem tin-eared to the educational damage this is causing.

In a word, this is why the work of Minkang Kim and Derek Sankey is so important and so timely. It focuses principally on the ramifications of the findings of cutting-edge brain science and complex systems theory for human learning and development. It offers a distilled version of the complexities therein in a logical, step-by-step and highly digestible form, such that the reader does not need a background in these sciences in order to understand the book's content. Nonetheless, one can be certain that the reader's understanding of the nuances of learning will be deepened by the reading, regardless of their background. However, its unique contribution is in offering insights into the wisdom of the past through sifting the findings of the most recent research in brain and systems sciences.

I proffer that the book lays bare why the surprise effect of AVEP was no surprise at all and why the only surprise left is that our systems of learning so persistently gravitate to that sign on the exit lane of the highway, 'Stop: You are Going the Wrong Way!' This excellent book gets us all back on the right road.

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CONTENTS

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Derek Sankey (PhD), now retired, gained his PhD at the Institute of Education, London University, where he taught and researched from 1986 to 1995, playing a leading role in teacher education reform. He had previously directed a national project for the Farmington Institute, Oxford on the interface between science, religion and the humanities. He taught at the Hong Kong Institute of Education from 1995 to 2006. His academic background is in the history and philosophy of science, with a particular interest on the interplay of philosophy and neuroscience. His ongoing research is focused on the application of complexity theory and neuroscience in understanding the human self and its education.

PREFACE

When the American National Academy of Sciences published the second edition of *How People Learn* in 2018, they noted that, since the publication of the first edition in 2000, 'researchers have continued to make important discoveries about influences on learning, particularly sociocultural factors and the structure of learning environments. At the same time, technological developments have both offered new possibilities for fostering learning and created new learning challenges' (NASEM, 2018, p. 1). This new body of scientific research is revealing that, 'Learning is a remarkably dynamic process; from before birth and throughout life, learners adapt to experiences and their environment' (p. 3).

The aim of this new text is to introduce teachers to the *dynamics* of learning and development and the many changes that have taken place as a result of *scientific research* over the past quarter of a century, and their historical foundations. It is especially concerned with the interplay between the biological and sociocultural factors that influence learning, as well as the impact of learning environments. The focus of this book is on what scientific *research* and taking a *scientific approach* to understanding learning and development are able to offer education in deepening teachers' understandings of children and adolescents in their care – hence the emphasis in the book's title on 'the science' of learning and development, while recognising the contribution of many sciences in deepening our understandings as educators.

The past quarter of a century has witnessed a quiet revolution in two main areas of scientific research that are especially relevant to education, namely the changes that have occurred in our understanding of *brain science* and the *science of complex systems* as it applies to human development. These changes have challenged, and are still challenging, many previous beliefs about how children and adolescents learn and develop – and, indeed, about how we should view them as learning and developing, sentient, emotional, relational beings.

Although this book does not require any prerequisite knowledge of brain science or the science of complex systems, it nevertheless takes the reader, step by step, to the cutting edge of the dynamics of child and adolescent learning and development. In doing so, it encourages readers to take a critical approach to their study of learning and development and introduces them to some of the core philosophical issues that arise in regard to the science being discussed. Moreover, it situates the scientific study of learning and development firmly within the study of education, conceived as a discrete discipline in its own right, although always in cross-disciplinary dialogue with other relevant disciplines.

Past and present students may recognise some topics previously covered in lectures and seminars, but this book does not contain previous lecture or seminar notes. From the start, the aim was to provide an entirely new text, tailored to meet the varying needs of multiple readers, including preservice and in-service teachers, but also parents curious to know what is happening in the heads of their children, as they learn and develop.

It is our earnest hope that all readers will enjoy engaging with this book as much as we have enjoyed writing it. We wish you all the best for your continued learning and development, as you constantly adapt to the changing experiences afforded by the many dynamic, physical and sociocultural environments you will encounter on your continuing life's journey.

Minkang Kim and Derek Sankey

Sydney, Australia, 2022

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HOW TO USE THIS BOOK

In using this book, you will quickly discover you don't require prior knowledge of the science. It is recommended that chapters be read in sequence, as they are progressive, deepening your understanding as you move through the book. You will also discover that the book does not simply provide the 'scientific facts' of what is currently known about how we learn and develop, but also offers historical background to current knowledge and understandings and raises important philosophical issues about how we understand ourselves in light of the science of human learning and development.

Various features are used throughout the book in order to enhance your own learning and development. You will find that many of these features help to deepen an understanding of the topics being presented.

CONCEPT MAPS

Each of the three parts of the book is introduced with a concept map that provides a visual explanation and connection between the concepts discussed in the chapters that follow.

REFLECTION

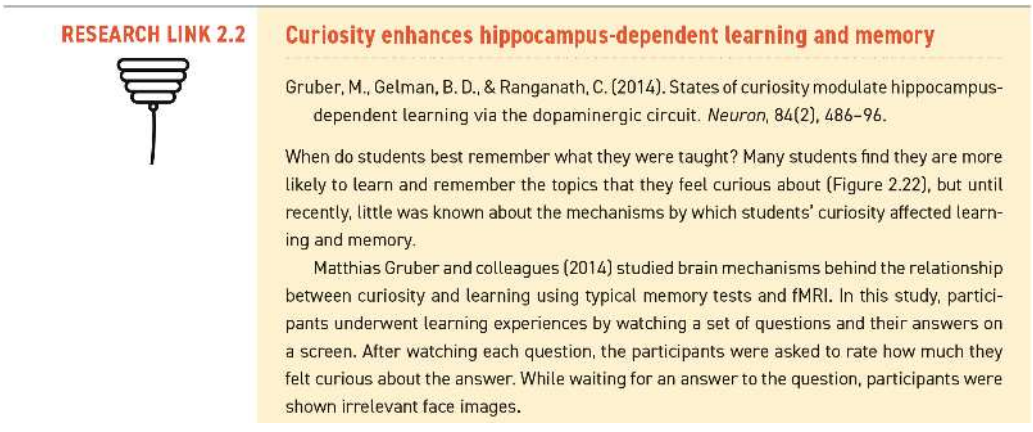
Reflection prompts appear throughout each chapter to encourage you to take a moment to pause and briefly reflect on important points raised in the text.

REFLECTION

Using the metaphor of the teacher's professional toolkit, in addition to a sound and accurate understanding of how children and adolescents learn and develop, what other professional 'tools' do teachers need, as an absolute priority, to do their job effectively?

RESEARCH LINKS

Links to research throughout each chapter provide extensive discussion on relevant and essential explorations of concepts and focus areas. They also provide important context for the discussion, as well as further understanding of scientific progress in the education field.


RESEARCH LINK 2.2

Curiosity enhances hippocampus-dependent learning and memory

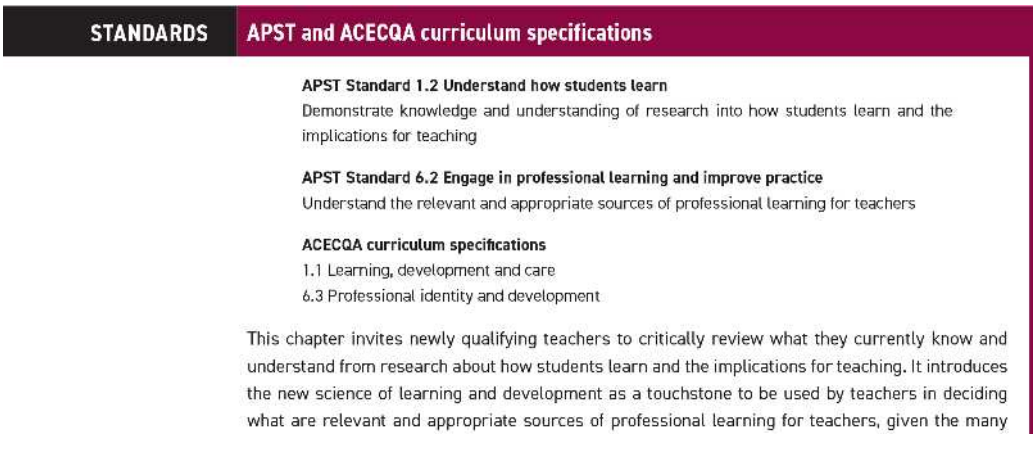
Gruber, M., Gelman, B. D., & Ranganath, C. (2014). States of curiosity modulate hippocampus-dependent learning via the dopaminergic circuit. *Neuron*, 84(2), 486–96.

When do students best remember what they were taught? Many students find they are more likely to learn and remember the topics that they feel curious about (Figure 2.22), but until recently, little was known about the mechanisms by which students' curiosity affected learning and memory.

Matthias Gruber and colleagues (2014) studied brain mechanisms behind the relationship between curiosity and learning using typical memory tests and fMRI. In this study, participants underwent learning experiences by watching a set of questions and their answers on a screen. After watching each question, the participants were asked to rate how much they felt curious about the answer. While waiting for an answer to the question, participants were shown irrelevant face images.

APST AND ACECQA CURRICULUM SPECIFICATIONS

Each chapter ends by identifying the Australian Professional Standards for Teachers (APST) (AITSL, 2011) and Australian Children's Education and Care Quality Authority (ACECQA) standards (ACECQA, 2021) or focus areas most relevant to the material. The APST enumerate essential knowledge, professional skills and engagement for teachers, organisations and professional associations. The full standards are available online at: www.aitsl.edu.au/teach/standards. The ACECQA standards provide essential resources, guidance and support to governments to ensure quality outcomes across Australia in children's education. The full standards are available online at: www.acecqa.gov.au/nqf/national-quality-standard.


STANDARDS

APST and ACECQA curriculum specifications

APST Standard 1.2 Understand how students learn
Demonstrate knowledge and understanding of research into how students learn and the implications for teaching

APST Standard 6.2 Engage in professional learning and improve practice
Understand the relevant and appropriate sources of professional learning for teachers

ACECQA curriculum specifications
1.1 Learning, development and care
6.3 Professional identity and development

This chapter invites newly qualifying teachers to critically review what they currently know and understand from research about how students learn and the implications for teaching. It introduces the new science of learning and development as a touchstone to be used by teachers in deciding what are relevant and appropriate sources of professional learning for teachers, given the many

KEY POINTS FOR TEACHERS

Each chapter ends with a summary of important points for teachers to encourage reflection on the importance of interweaving research outcomes with the practical applications of each concept or focus area in the classroom.

- Affordances are not only provided by the structure of the space, but also by the design and configurations of furniture placed in a learning space. Whatever classroom you find yourself in as a teacher, try to see how you can creatively use and even enhance the affordances it provides.

REVIEW QUESTIONS

Guided responses

1. What is meant by 'analogy' and what do you think one brain scientist would have meant by saying that a characteristic of good teachers is their ability to create appropriate analogies for explanation and clarification (Geake, 2009, p. 95)?
2. Can you name and explain four characteristics of environmental ecosystems that can be applied as similarity relations in understanding classrooms as ecosystems?
3. What is meant by embodied cognition and how is that related to conceiving the brain as a feedback control system, employing perception/action feedback loops?
4. What, precisely, is meant by Gibson's notion of affordance and how is it applicable in understanding classroom learning environments?
5. What factors have contributed to a resurgence of research into open-plan classroom design and what has contributed to resolving the problem of noisy open-plan classrooms?

FOOD FOR THOUGHT

1. In what ways could picturing classrooms as highly dynamic and variable ecosystems help to explain why teaching can be very unpredictable, such that even the best planned lessons could fail to engage students? How might this help beginning teachers to reassess what can sometimes turn out to be chaotic lessons?
2. We use analogies and metaphors in all our thinking and also in science, but it is very important to note that some can prove to be very misleading if taken too literally. Would it be better if teachers did not use metaphors in their classroom teaching, or is that impossible – is language inherently analogical and metaphorical?

RESEARCH ACTIVITY: DESIGNING INNOVATIVE LEARNING SPACES

In many parts of the world, there is growing recognition that a physical learning environment is one of the critical parts of the school ecosystem. For example, the New Zealand Ministry of Education stresses that learning environment design should aim to align 'social', 'pedagogical' and 'physical' elements, and it should be 'capable of evolving and adapting as educational practices evolve and change – thus remaining future focused' (New Zealand Ministry of Education, 2018, para. 1).

Below is the list of government webpages that emphasise the importance of quality learning spaces. These webpages showcase photos of different schools that the government recognises as being equipped with well-designed learning spaces.

- NSW Department of Education: 'Learning Space Gallery'
- NSW Department of Education: 'Learning Space Videos'

REVIEW QUESTIONS

The end-of-chapter review questions prompt you to reflect on the central learnings of each chapter. You can test your knowledge by responding to each of the questions after you have worked your way through the material. Guided responses to these questions are available in the book's online resources.

FOOD FOR THOUGHT

The end-of-chapter 'Food for thought' questions encourage further discussion on the central learnings of each chapter. They provide the opportunity to think critically about their application in real-life settings and to communicate your understanding of the material.

RESEARCH ACTIVITY

The end-of-chapter research activities provide an opportunity to further your knowledge on a particular concept or focus area mentioned in the chapter by engaging with material through traditional research. Prompts and links to recommended resources are provided.

ONLINE RESOURCES

The student online resources for *The Science of Learning and Development in Education* are freely available online at: www.cambridge.org/highereducation/isbn/9781108999786/resources. Visit the site to explore a variety of resources, including weblinks and guided responses to the review questions.

This margin icon is used throughout the book to indicate that a resource relating to the content under discussion is available online. The icon's descriptor can be used to help you easily identify each resource in the chapter's downloadable document.