Knowledge and/for learning

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A personal introduction

When thinking about what teachers need to know and be able to do, there is much discussion in the New Zealand context about the importance of curriculum knowledge (what to teach) and pedagogy (how to teach), but considerably less time given to an area of research commonly called the science of learning (the neuroscience of how people learn). Indeed in my own experience (which certainly should not be taken as being representative of any wider context), it was not until I started my master's that I first really engaged with the research literature on how people learn, and it was much later still that I became interested in the connections between neuroscience and education.

These first encounters with research on learning were something of a revelation for me. I was struck by how useful this knowledge would have been when I was in the classroom, providing guidance on how to structure my teaching in ways that would most benefit my students' learning. It also was fascinating to find the scientific evidence base for some of the insights I had tacitly gleaned about my own learning over the years. It is some of this research on the science of learning that forms the basis of the argument here – that knowledge is critical to learning.

Knowledge of/for learning

While for many the statement that knowledge is intimately connected to learning and to education would seem axiomatic, it is not as straightforward or apolitical a statement as it would outwardly seem. Increasingly, gaining knowledge is seen as a secondary goal of our education system. It is the development of competencies and skills, such as critical thinking and problem solving, which is the primary goal. These generic skills and competencies undoubtedly are an important component of our education system – indeed employers consistently rank so-called soft skills such as collaboration, critical thinking and communication at the top of their list of desirable skills for employees.

While skills and competencies are undoubtedly important – for both an education and life more generally to develop – cognitive psychological research has demonstrated that general abilities and skills cannot be studied independently of content domains. For instance, while it is possible to teach general principles or approaches to problem solving, the ability to utilise these in response to a specific problem requires relevant content knowledge. The growing field of learning science research has found that knowledge is critical not only for the enactment of skills but also for enabling effective learning. That is, knowledge is not only the *product* of learning but also directly *influences* how and what we are able to learn.

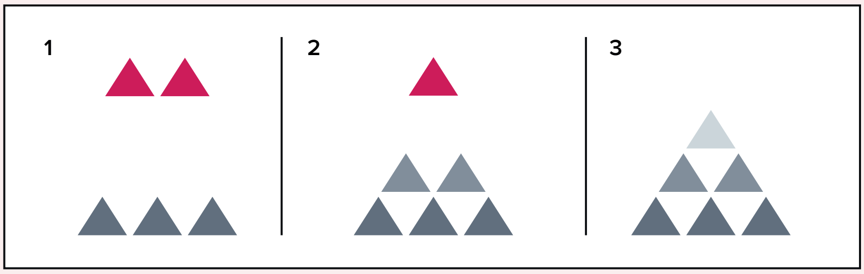
Knowledge begets knowledge

The more you know, the more you are able to know.

A new concept is always learned in association with already existing knowledge. When we encounter a new idea or new piece of information, we make sense of it in relation to what we already know on the topic. The amount of existing knowledge and the extent to which it is interconnected also influence the quality of learning – more interconnected knowledge leads to easier and faster learning. This suggests that both *what* we know and *how* we know influences our ability to learn.

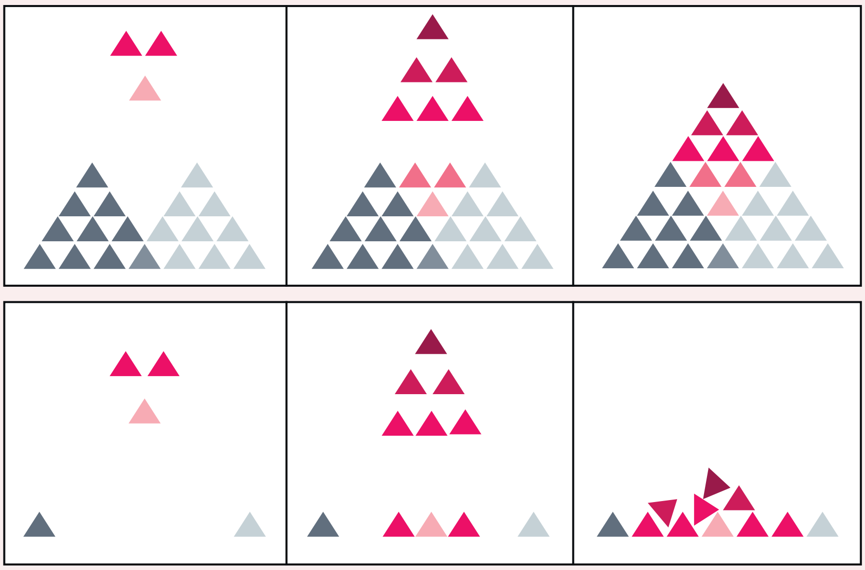
The hierarchical nature of the learning process can be described as a pyramid – where the knowledge pieces are the individual bricks and our broader understanding of a topic is the structure they form (see diagram 1). The final product is dependent on both the individual pieces of knowledge *and* our ability to form interconnections between them to develop understanding.

Diagram 1: The hierarchical nature of learning



As we learn more, we create more pyramids, as well as more opportunities for higher-order learning (where a whole pyramid becomes just a brick in a new one) and interdisciplinary learning (which is supported by several other pyramids). In such learning, we are able to reshape and reapply our knowledge in new situations and in relation to new contexts and problems (diagram 2).

Diagram 2: Higher order learning of learning



Higher-order learning abilities are dependent on the solid structure of well-established knowledge. For example, at the basic level of learning we attach a concrete meaning to a meaningless concept, such as a word – like the name of a person (Katie), an action (play) or an object (ball). The meaning relies on the ability to use the new concept to communicate effectively; the recurrent successful use of the word creates meaning. At higher levels of learning, concepts with concrete meaning are used as examples for more abstract or general concepts. For example, to teach the meaning of 'equal' it would be possible to say, 'If Katie has one ball and Roimata has one ball, then they have an equal number of balls.' Meaning of the new concept 'equal' is established on the basis of already known concepts – 'ball', 'Katie', 'has', 'one', etc. Later, we can go further up the pyramid and connect 'equal' with more abstract concepts such as 'equality' or 'equity'.

The importance of existing knowledge for ongoing learning is clearly demonstrated in the literature on reading comprehension. The ability to read a text and make sense of it is highly correlated with background knowledge. While the ability to decode enables you to identify words in a text, it is existing knowledge that helps you to infer meaning from those words. A frequently cited study clearly demonstrates the importance of knowledge for reading.[1] The researchers gave intermediate-aged students, who were classified as either good or poor readers based on their results in standardised tests, a text about a game of baseball. The students were then asked to use a replica baseball field to describe and re-enact what they had just read. Perhaps not surprisingly, the students' knowledge of baseball had a substantial impact on their performance. Those students with poorer reading skills but with a high knowledge of baseball displayed better understanding than those students with better reading skills but poorer knowledge of baseball.

Our existing knowledge base not only enables us to comprehend and think about information but also helps us to remember new information.[2] As the diagrams above indicate, it is easier to remember new material when we already have some existing knowledge of the topic because we already have an existing network, or cognitive schemata, in which to situate and orient the new information. By contrast, if we have no existing network in our memory, we have nothing to tie the new information to. The result is that students who know more will also be able to learn more and more effectively and efficiently. This has substantial implications for education. Teaching both breadth and depth of knowledge in meaningful ways must be a central goal of education. This does not negate the importance of skills; it fosters a robust knowledge base that enables the effective enactment of skills, as the following section will demonstrate.

Knowledge for thinking

One must have something to think critically about.

Knowledge not only supports our ability to gain new knowledge, it also facilitates our ability to think and to apply our knowledge in relation to particular tasks and problems. This is largely because knowledge frees up space in our 'working memory' for undertaking more complex tasks.

Working memory is where all our mental processing takes place, our real-time thinking. All new information is received and processed in the working memory before it is either forgotten or enters the long-term memory. Working memory also is where we combine incoming information with knowledge retrieved from our long-term memory, and use both to make a decision or perform an action. The most prominent feature of the working memory system is its limited capacity. It is only able to handle a small number of items at any given moment. If the working memory is overloaded, it leads to information loss – either incoming information will not be processed, or an item 'in process' will be dropped for a new one.

The relationship between working and long-term memory has significant implications for the position of knowledge in and for learning, and in particular the importance of knowledge for undertaking complex tasks and problem solving. When undertaking particular tasks – such as writing an essay or solving a complex problem – if we do not have sufficient domain-specific knowledge, simply understanding the problem or task can take up most of our working memory, leaving limited space for devising solutions. It is for this reason that we struggle to write an essay on a topic that we do not know well enough. While we may be familiar with the key components required in essay writing – an introduction, a clear argument, the use of paragraphs, etc. – our lack of knowledge on the topic of the essay puts too much pressure on our working memory. Similarly, a meta-analysis of 40 studies on ways to improve scientific problem-solving skills demonstrated that the most successful interventions focused on strengthening students' knowledge base, while interventions focused on problem-solving strategies had little or no impact.[3]

Knowledge matters

In the age of Google and near-instant access to an incalculable wealth of information, knowledge continues to matter. Knowledge, while often downplayed, is in fact crucial to the skills and competencies – critical thinking, meta-cognition, problem solving, lifelong learning – that are so desired both by our education system and among employers. A person's knowledge base determines both what and how easily they are able to learn, as well as their ability to demonstrate particular skills and higher-order learning. Understood in this light, knowledge is directly related to discussions of equity in education. While increasing knowledge is not a silver bullet, it does represent an important component in building a more equitable education system.

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Dr Nina Hood is a trained secondary school teacher, and taught at Epsom Girls Grammar and Mt Roskill Grammar in Auckland. Nina undertook an MSc (with distinction) in learning and technology, and a DPhil in Education at the University of Oxford. Since returning to New Zealand in mid 2015 Nina has been employed as a lecturer at the Faculty of Education and Social Work at the University of Auckland where she specialises in new technologies in education. She now is responsible for the strategic direction and day-to-day operations of The Education Hub.

1. Recht, D. R. and Leslie, L. (1988). Effect of prior knowledge on good and poor readers' memory of text. *Journal of Educational Psychology*, 80, 16–20.
2. See, for example, Arbuckle, T. Y., Vanderleck, V. F., Harsany, M., and Lapidus, S. (1990). Adult age differences in memory in relation to availability and accessibility of knowledge-based schemas. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 305–315. Beier, M. E., and Ackerman, P. L. (2005). Age, ability and the role of prior knowledge on the acquisition of new domain knowledge: Promising results in a real-world environment. *Psychology and Aging*, 20, 341–355; Hambrick, D. Z. (2003). Why are some people more knowledgeable than others? A longitudinal study of knowledge acquisition. *Memory & Cognition*, 31, 902–917; Schneider, W., Korkel, J., and Weinert, F. E. (1989). Domain-specific knowledge and memory performance: A comparison of high- and low-aptitude children. *Journal of Educational Psychology*, 81, 306–312; Van Overschelde, J. P., and Healy, A. F. (2001). Learning of nondomain facts in high- and low-knowledge domains. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27, 1160–1171.
3. Taconis, R., Ferguson-Hessler, M. G. M., and Broekkamp, H. (2001). Teaching science problem solving: An overview of experimental work. *Journal of Research in Science Teaching*, 38, 442–468.

