

SCIENCE OF LEARNING



NEW ZEALAND GRAPHICS AND
TECHNOLOGY TEACHERS ASSOCIATION
NGA POUAKO TOI O AOTEAROA

– Definition

The science of learning draws on research from cognitive psychology, neuroscience and education to understand the processes through which we learn. While there is a focus on the cognitive processes involved in learning, the science of learning also recognises that cognition is affected by affective, emotional and contextual factors.

Science of learning

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Topic summary

An understanding of how we learn should be at centre of all teaching and learning.



Definition



Relevance



State of the evidence



In practice

- **Activating existing knowledge:** A new concept is always learned in association with already existing knowledge. The amount of existing knowledge and level to which it is interconnected influence the quality of learning (more interconnected knowledge leads to easier and faster learning).
- **Cognitive load:** all new information must be processed in the working memory before it is processed to long-term memory. Our working memory has limited capacity, and therefore if tasks are too cognitively demanding or if confronted with too much new information at once, learning is impeded.
- **Practice is essential to learning:** students need to practice retrieving information from their long-term memories to use in a new situation or context. Practicing a particular skill or retrieving particular information is more effective when spread over time, rather than repeated sequentially over a short time period.
- **Effective feedback is essential to the learning process.**
- **Affective learning skills are essential:** students' sense of self-belief about their ability to learn, that is, believing that intelligence is mutable, greatly impacts their achievement. Furthermore, so-called non-cognitive skills such as self-regulation and motivation are essential to successful learning.

The 'Science of Learning' needs a strong profession

27 June 2024

The Minister of Education's Ministerial Advisory Group [report](#), released this month, highlights 'The Science of Learning' as a valuable tool to guide teaching practice.

A lot of the focus to date has been about what neuroscience and other disciplines can tell us about cognition—the thinking processes that underpin the way people learn.

This is important, and, carefully translated into evidence-based implications for instruction, can provide teachers with some practical and actionable insights. This can help teachers to help all learners and can be especially valuable in helping you to support neurodiverse learners. That is what researchers and practitioners are looking to do with structured literacy.

The Teaching Council agrees that setting some expectations about pedagogical approaches in specific areas can be helpful in our otherwise highly flexible system. At the same time, however, no one pedagogical strategy will ever fully meet the needs of all learners—the skill of the teacher is still the most critical component in the success of learning for all students.

Some concerns have been expressed about the risk of the teaching profession being de-professionalised into simply acting out scientifically prescribed lesson plans. We would strongly resist this tendency if it was to surface.

But, in any case, an education system genuinely guided by the learning and development sciences is one that values and reinforces teacher professionalism.

For one thing, the Ministerial Advisory Group report clearly states that cognition is only a part of the picture:

Another source of evidence contributing to the science of learning is literature on human development. Cognition, affect and motivation all develop and change during the process of human maturation. Choice of teaching approach should be shaped by knowledge of relevant developmental tendencies. (p. 6)

Internationally, the learning and development sciences are highlighting the individual importance, and integrated nature, of cognition, motivation, identity, and individual variability, as characteristics that teachers need to understand and work with.

In other words, yes, science can help inform a knowledge-based curriculum, but it also points to the importance of:

- the learner's identity, language and culture as both as source of motivation and a reference point for taking on board new knowledge and ideas – this underpins the cultural relationships for responsive pedagogy conceptualised by researchers like Mere Berryman, and reflected in our [Tātaiako](#) and [Tapasā frameworks](#)
- social and emotional learning such as teaching in a way that integrates emotional skills such as emotion recognition, empathy, emotion regulation, and social skills like cooperation and helping, communication with cognitive skills (problem-solving, responsible decision making, perspective taking). It helps foster mindsets that are conducive to educational success
- helping children to become self-reflective learners, including developing metacognition (thinking about how you think) and strategic learning skills.

For teachers, all of this requires a continuous process of making decisions, which take account of the individual learners, and are guided by knowledge, judgment, and values. Professor Graeme Aitken, who is now on the [Curriculum writing group](#) on the science of learning, illustrated this interplay a few years ago in a framework he did for us for applying *Ngā Paerewa | Standards*.

This is a timely reminder of the range of knowledge, skills, and dispositions that we need to foster in Initial Teacher Education and beyond. A grounding in the teaching practices recommended by the latest evidence is an important part of that, but evidence also reinforces that developing adaptive expertise and emotional intelligence are, too.



Science of Learning and Development

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The science of learning and development (SoLD) refers to the growing body of research from the fields of neuroscience, psychology, and other developmental and learning sciences, which tells an optimistic story about the potential of all learners. This evidence shows that the brain continues to develop throughout life as a product of relationships, environments, and experiences. Findings from this work have serious implications and powerful lessons for improving education. The foundations of the U.S. education system were built more than 100 years ago and were designed to select and sort—through segregation, unequal school funding, and tracking—rather than promote development and help every student access opportunities and reach their full potential.

REPORT

Design Principles for Teacher Preparation: Enacting the Science of Learning and Development

PUBLISHED JULY 23, 2025

By *Linda Darling-Hammond, Maria E. Hyler, Steve Wojcikiewicz, Joy Rushing*



- ➊ **Principle 1: Curriculum Rooted in a Deep Understanding of Learners, Learning, and Development**
- ➋ **Principle 2: Development of Skills, Habits, and Mindsets of an Equitable Educator**
- ➌ **Principle 3: Rich, Experiential Learning Opportunities**
- ➍ **Principle 4: Pedagogical Alignment and Modeling**
- ➎ **Principle 5: Supportive Developmental Relationships in Communities of Practice**

This report incorporates the emerging research with the wisdom of practice found in exemplary teacher preparation programs to create a set of five design principles that enable preparation programs to model Science of Learning and Development (SoLD)-aligned approaches to teachers.

These principles include both the “what” of teacher preparation—the content educators need to learn about children and how to support their development and learning—and the “how”—the strategies for educator learning that can produce deep understanding; useful skills; and the capacity to reflect, learn, and continue to improve.



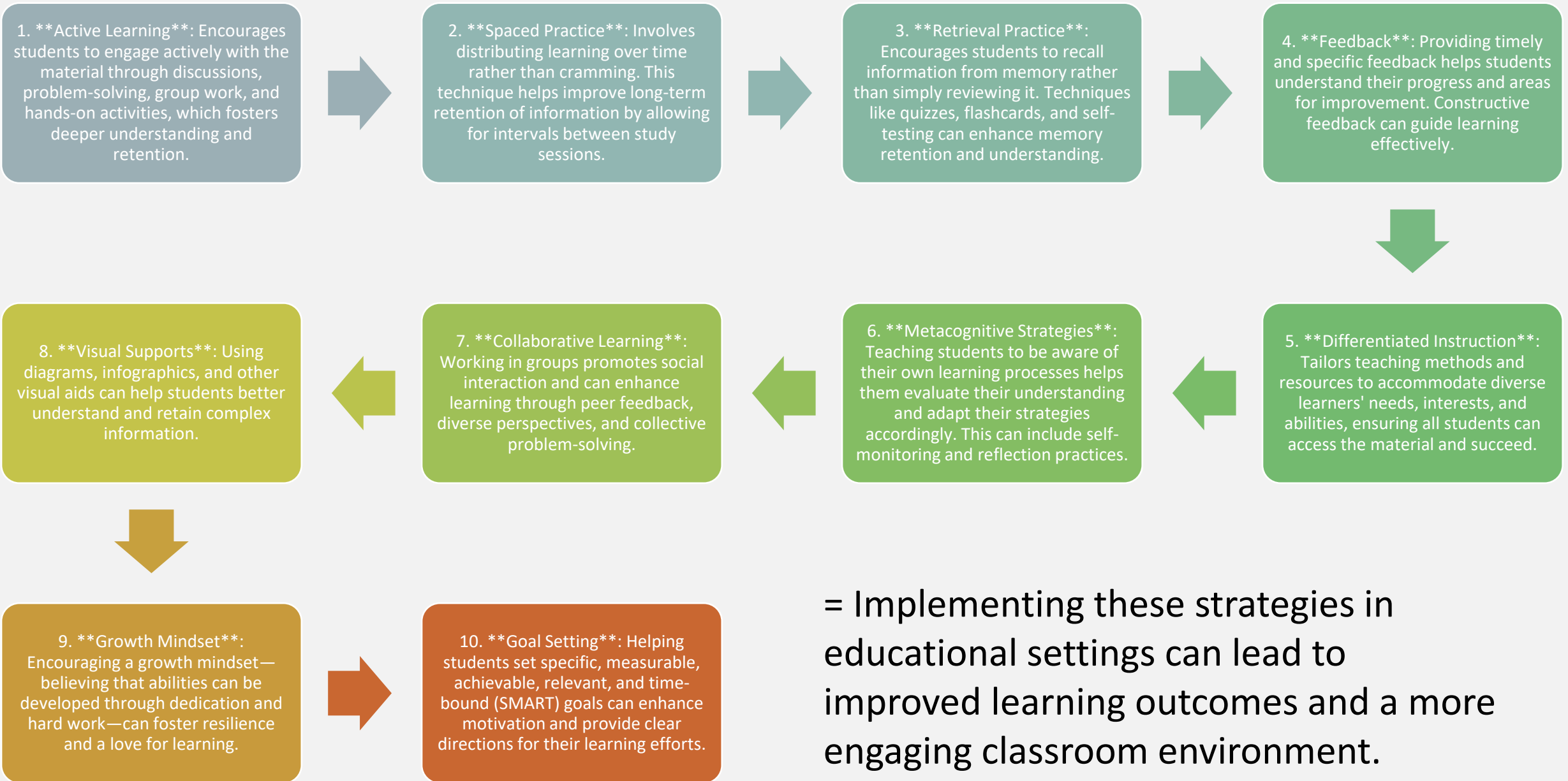
The science of learning is an **interdisciplinary field** that explores how people learn, the processes involved in learning, and the factors that affect learning outcomes.

It combines insights from psychology, cognitive science, education, neuroscience, and other disciplines to understand the mechanisms of learning and develop **evidence-based strategies to enhance educational practices.**

This field examines various aspects of learning, including cognitive processes, motivation, memory, and the influence of environment and social interactions on the learning experience.

Ultimately, the goal of the science of learning is to improve teaching and learning methods to foster effective education.

Here are several evidence-based strategies derived from the science of learning that can enhance educational practices:



= Implementing these strategies in educational settings can lead to improved learning outcomes and a more engaging classroom environment.



Six specific cognitive strategies that have received robust support from decades of research:

spaced
practice

interleaving

retrieval
practice

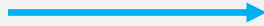
elaboration

concrete
examples

dual coding

spaced practice

The effect is simple: the same amount of repeated studying of the same information spaced out over time will lead to greater retention of that information in the long run, compared with repeated studying of the same information for the same amount of time in one study session



What teachers can do:

Teachers can introduce spacing to their students in two broad ways.

1. creating opportunities to revisit information throughout the term, or even in terms.
2. putting the onus to space on the students themselves, the teacher helping the students to plan out their study.

interleaving

Interleaving occurs when different ideas or problem types are tackled in a sequence, as opposed to the more common method of attempting multiple versions of the same problem in a given study session (known as blocking).



What teachers can do:

Interleaving can be applied in different ways such as:

Interleaving different types of problems during learning, which is particularly applicable to subjects such as math and physics

For problem-based subjects, the interleaving technique is straightforward: simply mix questions on homework and quizzes with previous materials (which takes care of spacing as well); for languages, mix vocabulary themes rather than blocking by theme

retrieval practice

While tests are most often used in educational settings for assessment, a lesser-known benefit of tests is that they actually improve memory of the tested information. ...we know from a century of research that retrieving knowledge actually strengthens it



What teachers can do:

Practicing retrieval is a powerful way to improve meaningful learning of information, and it is relatively easy to implement in the classroom.

For example, requiring students to practice retrieval can be as simple as asking students to put their class materials away and try to write out everything they know about a topic.

Other examples are practice tests (e.g., short-answer or multiple-choice), provide open-ended prompts for the students to recall information or ask their students to create concept maps from memory

elaboration

Elaboration involves connecting new information to pre-existing knowledge.

“A conscious, intentional process that associates to-be-remembered information with other information in memory.”

The common thread in all the definitions is that elaboration involves adding features to an existing memory



What teachers can do:

Elaboration is thinking about information on a deeper level.

One way to view elaboration involves making information more integrated and organized with existing knowledge structures.

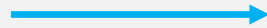
By connecting and integrating the to-be-learned information with other concepts in memory, students can increase the extent to which the ideas are organized in their minds, and this increased organization presumably facilitates the reconstruction of the past at the time of retrieval.

Students can also be encouraged to self-explain concepts to themselves while learning e.g. by saying out loud the steps needed for an equation.

Acknowledged as difficult to tell if it always helps learning

concrete examples

Providing supporting information can improve the learning of key ideas and concepts. Specifically, using concrete examples to supplement content that is more conceptual in nature can make the ideas easier to understand and remember.



What teachers can do:

Concrete examples can provide several advantages to the learning process:

- (a) they can concisely convey information,
- (b) they can provide students with more concrete information that is easier to remember, and
- (c) they can take advantage of the superior memorability of pictures relative to words

One concern with using concrete examples is that students might only remember the examples

- important elements of learning may not be retained or
- only the surface details are remembered of an example rather than the underlying structure

More work is needed on this cognitive strategy

dual coding

“a picture is worth a thousand words”

It is well-understood that more information can be conveyed through a simple illustration than through several paragraphs of text

Illustrations can be particularly helpful when the described concept involves several parts or steps and is intended for individuals with low prior knowledge

being able to convey information more succinctly, pictures are also more memorable than word



What teachers can do:

Dual coding follows from the notion of text being accompanied by complementary visual information to enhance learning

However each representation also increases cognitive load and can lead to over-saturation.

An example provided was when students were given visually rich examples, they performed more poorly than students who were not given any visual example, suggesting that the visual details can at times become a distraction and hinder performance. Thus, it is important to consider that images used in teaching are clear and not ambiguous in their meaning

In Summary

It's a combination of the different cognitive strategies that will be of benefit to a student's learning.

Spacing can be particularly potent for learning if it is combined with retrieval practice.

The additive benefits of retrieval practice and spacing can be gained by engaging in retrieval practice multiple times.

Interleaving naturally entails spacing if students interleave old and new material.

Concrete examples can be both verbal and visual, making use of dual coding.

In addition, the strategies of elaboration, concrete examples, and dual coding all work best when used as part of retrieval practice.

Etc etc.



Educating teachers to enact the science of learning and development

Linda Darling-Hammond, Abby C. W. Schachner, Steven K. Wojcikiewicz & Lisa Flook

The brain and development are malleable. The brain grows and changes throughout life in response to experiences and relationships: The brain's capacity develops most fully when children feel emotionally and physically safe; when they feel connected and supported; and when they have engaging opportunities to inquire into the world around them.

Four design principles for schools for putting this knowledge into action

Learning is social,
emotional and cognitive

People actively construct
knowledge based on
their experiences,
relationships, and social
cultural contexts

Variability in human
development is the norm
not the exception

Adversity affects learning

Learning is social,
emotional and
cognitive

Emotions and social relationships affect learning.

Positive relationships, including trust in the teacher, and positive emotions, such as interest and excitement, open up the mind to learning.

Negative emotions such as fear of failure, anxiety, and self-doubt reduce the capacity of the brain to process information and to learn.

Learning is shaped by intrapersonal awareness, including the ability to manage stress and direct energy in productive ways, and by interpersonal skills, including the ability to interact positively with others, resolve conflicts, and work in teams.

These skills can be taught.

People actively construct knowledge based on their experiences, relationships, and social cultural contexts

Children and adults dynamically shape their own learning, connecting new information to what they already know in order to learn.

This process is facilitated when teachers draw connections to students' prior knowledge and experiences; create engaging, minds-on tasks; watch and guide children's efforts, and offer constructive feedback with opportunities to practice and revise work toward growing competence.

Variability in human
development is the norm
not the exception

Because each child's experiences create an individual trajectory for growth, there are multiple pathways – and no one best pathway – to effective learning.

When schools try to fit all children to one pace and sequence, they miss the opportunity to reach each child, and they can cause children to adopt counter-productive views about themselves and their own learning potential, which undermines their progress

Adversity affects learning

Each year in the United States, at least 46% of children are exposed to violence, crime, abuse, or trauma, as well as homelessness and food insecurity.

These adverse childhood experiences create toxic stress that can affect attention, learning, and behaviour.

Poverty and racism, together and separately, make chronic stress and adversity more likely. In schools where students encounter punitive responses rather than support for handling adversity, their stress is magnified.

Schools can buffer the effects of stress by creating supportive environments that are personally attentive and culturally responsive; facilitating supportive adult-child relationships that extend over time; teaching social and emotional skills; and offering integrated student supports that enable healing and recuperation as they remove obstacles to learning.



Also...

it is important to consider the kind of learning today's young people need to engage in.

In a context where knowledge is rapidly expanding and technologies and societies are rapidly changing, children need well-developed critical thinking and problem solving skills; the capacity to find, analyze, synthesize, and apply knowledge to novel situations; interpersonal skills that allow them to work with others and engage effectively in cross-cultural contexts; self-directional abilities that allow them to manage their own work and complex projects; abilities to competently find resources and use tools; and the capacity to communicate effectively in many ways.

To do this...

- knowledge of learners and how they learn and develop within social contexts,
- an understanding of the subject matter and curriculum to be taught in light of the social purposes of education,
- an understanding of teaching in light of the content and learners to be taught, as informed by assessment and supported by a productive classroom environment

Sources and additional reading :

Darling-Hammond, L., Schachner, A., Wojcikiewicz, S.K. & Flook, L. 2024. Educating teachers to enact the science of learning and development. *Applied developmental science*. (28,1) 1–21. <https://doi.org/10.1080/10888691.2022.2130506>

Weinstein, Y., Madan, R. & Sumeracki M. A. 2018. Teaching the science of learning. *Cognitive Research: Principles and Implications*. <https://cognitiveresearchjournal.springeropen.com/articles/10.1186/s41235-017-0087-y>

<https://theeducationhub.org.nz/category/school-resources/science-of-learning/>

<https://teachingcouncil.nz/about-us/news-advocacy/news/the-science-of-learning-needs-a-strong-profession/>

Cantor, P., Osher, D., Berg, J., Steyer, L., & Rose, T. (2019). Malleability, plasticity, and individuality: How children learn and develop in context¹. *Applied Developmental Science*, 23(4), 307–337. <https://doi.org/10.1080/10888691.2017.1398649>

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97–140.

<https://doi.org/10.1080/10888691.2018.1537791>

Osher, D., Cantor, P., Berg, J., Steyer, L., & Rose, T. (2020). Drivers of human development: How relationships and context shape learning and development¹. *Applied Developmental Science*, 24(1), 6–36.

<https://doi.org/10.1080/10888691.2017.1398650>