CLASSROOM PRACTICE GUIDE

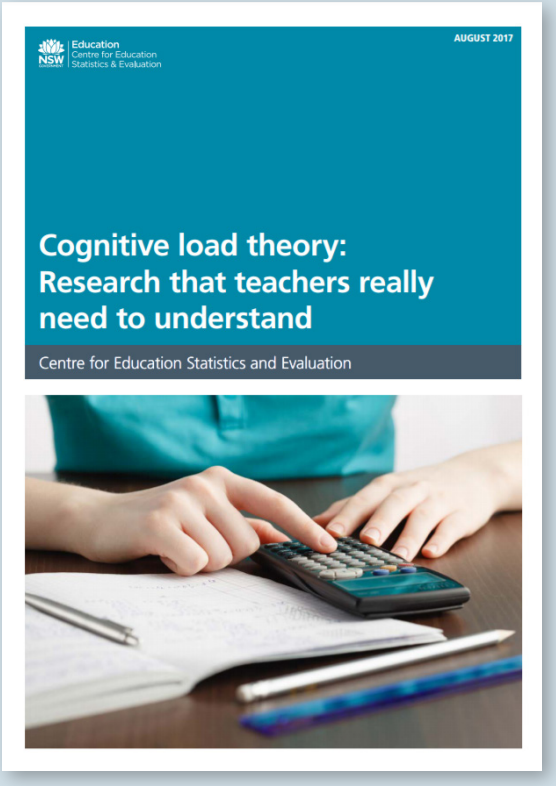
NSW GOVERNMENT

DEPARTMENT OF EDUCATION

Cognitive load theory in practice

Examples for the classroom

Centre for Education Statistics and Evaluation



More information

To read more about cognitive load theory and for references to the research this resource is based on, please see CESE's other publication, *Cognitive Load Theory: Research teachers really need to understand,* by visiting CESE's website:

www.cese.nsw.gov.au/publications

Cognitive load theory emerged from the work of educational psychologist John Sweller and colleagues from the 1980s, and has since developed into an influential learning theory supported by a robust evidence base. A more in-depth discussion of cognitive load theory and its effects can be found in:

John Sweller, Paul Ayres and Slava Kalyuga 2011, *Cognitive load theory*, New York, Springer-Verlag.

CESE wishes to thank Emeritus Professor Sweller for his comments on this publication.

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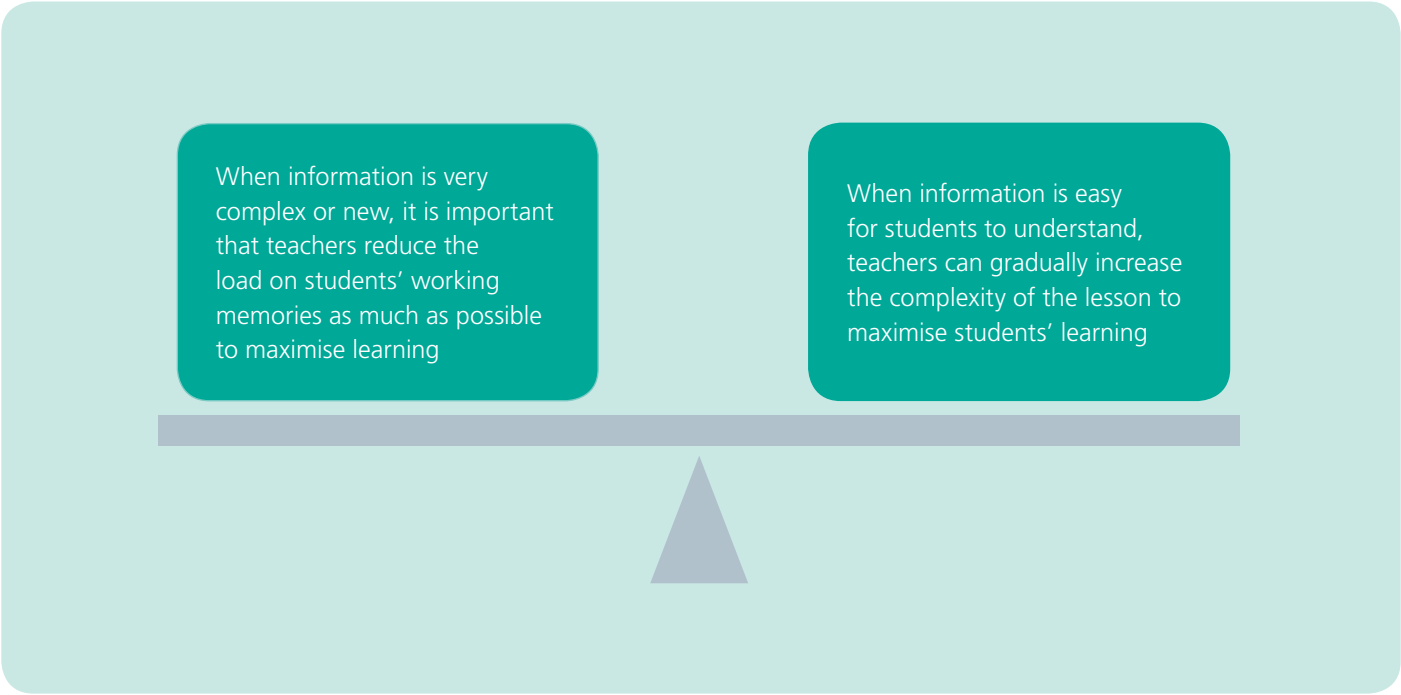
Introduction: Cognitive load theory in practice

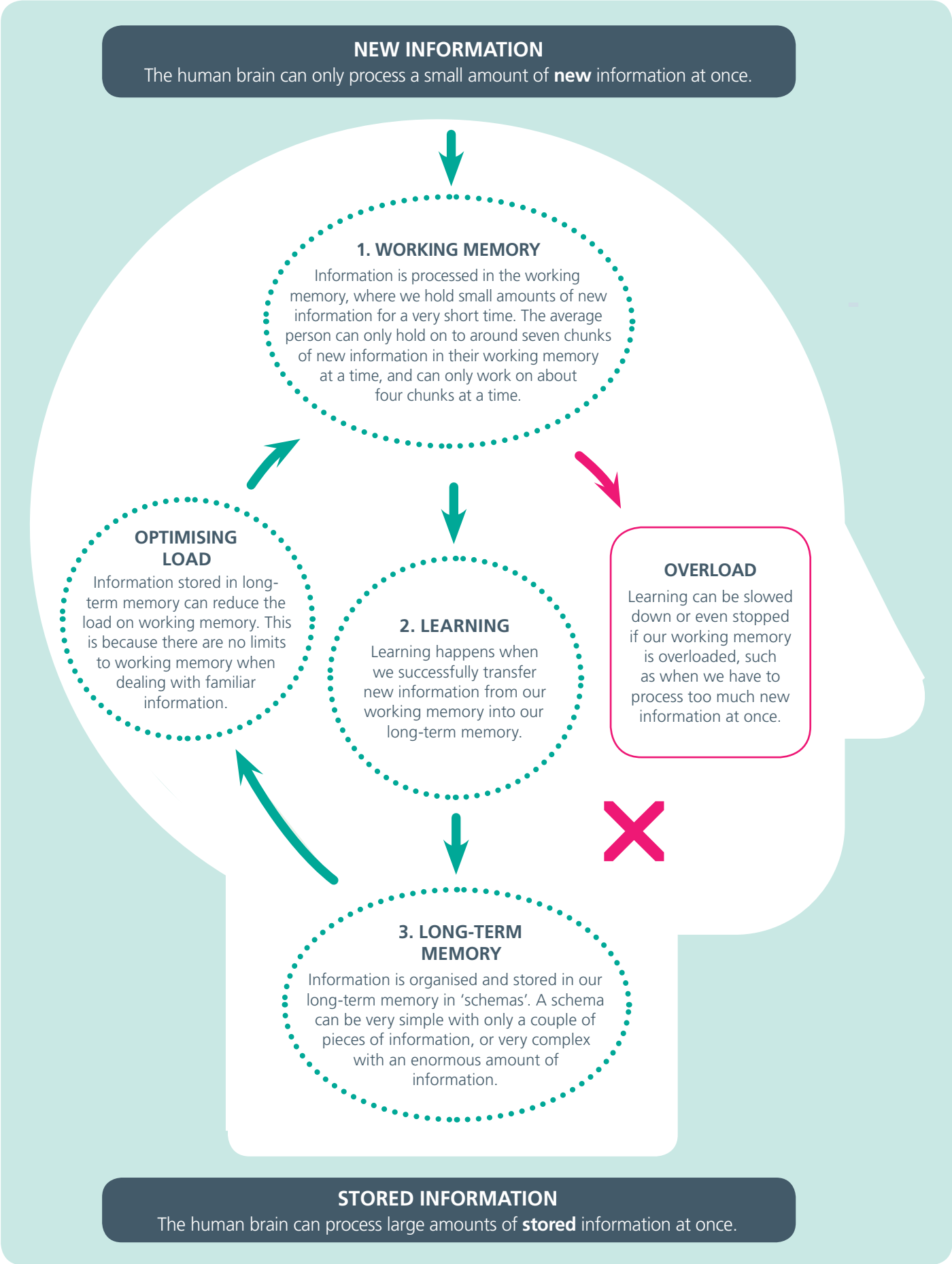
Understanding how human brains learn can help teachers to employ more effective teaching methods. This publication is designed to help teachers incorporate cognitive load theory into their teaching practice. It is intended to be a practical resource, and uses examples from the NSW syllabuses to illustrate how teachers can use cognitive load theory in the classroom.

What is cognitive load theory?

Dylan Wiliam has described cognitive load theory as 'the single most important thing for teachers to know'. Cognitive load theory uses knowledge of the human brain to design teaching strategies that will maximise learning. It provides theoretical and empirical support for explicit models of instruction, in which teachers show students what to do and how to do it, rather than having them discover or construct information for themselves. Cognitive load theory is about optimising the load on students' working memories to help maximise their learning.



How do human brains learn?



Teaching strategies from cognitive load theory

Cognitive load theory is supported by a robust evidence base which shows that students learn best when they are given explicit instruction accompanied by lots of practice and feedback. Through a significant number of randomised controlled trials (RCTs), researchers have identified a number of strategies that can help teachers to maximise student learning. These strategies work by optimising the load on students' working memories.

STRATEGY 1

Tailor lessons according to students' existing knowledge and skill

'Element interactivity effect'

STRATEGY 2

Use worked examples to teach students new content or skills

'Worked example effect'

STRATEGY 3

Gradually increase independent problem-solving as students become more proficient

'Expertise reversal effect'

STRATEGY 4

Cut out inessential information

'Redundancy effect'

STRATEGY 5

Present all the essential information together

'Split-attention effect'

STRATEGY 6

Simplify complex information by presenting it both orally and visually

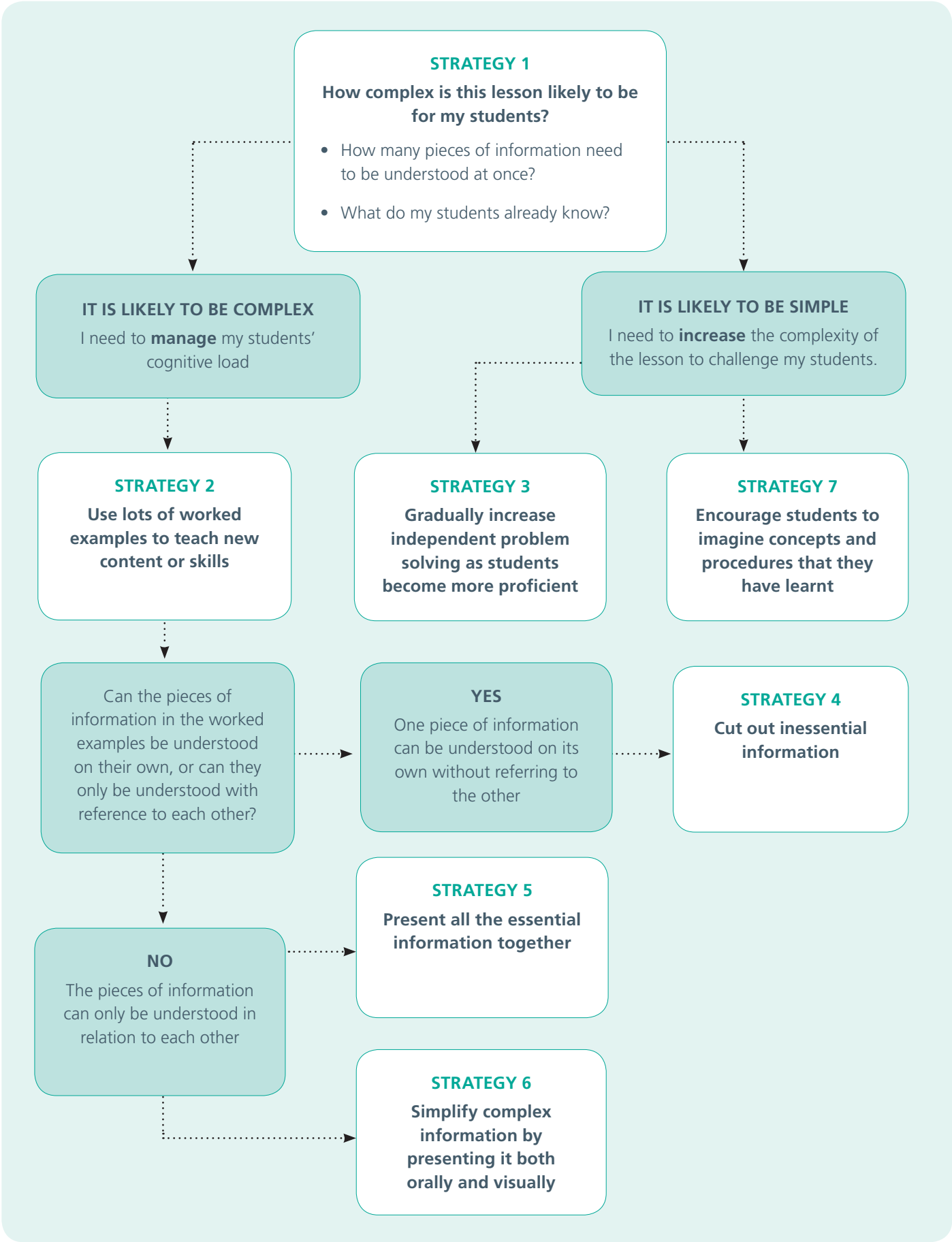
'Modality effect'

STRATEGY 7

Encourage students to visualise concepts and procedures that they have learnt

'Imagination effect'

Which strategy should I choose to optimise my students' cognitive load?



STRATEGY 1
Tailor lessons according to students' existing knowledge and skill

Students learn best when teachers tailor lessons to their existing knowledge and skill.

One of the most important implications of cognitive load theory for teaching practice is the need to optimise students' cognitive load, by striking the right balance between too much and too little load. To do this effectively, teachers need to have a strong understanding of where students already sit in their learning. When teaching a lesson that is relatively simple for students to understand, there is room in their working memories to process a little bit more information. In this case, teachers should aim to increase the complexity of the task to challenge their students. But when the task is already complex, there is no room in students' working memories to process any more information. In this case, teachers should focus on reducing the cognitive load.

Why is it effective?

The reason instruction is most effective when it is tailored to students' existing knowledge is because of how human brains learn and use knowledge. Human brains can only process a small amount of new information at once, but can process very large amounts of stored information. For this reason, drawing on information that is already stored in students' long-term memories can help reduce cognitive load – and thus result in more effective learning. By drawing on students' existing knowledge, and managing the amount of new information that students have to process at once, teachers can maximise student learning.

How can I use it in the classroom?

Teachers should consider two things when identifying whether a lesson is likely to place a heavy cognitive load on their students:

1. **The number of different pieces of information that need to be understood together to make sense of the material.**

   For example, the knowledge that one added to one equals two is not very complex, because it only has a few pieces of information that need to be understood together. On the other hand, an advanced arithmetic equation is quite complex because it has lots of different pieces that all need to be understood together.

2. **The prior knowledge of the student.**

   Information that is complex for a beginner might be simple for an expert. For example, a student who is just learning to read might find the task of reading the word 'cat' complex, but an expert reader will find this too easy and will benefit from being challenged more.

There are some techniques that teachers can use to make complex information more accessible for students. These include:

The 'part-whole approach'

The teacher breaks the complex task down into a series of sub-tasks, and gradually builds the students' skills at solving each sub-task before eventually bringing the sub-tasks together in the whole task.

The 'whole-part approach'

The teacher introduces the whole task to students from the beginning, but then directs their attention to each sub-task. This context can help students to understand how each of the sub-tasks interact with each other.

When teaching new content to students without much pre-existing knowledge, teachers should provide students with lots of detailed, fully guided instruction.

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As the students' knowledge and skill increases, teachers should provide a mix of guided instruction and problem-solving practice.

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Finally, as students become very proficient, teachers should provide minimal guidance and allow students to practise their skills with lots of problem-solving tasks. Some students will progress to independent problem-solving faster than others.

STRATEGY 1
Examples for the classroom

Example 1: Year 10 Science

A Year 10 science class is learning about Newton's Second Law and how the laws of physics can describe and predict the motion of objects. The aim of this lesson is for students to describe the relationship between force, mass and acceleration. Understanding the laws of physics is likely to place a heavy cognitive load on students' working memories, because they need to understand the concepts, the relationships between them, and the formula for Newton's Second Law. To help manage the students' cognitive load, the teacher decides to introduce Newton's Second Law using the part-whole approach.

What does it look like?

The teacher begins the lesson by recapping content that students have already covered in earlier stages of learning. She writes the four relevent concepts on the board – velocity, acceleration, mass and force – and asks the students to recall the definitions of each word as a class. She writes the correct definitions on the board.

- **Velocity** is the rate at which an object moves in a certain direction, calculated as 'metres per second'.
- **Acceleration** is the rate at which velocity changes (that is, speeds up or slows down), calculated as 'metres per second per second'.
- **Mass** is a measure of how much matter is in an object, indicating its resistance to acceleration when a force is applied. Mass is measured in kilograms.
- **Force** is a 'push' or 'pull' on an object resulting from interaction with another object, and is measured in 'Newtons'. One Newton is the amount of force required to accelerate an object with a mass of one kilogram one metre per second per second.

The teacher then introduces the students to the relationships between these different concepts. She checks their understanding by asking them to write out the tables in their workbooks and fill in the missing sections, before discussing the correct answers as a class.

Acceleration is directly proportional to net force. In other words, doubling the net force will result in a doubling of the acceleration, as long as the mass remains the same. Look at the table to the right. We can see that, as the numbers in the net force column double, so do the numbers in the acceleration column, as long as the mass remains the same.

Net Force (N)	Mass (kg)	Acceleration (m/s/s)
10	2	5
20	2	10
Net Force (N)	**Mass (kg)**	**Acceleration (m/s/s)**
40	2	20
80	2	?

Acceleration is inversely proportional to mass. In other words, doubling the mass of an object will result in a halving of the acceleration, as long as the force remains the same. Look at the table to the right. We can see that, as the numbers in the mass column double, the numbers in the acceleration column halve, as long as the net force remains the same.

Net Force (N)	Mass (kg)	Acceleration (m/s/s)
80	2	40
80	4	20
80	8	10
80	?	5
80	32	?

Next, she introduces the students to Newton's Second Law:

Force = mass x acceleration

Finally, she provides the students with lots of worked examples to practise using this formula to predict how force affects the movement of an object (see 'Strategy 2: Use worked examples to teach students new content or skills', page 9).

By presenting the lesson on Newton's Second Law using a part-whole approach, the teacher has managed the cognitive load of her students. Rather than overloading them with lots of new information that all needs to be understood at the same time, the teacher introduced her students to one set of new information at a time. By the time they reach the whole task – of using Newton's Second Law to predict how a force affects the movement of an object – the students are already familiar with the vocabulary, and the relationships between the different elements.

Example 2: Year 4 English

A Year 4 English class is learning to compose, edit and present imaginative texts, with a focus on narratives. The students have been learning about language features such as similes, and the aim of this lesson is for students to practise using similes in a piece of imaginative writing. The teacher knows that this task can place a heavy cognitive load on the students' working memories, because it requires them to think about many different things at once. As well as recalling what a 'simile' is and thinking of some relevant similes to add meaning and interest to their story, the students are required to think about the story they want to communicate, the organisation of ideas and text structure, and the appropriate vocabulary and syntax – all while monitoring these different elements to ensure they are appropriate for their intended audience. To help manage his student's cognitive load, the teacher decides to break the task down by using a genre with which they are familiar, using modelled writing, and using lots of scaffolded questions and tasks.

What does it look like?

In the first part of the lesson, the teacher recaps what a simile is. He asks the class if they can remember the definition of a simile and writes the correct definition on the board.

Simile: A description comparing one thing with another. Usually starts with 'as' or 'like'.

He then reads a familiar text to the class, asking students to put their hand up when they hear a simile. Next, he displays a picture of a monster and brainstorms some similes with students that describe what each of the monster's body parts looks like. He writes these on the board.

Hair like a mop	**Nose like a beak**	**Hands like claws**
Teeth as sharp as razors	**A voice like a hissing snake**	

He asks the class to draw their own scary monster, and then asks them to think of three similes that describe their monster and write these in their workbooks.

Next, the teacher uses a process of 'thinking aloud' to model for the students how to write a passage of text using similes to describe a scary character.

"I'm going to start with a description of our monster."

The monster was over ten metres tall, with <u>hair like a mop</u> and a <u>nose like a beak</u>.

"Next I want to show the reader how scary he was. Can anyone suggest another sentence using a simile to describe how scary our monster is?" The teacher uses the students' suggestions to write the next sentence.

He had <u>teeth as sharp as razors</u>, and they glinted in the dull light of the cave.

"Now I want to show what the monster sounded like, to give the reader a strong sense of how frightening he is. Who can suggest a simile that describes what a scary monster might sound like?" The teacher uses the students' similes to create the next sentences.

When he spoke, his voice was <u>like a hissing snake</u>. "Get out of my house," he said.

"Now I think the monster would attack the narrator, and try to chase her out of his cave."

Suddenly, he lunged forward and tried to grab me with his hands like claws.

"Let's read over what we've written so far."

The monster was over ten metres tall, with hair like a mop and a nose like a beak. He had teeth as sharp as razors, and they glinted in the dull light of the cave. When he spoke, his voice was like a hissing snake. "Get out of my house," he said. Suddenly, he lunged forward and tried to grab me with his hands like claws.

Next, the teacher asks the class to look back over the story and check the spelling, punctuation and grammar to see if they can spot any errors.

Finally, the teacher asks the students to return to the scary monster they drew in their workbooks and to write a paragraph describing their scary monster, using the three similes they wrote down earlier. At the end of the lesson, he asks them to check their work for correct punctuation such as using capital letters and full stops in the right places, spelling errors, and grammatical accuracy and correct sentence structure.

By breaking the task down into parts – recapping existing knowledge, using modelled writing, and using scaffolded questions to guide the students to think of their own similes, write their own text and then check for spelling, punctuation and grammatical accuracy – the teacher has managed his students' cognitive load.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

STRATEGY 2
Use worked examples to teach students new content or skills

Students learn new content or skills best when they are given lots of worked examples.

A 'worked example' is a problem that has already been solved for the student, with every step fully explained and clearly shown. Research consistently demonstrates that students who are given lots of worked examples learn new content more effectively than students who are required to solve the same problem themselves.

Why is it effective?

Worked examples are effective because they provide students with fully guided instruction, minimising unnecessary load on students' working memories. Fully guided instruction using worked examples is more effective than unguided problem-solving when teaching students new material, because unguided problem-solving places a heavy burden on working memory. A student left to solve a new type of problem with minimal guidance might solve the problem correctly, but because their working memory was overloaded, they may not remember the process that would allow them to quickly solve the same problem again.

Worked examples manage cognitive load and free up the student's working memory. Rather than being focused solely on finding the correct answer to a problem, students are able to focus instead on the more important knowledge of how to solve the problem. This means that they are more likely to recall how to solve this type of problem when they are faced with it again in the future.

How can I use it in the classroom?

Worked examples will look different in different learning areas. For example, in maths, the teacher might show students several examples of a fully solved algebraic equation. In English, the teacher might model for the students how to write an argumentative essay, by 'thinking aloud' through each step of the process. In food technology, the teacher might demonstrate how to correctly use a piece of food preparation equipment, and explain the correct procedures aloud as he does so.

Many of the strategies described in this publication are ways of ensuring that worked examples are effective. To use worked examples successfully in their classrooms, teachers can:

Target lessons according to students' existing knowledge and skill, by providing lots of worked examples when the material is new, and gradually increasing independent problem-solving as students become more proficient	**SEE STRATEGY 1, 2 & 3**
Cut out inessential information that adds to cognitive load	**SEE STRATEGY 4**
Present all the essential information together to reduce the chances of cognitive overload	**SEE STRATEGY 5**
Make complex information more accessible by using a combination of voice and visuals to describe it	**SEE STRATEGY 6**

STRATEGY 2
Examples for the classroom

Example 1: Year 3 English

A Year 3 class is learning about word contractions. The aim of this lesson is for students to learn that apostrophes can be used to signal missing letters. The teacher decides to create a worksheet for the students to practise identifying where apostrophes should be placed in contracted words.

What does it look like?

The teacher begins by introducing word contractions to the class, and gives some examples by writing two sentences with contracted words on the board.

1. I do not like eggs.
   I don't like eggs.

2. You are not the teacher; he is the teacher.
   You're not the teacher; he's the teacher.

He then gives the students a worksheet with ten sets of sentences. The first sentence in each set is a worked example of how to correctly contract a word. The second sentence is almost identical to the first, but the student must place the apostrophe correctly themselves. For example:

3. She won't like them.
   The boy wont eat carrots.

4. There's a brown cow.
   On Friday theres a football game.

5. That's what I'd have done.
   Id eat her chocolate, but thats wrong.

This manages the cognitive load placed on the students' working memories, and allows their attention to be focussed only on the key features of the problem. By freeing up space in the students' working memories to focus on how to solve the problem, they are more likely to remember the rule that will allow them to correctly identify the contracted form again.

Example 2: Year 10 English

A Year 10 English class is studying Shakespeare's 'A midsummer night's dream'. When planning her lesson, the teacher decides to present her students with an extract from the important first scene of the play. In this scene, many of the major characters and their relationships are introduced, important narrative information is given, and some of the themes of the play are established. The aim of the lesson is for students to interpret the events, situations and characters in the scene, and to analyse the language used to express ideas about love, which is a major theme of the play.

What does it look like?

To make it easier for her students to understand the extract, the teacher decides to use two forms of worked examples. First, she gives the students a worksheet with an excerpt from the play. Under every line of the original Shakespearean text, an explanatory line is provided which simplifies the verse into contemporary English. Students are given time to read the extract themselves and to interpret the action and characters in the scene using the guidance provided by the modern English translation. They are then given a series of scaffolding questions to help them understand how the author has used language to express ideas about love.

Reading Shakespearean text can place a heavy cognitive load on students' working memories, because as well as grasping the action of the scene, they also need to understand the unfamiliar Elizabethan English language, interpret the poetic form and imagery, and recognise the many references to religion and mythology. Providing guidance in the form of worked examples helps to reduce this cognitive burden, making it easier for students to interpret the play and analyse how language is used.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

STRATEGY 3
Gradually increase independent problem-solving as students become more proficient

Students benefit from gradually being given more opportunities for independent problem-solving to practise using the knowledge and skills they have learnt.

While fully guided instruction is very effective for teaching students new material, it becomes less effective as students become more expert at a particular skill. Eventually, fully guided instruction becomes redundant or even counter-productive and students benefit more from independent problem-solving. As students become more skilled at solving a particular type of problem, they should gradually be given more opportunities for independent problem-solving.

Why is it effective?

As students develop expertise in a particular area, the information that was once essential becomes counter-productive. Providing too much guidance can cause more expert students to try and crosscheck the teacher's guidance against what they already know. This crosschecking causes an unnecessary load on students' working memories, but does not add anything to their understanding.

How can I use it in the classroom?

This strategy reinforces the need for teachers to give students more opportunities for independent problem-solving, by:

- Omitting some of the steps from a worked example
- Gradually giving the students fewer worked examples

Teachers can continuously monitor students' knowledge and skill levels, and adjust their teaching strategies accordingly as students gradually become more proficient at a particular type of skill or area of knowledge.

STRATEGY 3
Examples for the classroom

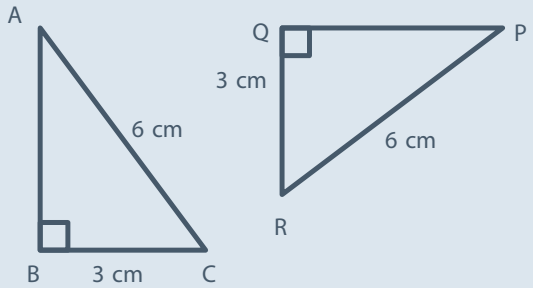
Example 1: Year 10 Maths

A Year 10 maths class is learning about geometric reasoning. The aim of this lesson is for students to practise formulating proofs involving congruent triangles and angle properties. The teacher knows that her students already understand the properties of triangles and how to establish whether two triangles are congruent. In this lesson, she wants them to practise formulating proofs that demonstrate whether two triangles are congruent.

What does it look like?

The teacher begins the lesson by showing the students a worked example of how to formulate a proof that two triangles are congruent. The proof demonstrates that the triangles are congruent because both have a right angle, and their hypotenuse and one other side are equal.

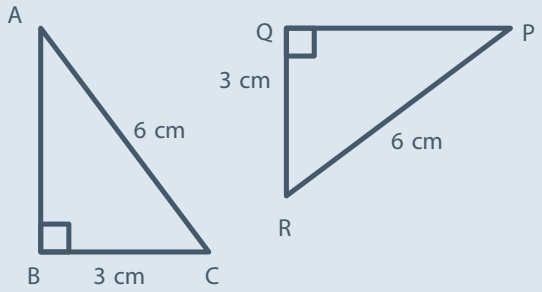
Fully worked example



In ΔABC and ΔPQR,
AC = PR (given information)
BC = QR (given information)
∠ABC = ∠PQR = 90°
∴ ΔABC ≡ ΔPQR (RHS)

She then provides the students with a series of similar problems. The first few problems have one step missing that the students have to complete themselves. The next few problems have a few steps missing that the students have to complete, and so on.

Partially worked example



In ΔABC and Δ_____,
AC = PR (_____)
BC = ___ (given information)
∠ABC = ∠PQR = 90°
∴ ΔABC ≡ ΔPQR (____)

By the end of the worksheet, the solution steps to the problems are totally missing, and the students are required to solve the entire problem themselves.

By gradually fading out the guidance that is provided to students, the teacher has managed their cognitive load and allowed them to practise their skills at formulating geometric proofs independently.

Example 2: Year 8 Spanish

A Year 8 Spanish class is practising translating and interpreting a range of texts. The aim of this lesson is for students to prepare a written transcription of a newspaper article from Spanish into English. The students already have a strong grasp of all the vocabulary used in the newspaper article, and have been regularly using these words in their lessons.

What does it look like?

The teacher provides the students with the text of the article in Spanish. Because he knows the students already have a strong grasp of the vocabulary used in the lesson, he does not include definitions of the key vocabulary in the text. The teacher asks the students to read the text and translate it into English.

Because he has considered his students' existing knowledge and adjusted the lesson by not including translations that the students already know, the teacher has successfully managed the load on his students' working memories.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

STRATEGY 4
Cut out inessential information

Students do not learn effectively when their attention is directed to inessential information.

We sometimes assume that providing students with extra information is helpful, or at the very least harmless. However, presenting students with inessential information can hinder learning. Inessential information can be information that students already know, additional information that is not directly relevant to the lesson, or the same information presented in multiple forms.

Why is it effective?

When students are provided with inessential information, they may not be able to distinguish between the information that they need to understand the lesson, and the inessential information that does not contribute to their learning. The inessential information adds to the load on their working memory, but does not contribute to their learning. If students' working memories are overloaded, it is harder to transfer knowledge into their long-term memories and learning is inhibited.

How can I use it in the classroom?

For lessons that students find very challenging, extra information that is not directly relevant to the lesson should be minimised. For information that is less complex, it is not as important to minimise extra information.

Information that is essential for beginning students might become redundant as they become more advanced. For example, for students who have just begun learning Spanish, it might be very important to provide a reminder of how to conjugate verbs. For students who are proficient Spanish speakers, this extra information is redundant and might distract them from the lesson.

Multimedia presentations

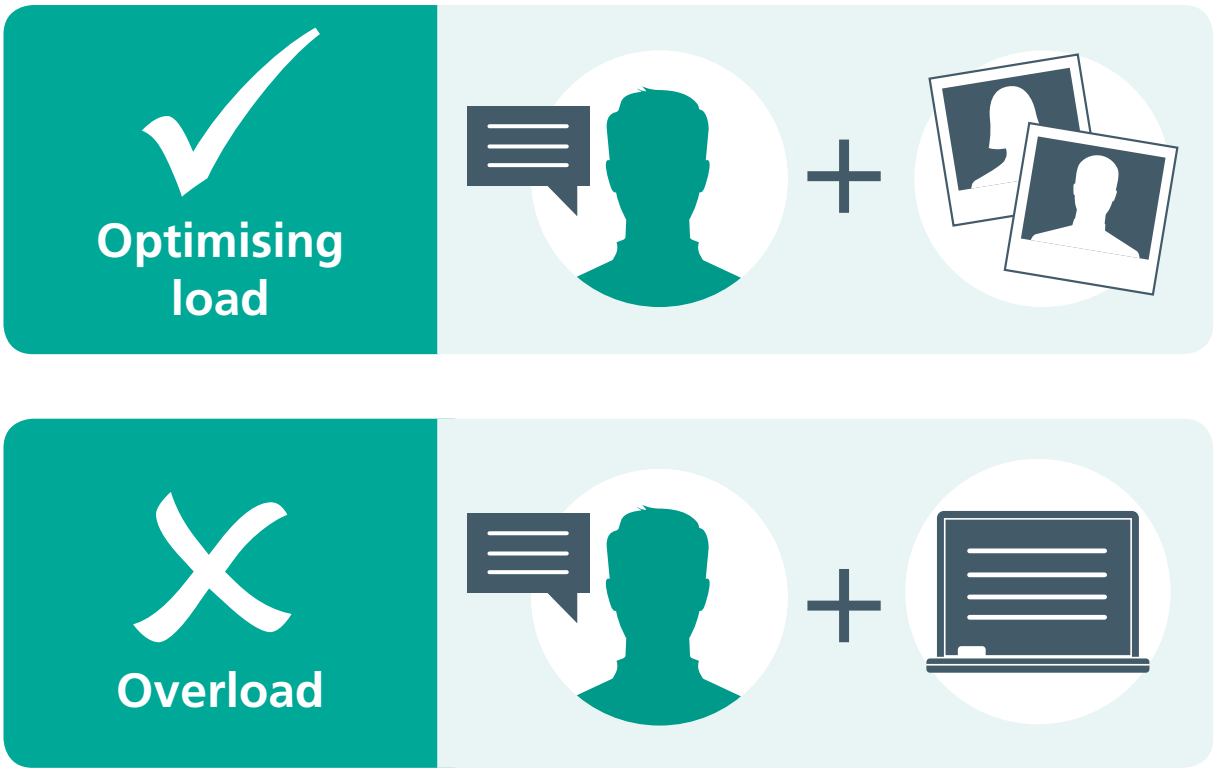
Cutting out inessential information is particularly relevant when teachers deliver lessons using multimedia presentations such as PowerPoint.

In this type of lesson it is very common to use verbal explanations and written text at the same time. For example, the teacher might show their students a quote on a PowerPoint slide, and also read the quote aloud at the same time. But presenting the same information in two forms is redundant – students' working memories can become overloaded when they are required both to listen and to read at the same time.

The best strategy to avoid overloading students' working memories is for the teacher to either read the text out loud (without presenting it on the slide), or allow the students to read it themselves – not both. It is still okay for the teacher to read the text out loud and present a relevant image or diagram on the PowerPoint slide at the same time – see Strategy 6.

While providing the same information in both written and spoken forms can overload working memory, there are some strategies that can reduce the chance of this occurring:

- The material can be presented in small chunks. For example, instead of presenting a quote as one big block of text on a PowerPoint slide, the teacher could break the quote up into smaller sections of text across several slides.
- The students, rather than the teacher, can direct the pacing of the presentation. When students can take their own time to process the information on one slide before moving onto the next, they are more likely to be able to process the information.



STRATEGY 4
Examples for the classroom

Example 1: Year 3 Geography

A Year 3 class is learning about climate types. The aim of this lesson is to identify the main climate types in Australia. The teacher knows that this is new material for his students, so it is important to avoid overloading their working memories with inessential information.

What does it look like?

While planning his lesson, the teacher is choosing between two worksheets that illustrate the main six climate types of Australia.

The first worksheet has a map of Australia showing the main six climate types, with each climate region labelled and shown in a different colour. To the left of the diagram is a key, which redescribes the same information already shown in the diagram (for example: 'Grey = equatorial, blue = tropical, yellow = desert'). The worksheet also includes a funny cartoon that does not add to the students' understanding.

The second worksheet also has a map of Australia showing the main six climate types, with each climate region labelled and shown in a different colour. There is no inessential information to distract the students from the aim of the lesson. This is the worksheet the teacher chooses.

Because the teacher has selected a worksheet that avoids overloading students with unnecessary information, the students have space available in their working memories to do the important work of transferring knowledge of climate types into their long-term memories.

Example 2: Year 8 History

A Year 8 history class is covering 'Expanding Contacts', focussing on contacts between Aboriginal and non-Aboriginal people in Australia. The aim of this lesson is for students to be able to describe the differences between Aboriginal and non-Aboriginal relationships to Land and Country.

The teacher decides to use a PowerPoint presentation to introduce the students to a primary source that illustrates a non-Aboriginal person's relationship to Land. She decides to use the journal of explorer Major Thomas Mitchell.

What does it look like?

The first slide includes a photograph of Major Mitchell, with a short list of dot points briefly summarising the most important information. While the students look at the photograph, the teacher verbally expands upon the dot points by explaining Major Mitchell's role in the colonisation of Australia. The second slide includes a quote from Major Mitchell's journal in which he describes the Australian landscape. The teacher asks her students to read the written quote silently to themselves, and gives them ample time to do so. Finally, she asks the students to reflect on what the quote reveals about non-Aboriginal relationships to Land and Country in the nineteenth century.

By reducing the on-screen text to a short list of the most important points and then explaining them in detail orally, the teacher has managed the cognitive load of her students. Similarly, by only presenting the textual information in one form at a time – either spoken or written – the teacher has managed her students' cognitive load. Both of these strategies free up the students' working memories to focus on transferring the information into their long-term memories.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

STRATEGY 5
Present all the essential information together

Students do not learn effectively when their limited attention is split between two or more sources of essential information that have been separated.

Cognitive overload can occur when students have to split their attention between two or more sources of information that have been presented separately, but can only be understood in reference to each other.

Why is it effective?

Presenting information in a split format means that students have to hold two separate pieces of information in their heads at the same time, and mentally integrate them. This can overload the working memory and inhibit learning. Cognitive overload can be avoided by presenting separate sources of information together.

There are two types of split information, which teachers should avoid:

Split by time

- x A maths teacher explains how to solve an algebraic equation but does not show the students an example of the equation until several minutes later.

Split by space

- x A biology textbook includes a diagram of the human respiratory system on one page, but does not provide a description of each respiratory organ until the next page.

How can I use it in the classroom?

The table below shows some lesson formats that include multiple sources of information, and gives examples of how they could be changed from a split format to an intergrated format.

Lesson format	Example	Split format	Integrated format
A combination of diagrams and written explanations.	A science lesson on the life cycle of a frog.	Students are given a diagram illustrating the life cycle of a frog, but the written explanations of each stage of the cycle are provided in a separate text box below.	The written descriptions of each stage of the life cycle are incorporated directly into the diagram, as close as possible to the relevant section.
Two or more sources of written information.	A language lesson in which students have to translate a passage of text with unfamiliar words.	Students are given an extract of text written in French, and a French-English dictionary to look up unfamiliar words.	The vocabulary translations are incorporated into the passage itself, directly above each unfamiliar word.
Students read instructions while learning to operate a piece of software or equipment.	A lesson on how to use an Excel spreadsheet to create mathematical formulas within cells.	Students are given a printed set of instructions to follow while they enter the formulas into the cells.	The instructions are incorporated directly into the spreadsheet, with each instruction positioned in the cell adjacent to where the formula needs to be created.

STRATEGY 5
Examples for the classroom

Example 1: Year 7 English

A Year 7 English class is learning about how language is used to create layers of meaning in texts. The aim of this lesson is for students to understand how sound and rhythm are used in poetry. The teacher decides to use "Mulga Bill's Bicycle", by A.B. 'Banjo' Paterson, to teach the students about iambic heptameter. He designs a worksheet to help the students understand the aim of the lesson.

What does it look like?

In this worksheet, a visual demonstration of where the stress is placed on each syllable is positioned directly below each word. The definitions of 'iamb' and 'heptameter' are located within the illustration itself, directly above where each element is located.

Iambic heptameter

iambic = An unstressed syllable followed by a stressed syllable

heptameter = 7 groups of iambs

'Twas Mul | ga Bill, | from Eag | lehawk | that caught | the cyc | ling craze;

He turned | away | the good | old horse | that served | him ma | ny days;
He dressed | himself | in cyc | ling clothes, | resplend | ent to | be seen;
He hurr | ied off | to town | and bought | a shin | ing new | machine;
And as | he wheeled | it through | the door, | with air | of lord | ly pride,
The grin | ning shop | assis | tant said, | 'Excuse | me, can | you ride?'

By physically incorporating the four different sources of information in the worksheet – the definition, diagram, poem and word list definitions – this worksheet manages the cognitive load placed on students. Now that the students' working memories are not overloaded, they have more space available to transfer the knowledge of iambic heptameter into their long-term memories.

Example 2: Year 3 Maths

A Year 3 class is learning to recognise the connection between addition and subtraction. The aim of this lesson is for students to learn how to solve arithmetic word problems. The teacher decides to use a worksheet of worked examples to help her students practise solving this type of problem.

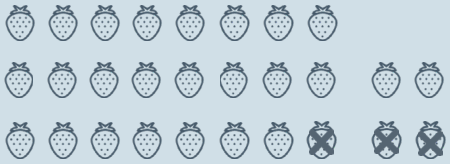
What does it look like?

The teacher provides the students with a worksheet on which a visual representation of how to solve the word problem is presented alongside the statement.

Brian has 8 strawberries.

Charlie has 2 strawberries more than Brian.

Maggie has 3 strawberries less than Charlie.



How many strawberries does Maggie have? **Answer: Maggie has 7 strawberries.**

Because the teacher has already physically integrated the word problem and the solution, the students do not have to integrate the information in their heads. This reduces the burden on their working memories, leaving more mental space available for the important work of transferring this knowledge into their long-term memories.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

STRATEGY 6
Simplify complex information by presenting it both orally and visually

Students can process complex information more easily when it is presented in both oral and visual forms at the same time.

When there are two or more sources of information that can only be understood in reference to each other, cognitive load can be managed by presenting information both orally and visually. This strategy increases the capacity of students' working memories, creating more mental space for learning.

Why is it effective?

Our working memories have two separate 'channels' – one for dealing with visual information, and another for dealing with auditory information. By spreading the delivery of information across both of these channels at once, teachers can manage cognitive load and make it easier for students to learn the information. This can be done by communicating information using both images and sound. For example, the teacher could show students a diagram, and explain it orally at the same time.

How can I use it in the classroom?

Combining oral and visual information is particularly effective for teaching content that is very complicated and difficult to understand. Students' working memories can easily be overloaded by trying to process a lot of new information that is only presented visually, such as a combination of written descriptions and diagrams. Teachers can manage students' cognitive load in situations like this by communicating some of that information verbally – such as by removing the written descriptions from the diagrams, and reading the descriptions out loud instead.

It is important to remember that this strategy only applies to essential information. Information that is not essential to the lesson should be removed.

At first glance, Strategy 6, "Simplify complex information by presenting it both orally and visually", might seem to contradict Strategy 5, "Present all the essential information together". Actually, both of these two strategies work to reduce cognitive load, just in different ways. By presenting separate sources of information in one place, cognitive load is reduced by **decreasing** the total amount of information that students have to process. By communicating complex information both orally and visually, the capacity of students' working memories is **increased** so that they can process more information. See "Which strategy should I choose to optimise my students' cognitive load?", page 4.

The strategy of combining oral and visual information is particularly effective for teaching students very well-defined material, such as technical procedures or mathematical processes. The strategy is not known to be as effective in areas that are less well-defined, such as the creative arts.

For this strategy to be effective, teachers should:

1. **Break down spoken explanations into short, simple statements.**

   Using long, complex sentences in spoken language places large demands on working memory because the student has to retain lots of information in order to understand each sentence. This does not leave much capacity for absorbing new information.

2. **Use visual cues to indicate which section of a diagram they refer to.**

   This could be done simply by pointing to the relevant section of the diagram. This is important because, if students have to listen to a verbal description while also searching for the relevant section of the diagram, they are likely to experience cognitive overload.

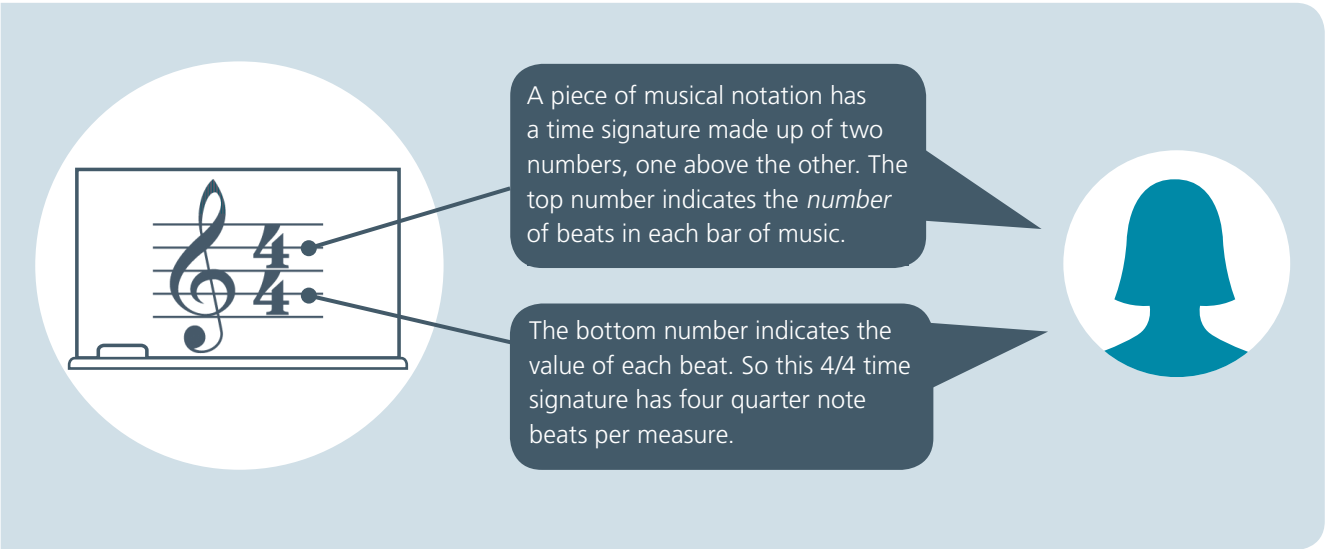
STRATEGY 6
Examples for the classroom

Example 1: Year 7 Music

A Year 7 music class is learning how to read musical notation. The aim of this lesson is for students to understand time signatures. The teacher knows that this lesson involves two separate sources of information that can only be understood in reference to each other – the time signature, and the description of how to understand it. This will create a heavy cognitive load for her students. She has two options to reduce this load. She could present the two sources of information visually as text and a diagram, and make sure they are physically integrated (Strategy 5, page 21). Or, she could present the two sources of information using both auditory and visual channels of communication. She decides to use the second approach.

What does it look like?

The teachers shows the students a PowerPoint slide with a time signature and explains that the time signature indicates the meter of the piece of music. While the students look at the slide, she verbally describes the steps required to read the time signature, pointing to the relevant section of the time signature as she describes each step.



By presenting the two sources of information both orally and visually, the teacher has created more mental 'space' for the students in which to learn the skill of reading time signatures. By also pointing out each section of the diagram that she is referring to, she has saved the students from having to search for each relevant section themselves. Now their working memories are freed up to learn the skill of reading time signatures.

Example 2: Year 6 Science

A Year 6 class is learning how electrical energy can be transferred and transformed in electrical circuits. The aim of this lesson is for students to understand how coal can generate electricity. The teacher knows that to explain this process, she will need to use both text and a diagram. This is likely to place a heavy burden on the students' working memories, so the teacher decides to manage their cognitive load by presenting the information both orally and visually.

What does it look like?

The teacher creates a PowerPoint slide with a flow chart showing five stages of electricity generation. While the students look at the slide, the teacher explains each of the five stages of the process. She keeps her descriptions of each stage short and easy to understand.

By using a combination of oral and visual communication, the teacher has managed the cognitive load of her students. By also keeping the verbal descriptions short, the teacher has ensured that the strategy will be effective.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

STRATEGY 7

Encourage students to visualise concepts and procedures that they have learnt

Students understand and recall information better when they visualise the things they have learnt.

Encouraging students to visualise what they have learnt helps them to better understand and recall the information. Once students have a good grasp of the content, the mental process of visualising helps students to store the information more effectively in their long-term memories. This strategy should only be used once students are familiar with the content, as visualising imposes quite a heavy cognitive load.

Why is it effective?

The process of visualising means mentally reproducing a procedure or concept. For example, a student learning how to solve a geometry problem might visualise each of the steps required to reach the solution. When students have to visualise something they have learnt, they are required to retrieve information held in their long-term memory and process it in their working memory. This mental process helps students to engage with information more deeply, and to begin to recall it automatically without much conscious effort.

How can I use it in the classroom?

Recalling something takes up a lot of mental resources, so these strategies will only be effective if there is enough mental space available in the working memory. For this reason, visualising concepts is a very useful practice once students have a good grasp of the content, but should not be used for students who are new to the material.

Encouraging students to visualise concepts is a way of adapting teaching strategies to suit more proficient learners. In this way, the strategy is similar to the approaches of omitting steps from a worked example or gradually giving students fewer worked examples. This strategy is often more effective than 'fading out' guidance, because it avoids providing redundant information.

Name
Activity 1 : Add or Subtract
Fill in the missing sign (+/-)
7 ◯ 2 = 5
9 ◯ 4 = 13
12 ◯ 1 = 11
6 ◯ 5 = 11
3 ◯ 9 = 12
19 ◯ 7 = 26
20 ◯ 13 = 7
12 ◯ 6 = 6
6 ◯ 11 = 17
15 ◯ 5 = 10
18 ◯ 11 = 7
9 ◯ 5 = 14
3 ◯ 6 = 9
15 ◯ 9 = 6
6 ◯ 2 = 8
20 ◯ 10 = 10
7 ◯ 4 = 11
3 ◯ 5 = 8
9 ◯ 12 = 21
17 ◯ 4 = 13
LESSON 1
LIFE CYCLE
THE CHICKEN
LIFE CYCLE

Example 1: Year 4 Maths

A Year 4 class is learning to read and interpret simple timetables. The students have been using bus timetables to practise this skill. They have already learnt the procedure for reading a bus timetable using lots of worked examples. The aim of this lesson is for students to learn how to read bus timetables automatically without having to think consciously about each of the steps involved.

What does it look like?

The teacher decides to encourage his students to visualise the process of reading a bus timetable. The teacher begins the lesson by showing his students one worked example of how to read a bus timetable.

01. Find Yellow Street in the "Bus Stop" row and move across until the two dotted lines meet.

02. Find 103 in the Route Number section and follow the dotted line down the column.

03. The box where the lines meet gives the time when the 103 bus departs from Yellow Street – 2:25pm.

Red Street to Violet Street Timetable

Bus stops	Route number							
	101	101	101	102	101	103	101	102
	am	am	am	am	pm	pm	pm	pm
Red Street	9:00	10:15	11:30	11:45 E	12:55	2:10	3:25	4:40 E
Orange Street	9:10	10:25	11:40		1:05	2:20	3:35	
Yellow Street	9:15	10:35	11:45		1:10	2:25	3:40	
Green Street	9:25	10:40	11:55	12pm	1:20	2:35	3:50	4:55
Blue Street	9:30	10:45	12:00		1:25	2:40	3:55	
Indigo Street	9:35	10:50	12:05		1:30	2:45	4:00	
Violet Street	9:40	10:55	12:10	12:10	1:35	2:50	4:05	5:05

He then tells the students to read instruction number one on the worked example, and when they are sure they understand it, to turn over the sheet of paper and to visualise following the instruction they have just read. He tells the students to continue this process for the second and third instructions, until they have visualised following all of the instructions.

By encouraging his students to visualise the process of reading a bus timetable, the teacher has helped them to build stronger schemas for this knowledge in their long-term memories. Lots of practice like this will help the students to automatically retrieve this knowledge from their long-term memories without much conscious effort.

Example 2: Year 6 Personal Development, Health and Physical Education

A Year 6 Personal Development, Health and Physical Education (PDHPE) class is learning to apply the movement skills needed in cricket. The aim of this lesson is to practice the correct cricket batting stance and grip. The students have already been studying diagrams and videos demonstrating the correct stance and grip, and have been practising this in pairs. The teacher has noticed that sometimes the students forget the correct stance, and hold the bat the wrong way. To help the students build stronger schemas for the information in their long-term memories so that they can recall it automatically, the teacher decides to have the students visualise the correct stance and grip.

What does it look like?

The teacher asks the students to sit with their eyes closed, and visualise themselves standing at the pitch. She asks them to picture how their feet are placed, using the correct stance they have already learnt. She then asks them to visualise themselves holding the bat, using the correct grip that they have been studying. Finally, she asks them to picture a cricket ball coming towards them, and to visualise using the technique they have learnt to hit the ball correctly. She encourages the students to imagine this sequence several times more, before returning to practice their stance and grip again in pairs.

Encouraging the students to visualise the correct stance and grip forces the students to access this information in their long-term memory and process it in their working memory. This type of practice requires a lot of mental effort, but it will help the students to automatically retrieve this information during games of cricket, with minimal conscious effort.

When have I used this strategy over the last year?

How could I use this strategy in future lessons?

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