COGNITIVE **LOAD** THEORY

JOHN SWELLER, PAUL AYRES, SLAVA KALYUGA, 2001, SPRINGER

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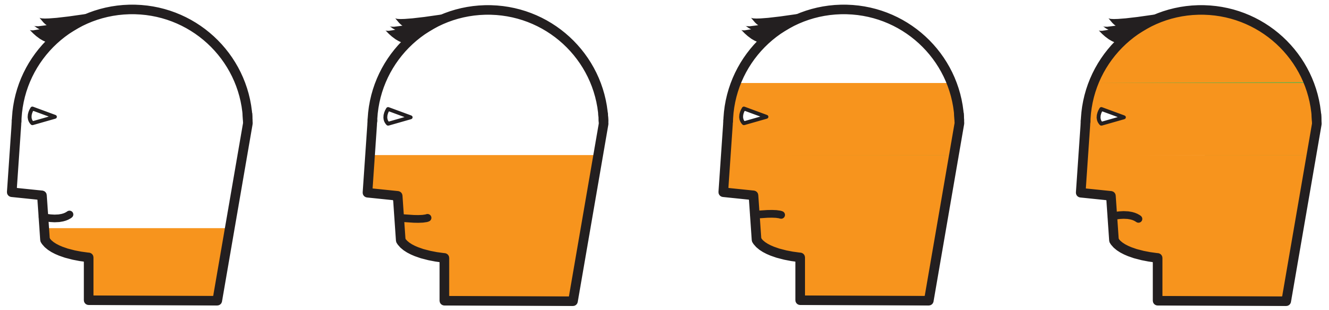
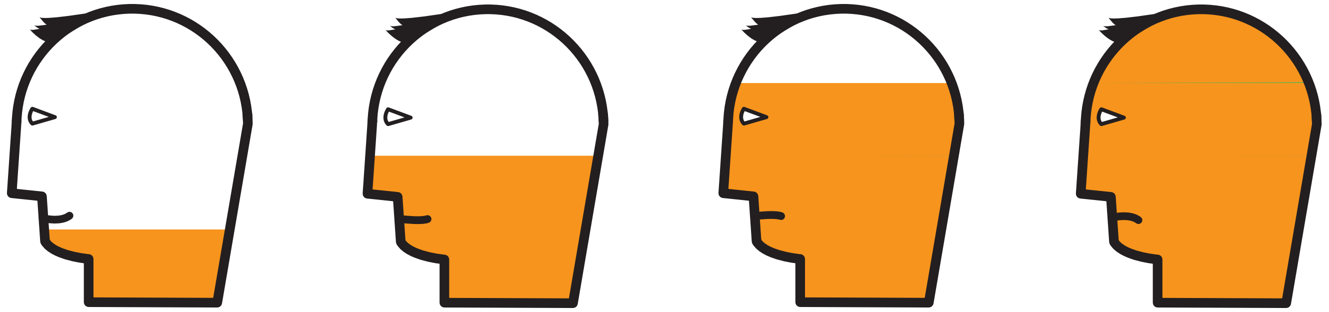
> Without knowledge of human cognitive processes, instructional design is blind.
>
> Human cognitive architecture can be used to generate instructional procedures that we otherwise would have considerable difficulty conceiving.

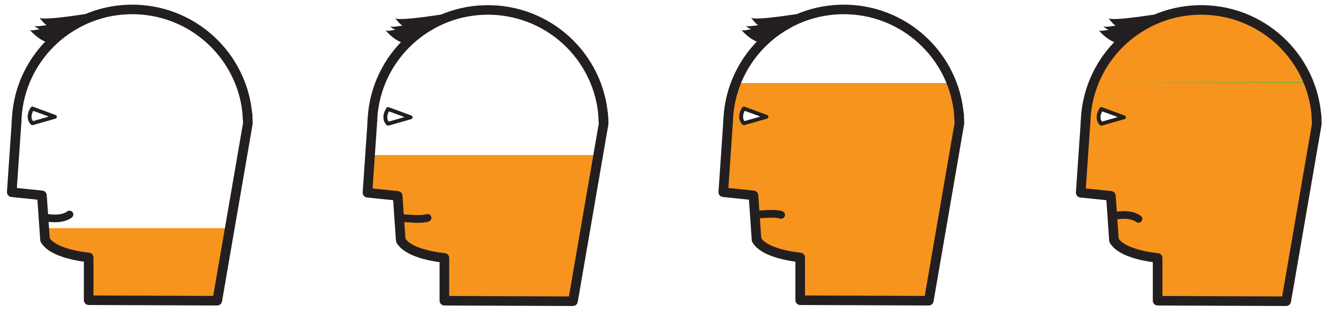
> We have evolved to assimilate biologically primary knowledge:
> - recognising faces and speech
> - general problem solving
> - basic social relations



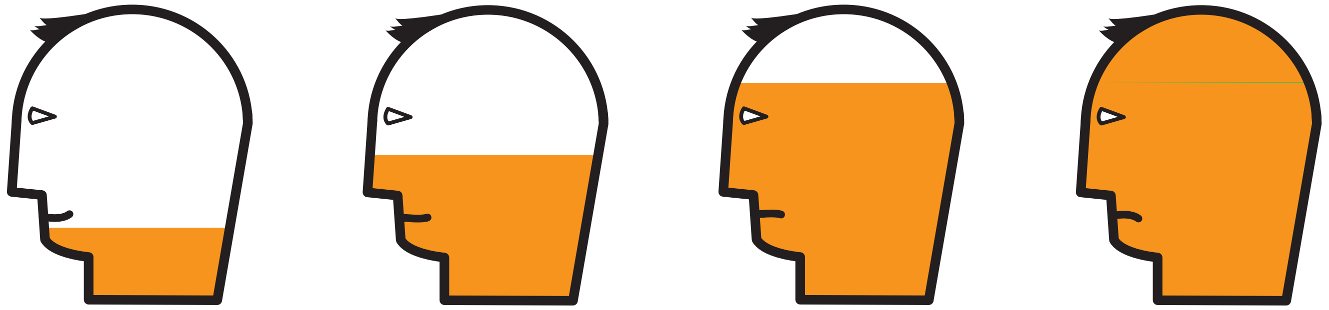
> Primary knowledge acquisition does not require institutional support.



“Secondary knowledge needs to be explicitly taught and is usually consciously learned, unlike primary knowledge.

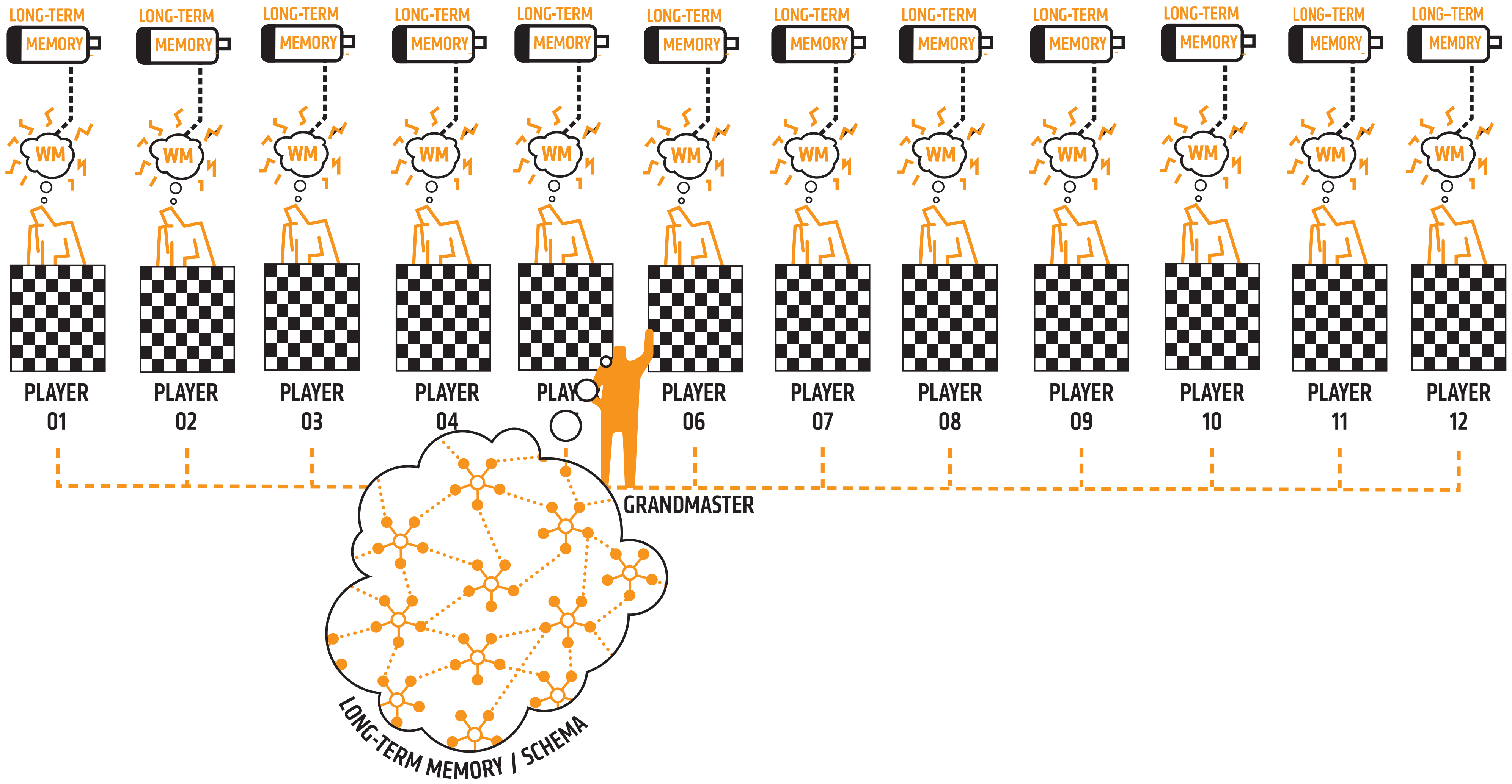


> We have not evolved to learn to write…accordingly, the instructional process required to learn to write are vastly different from those required to learn to speak.



2 Amassing Information: The Information Store Principle

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER



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Grandmasters played a dozen club players simultaneously and won them easily. The club players spent their time on strategy — thinking deeply about their future moves and their potential outcomes. Everything, in fact, that make up classic means–end problem solving.

2 Amassing Information: The Information Store Principle

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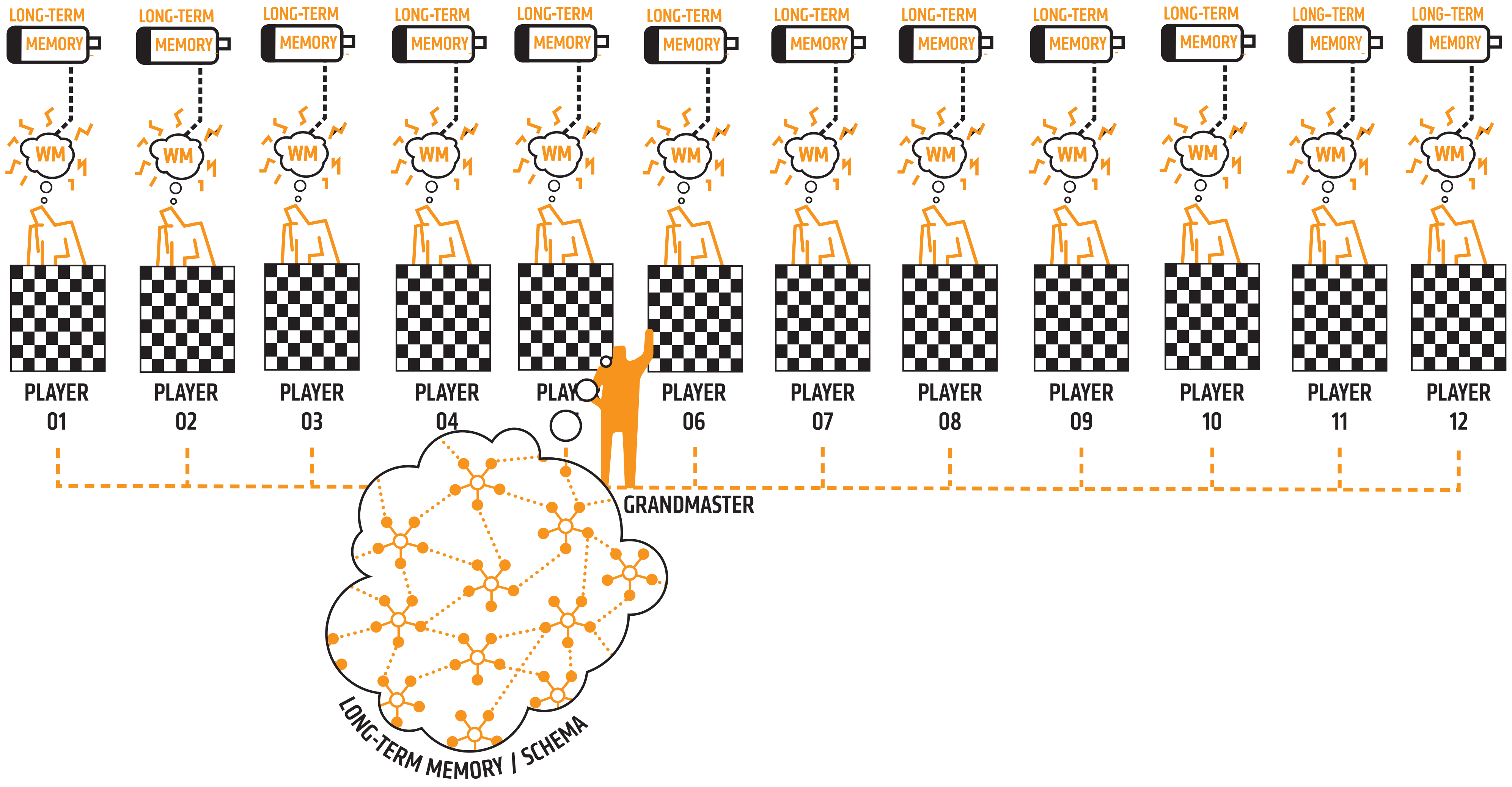


> Novices need to use thinking skills. Experts use knowledge.

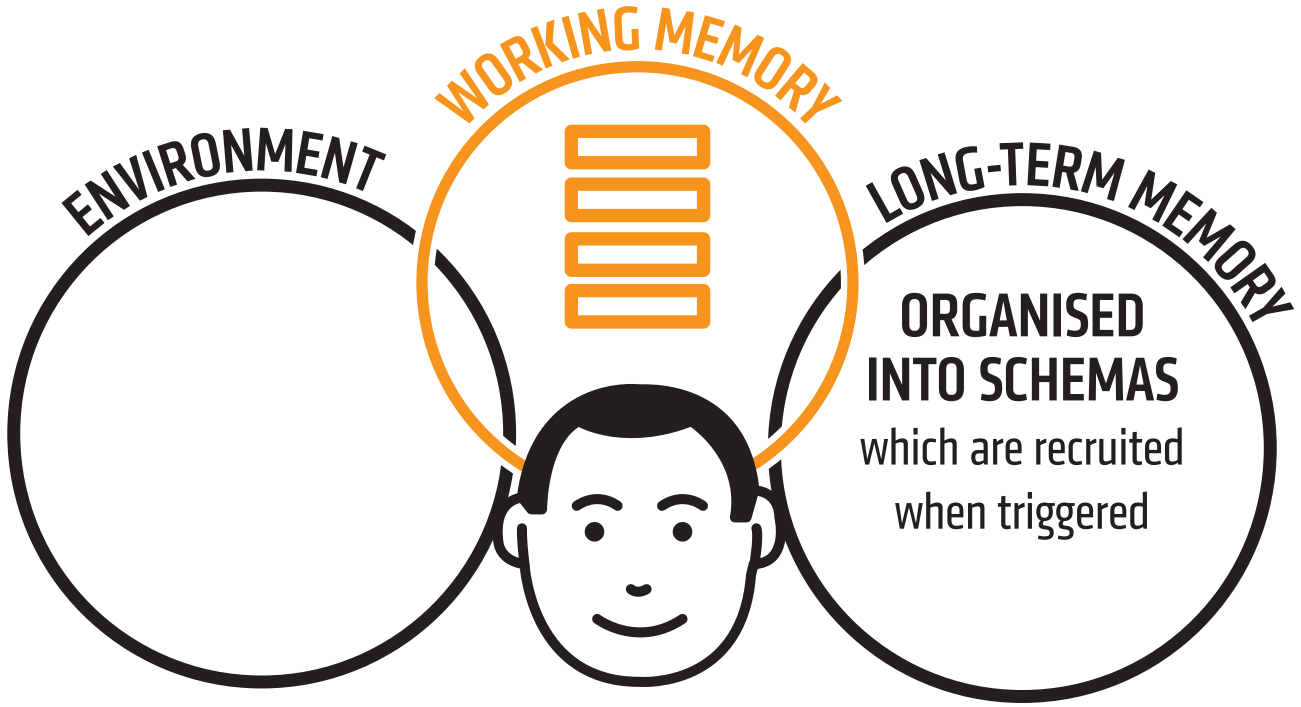
“

Devising instruction according to cognitive load theory, means devising instructional procedures that facilitate the borrowing of information.

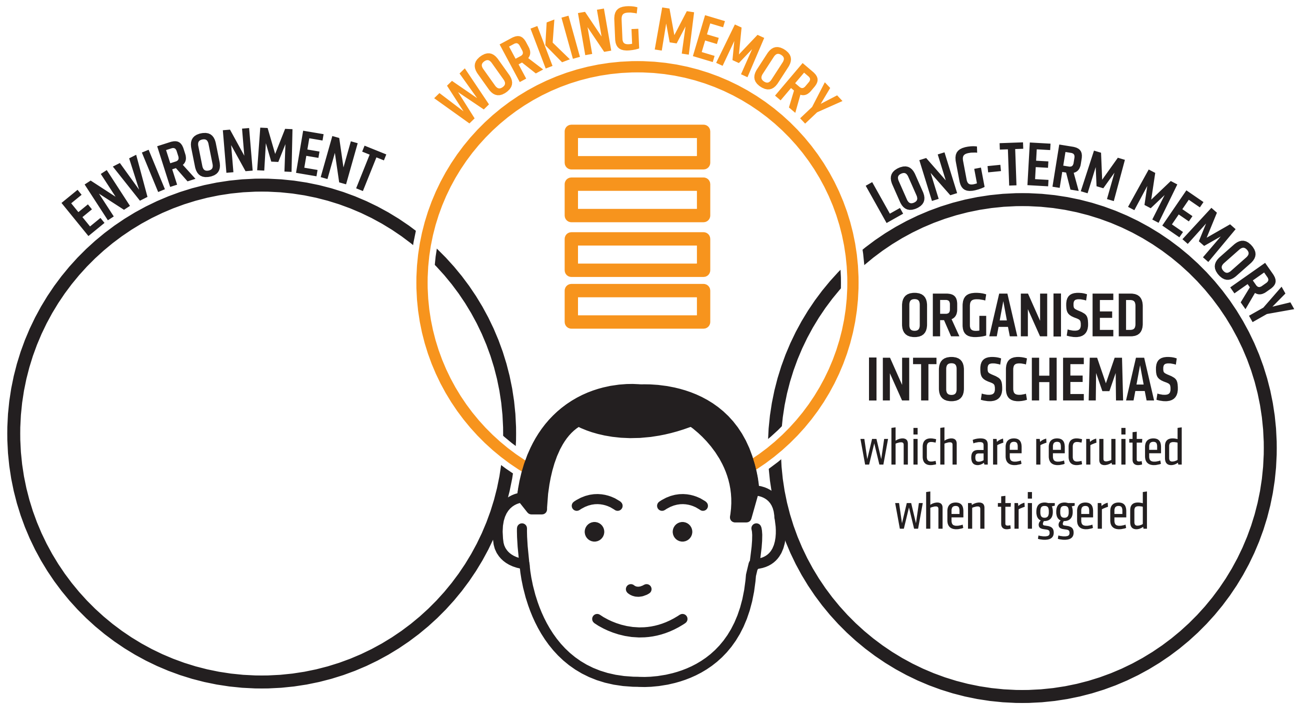
> Almost all of the secondary knowledge stored in long–term memory is borrowed from other people....
> Borrowed information has already been organised.

"The evidence is strong that borrowed information is reorganised.

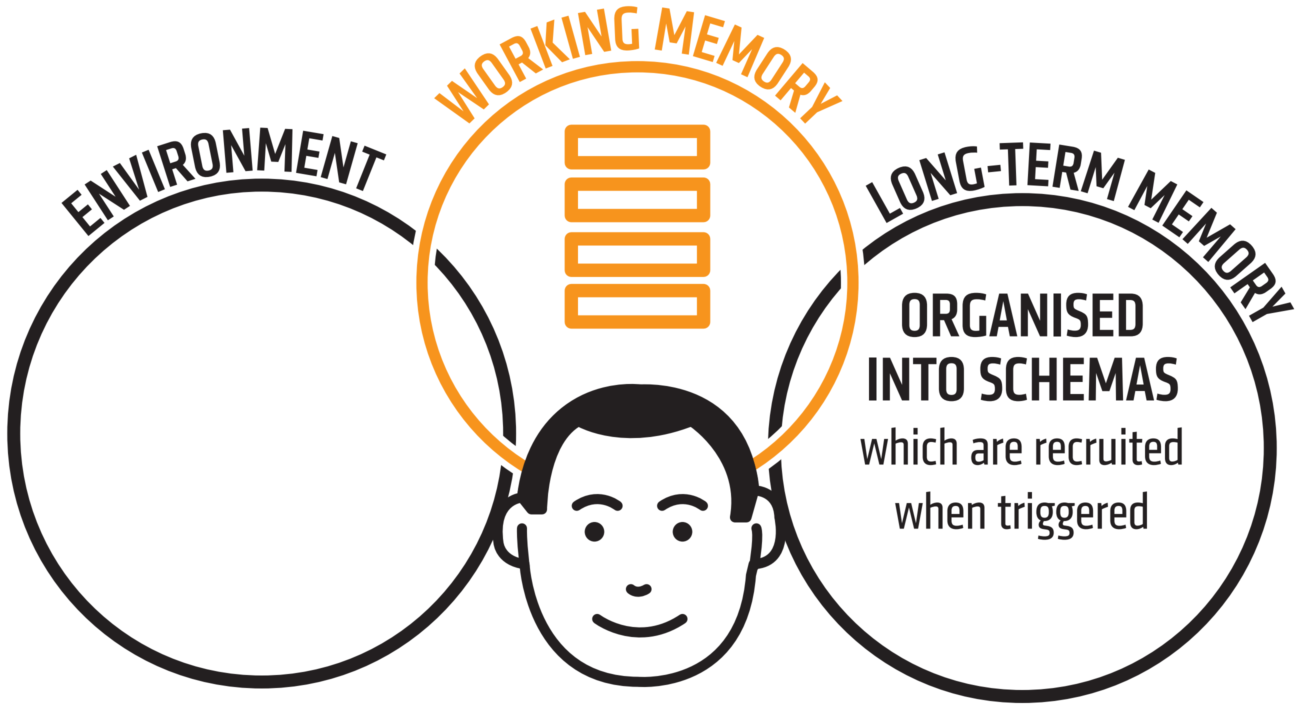
> In general terms, most students are novices and so most of the information provided to them is novel and must be processed by a limited capacity, limited duration working memory.



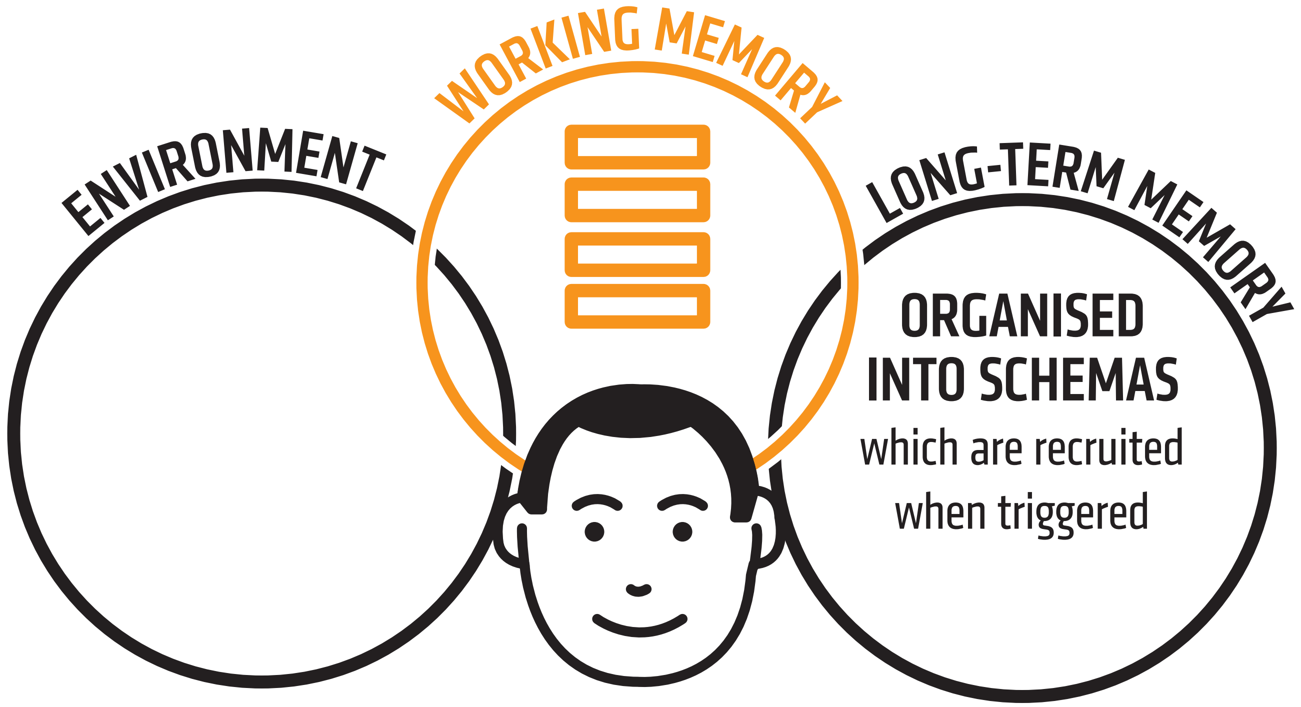
> The amount of organised information from long–term memory that can be dealt with by working memory has no known limits.



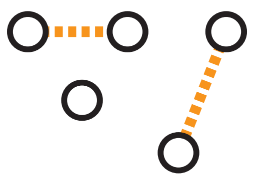
> “Information in long–term memory does not become active until it has been triggered by cues from the environment that induce working memory to choose one set of schema over another.



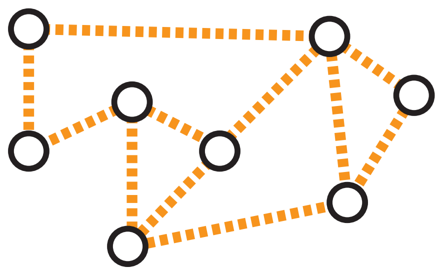
> A major purpose of education is to permit us to perform appropriately in our environment, requiring us to selectively access information from long–term memory.



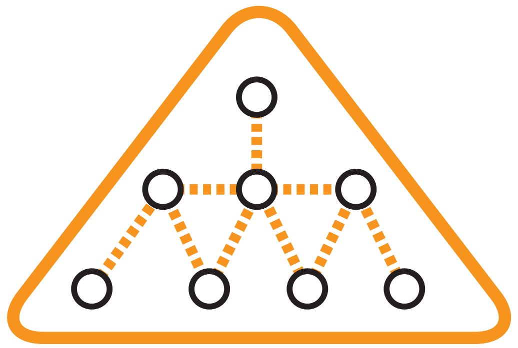
> “One aim of instructional design is to reduce extraneous cognitive load so that a greater percentage of the pool of working memory resources can be devoted to issues germane to learning rather than to issues extraneous to learning.



LOW LEVEL INTERACTIVITY

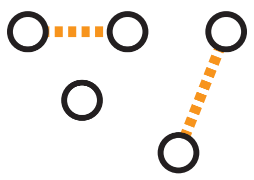


HIGH LEVEL INTERACTIVITY



SCHEMA FORMATION

Levels of both intrinsic and extraneous cognitive load are determined by element interactivity. Interacting elements are defined as elements that must be processed simultaneously in working memory because they are logically related.



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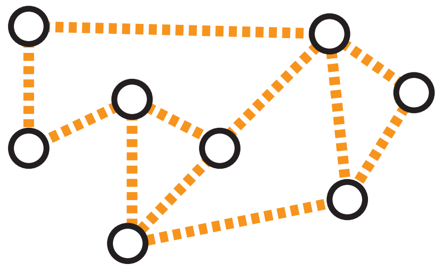

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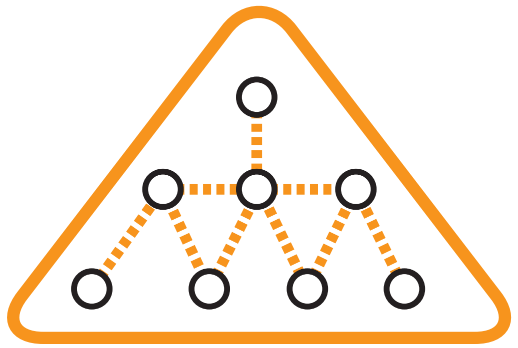
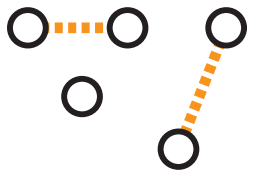


SCHEMA FORMATION

“When dealing with low element interactivity information, we assume correctly that learning *by rote* is unavoidable because no other form of learning is available.



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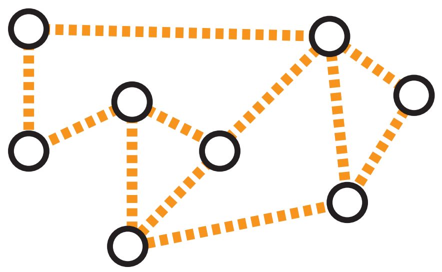

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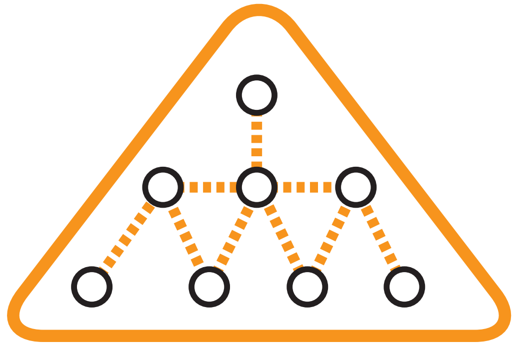
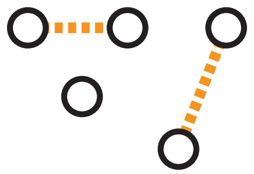


SCHEMA FORMATION

> Element interactivity can be used to define *understanding*. Information is fully understood when all of its interacting elements can be processed in working memory.



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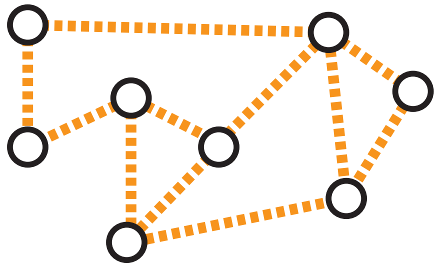

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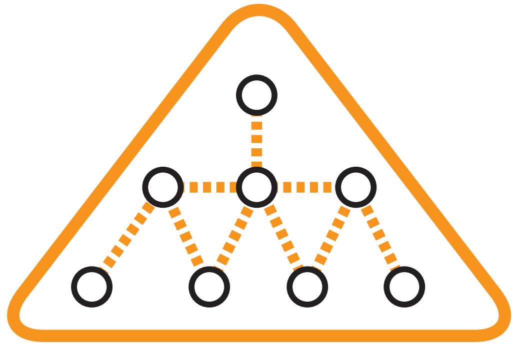
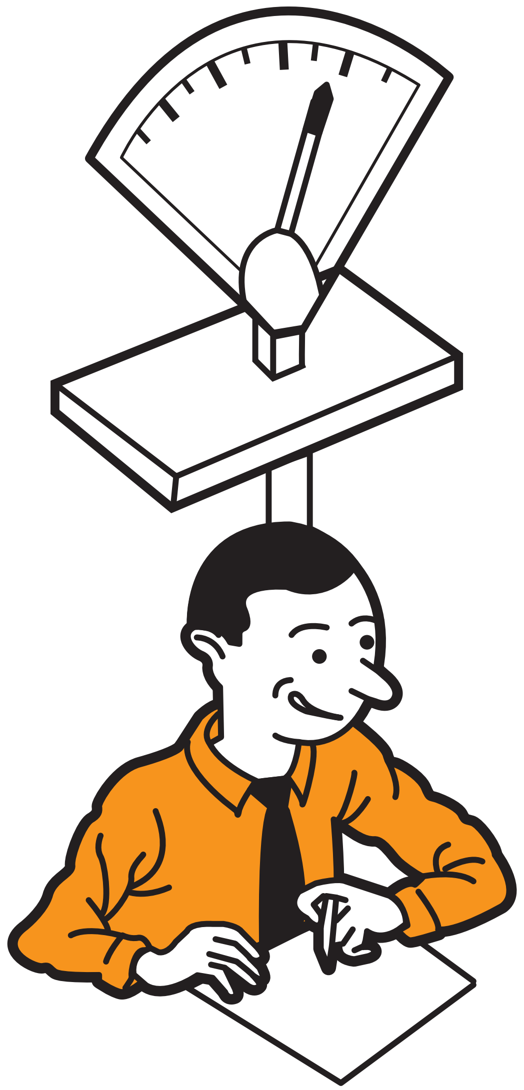
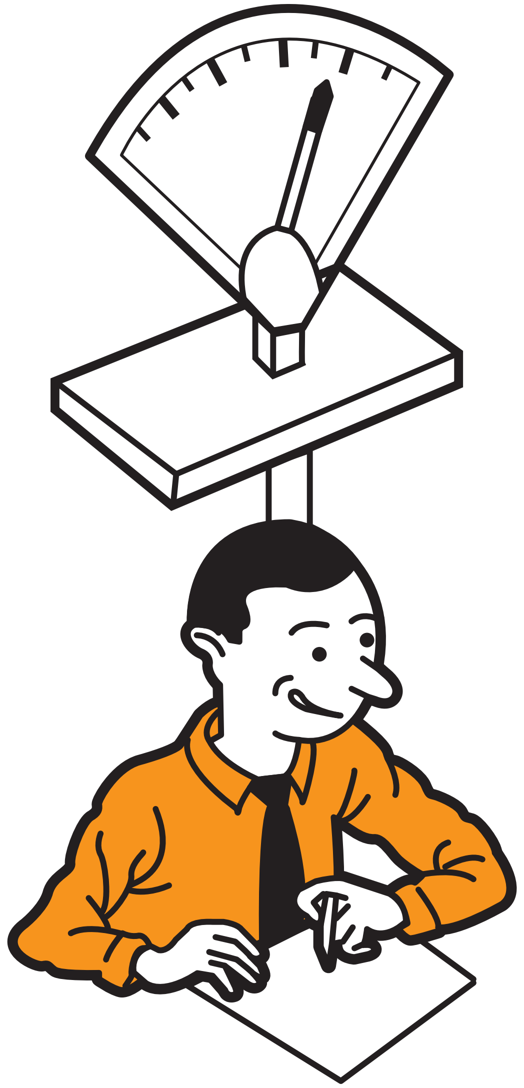


SCHEMA FORMATION

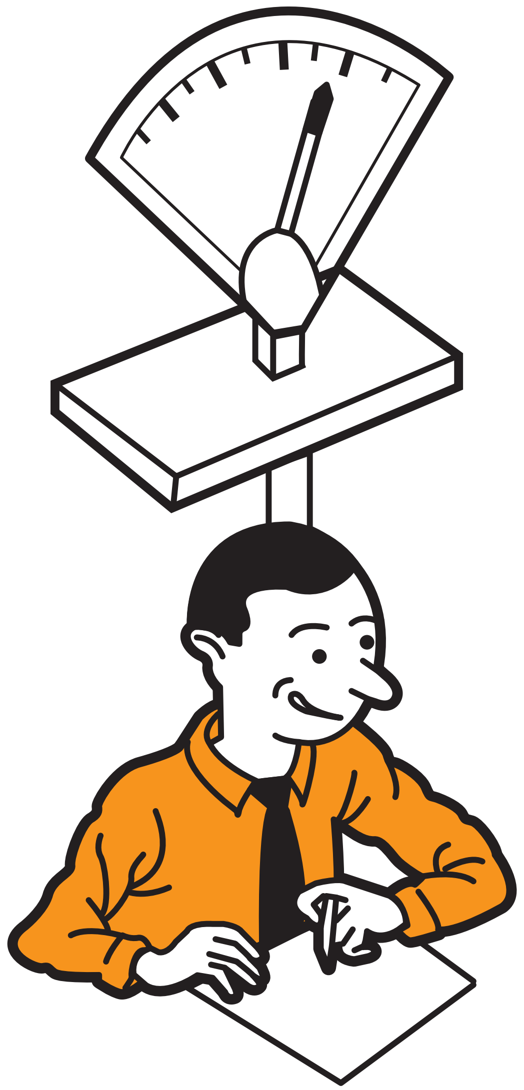
> Once a schema has been constructed, it becomes another single element that does not impose a heavy working memory load.



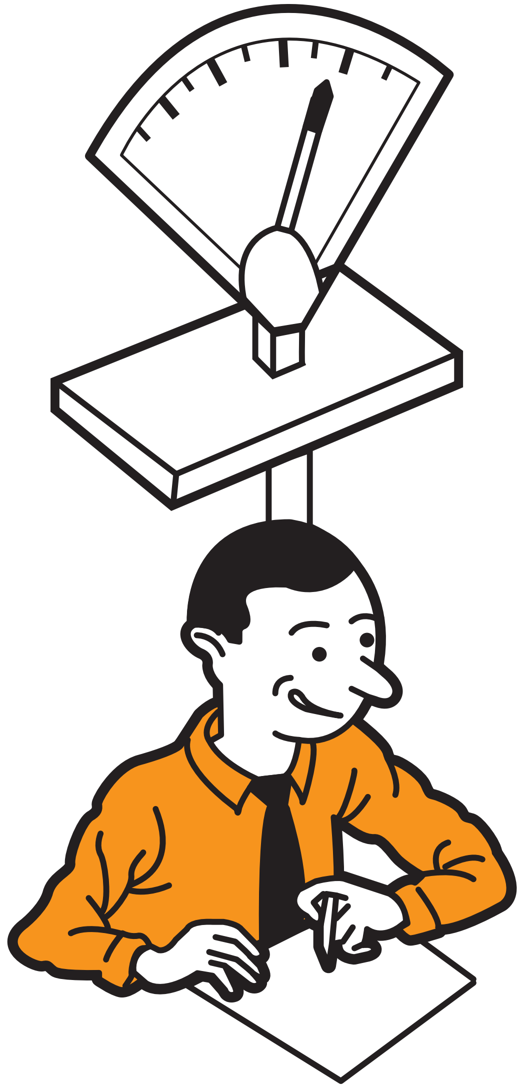
“Learners are able to introspect the amount of mental effort invested during learning and testing, and this *intensity of effort* may be considered to be an *index* of cognitive load.



“ High instructional efficiency results from high task performance and low mental effort.



> Learning efficiency may be a good indicator of schema acquisition and automation.



“ If the primary task imposes a heavy cognitive load, performance on the secondary task deteriorates.

“ Over a set of problems, the goal–free group gained more knowledge about the structure of the problems than the goal–specific group.

7 The Goal–Free Effect

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

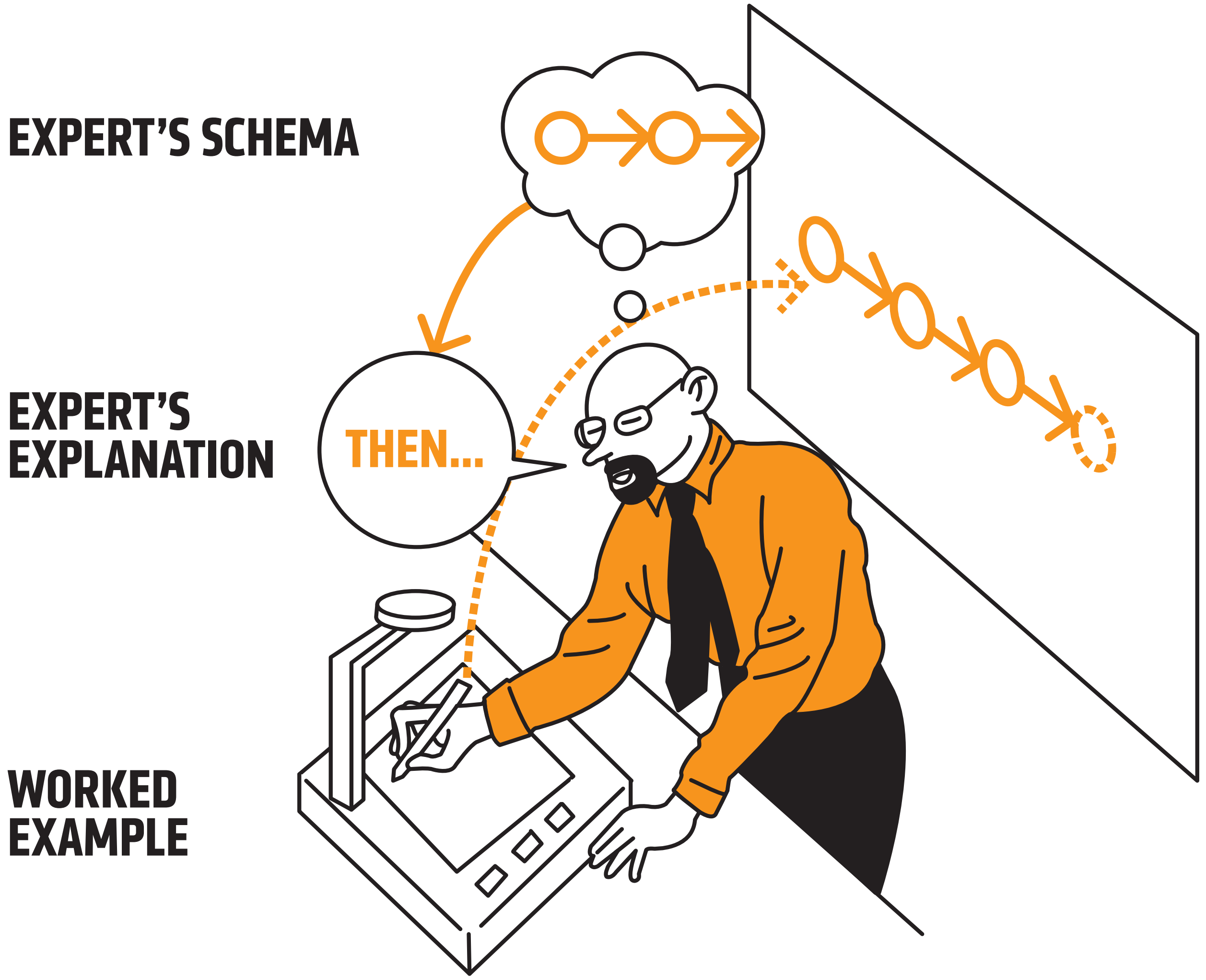
"When novices solve a conventional problem, they will frequently work backwards from the goal to the givens using a means–end strategy….but… working memory may be overwhelmed by a means–end strategy, reducing or even preventing learning.

“

Learners are more likely to acquire schemas under goal–free than conventional goal conditions.

“ Conventional problem solving, particularly for novices in a domain, should be avoided because of the extraneous cognitive load created by search strategies such as means–end analysis.

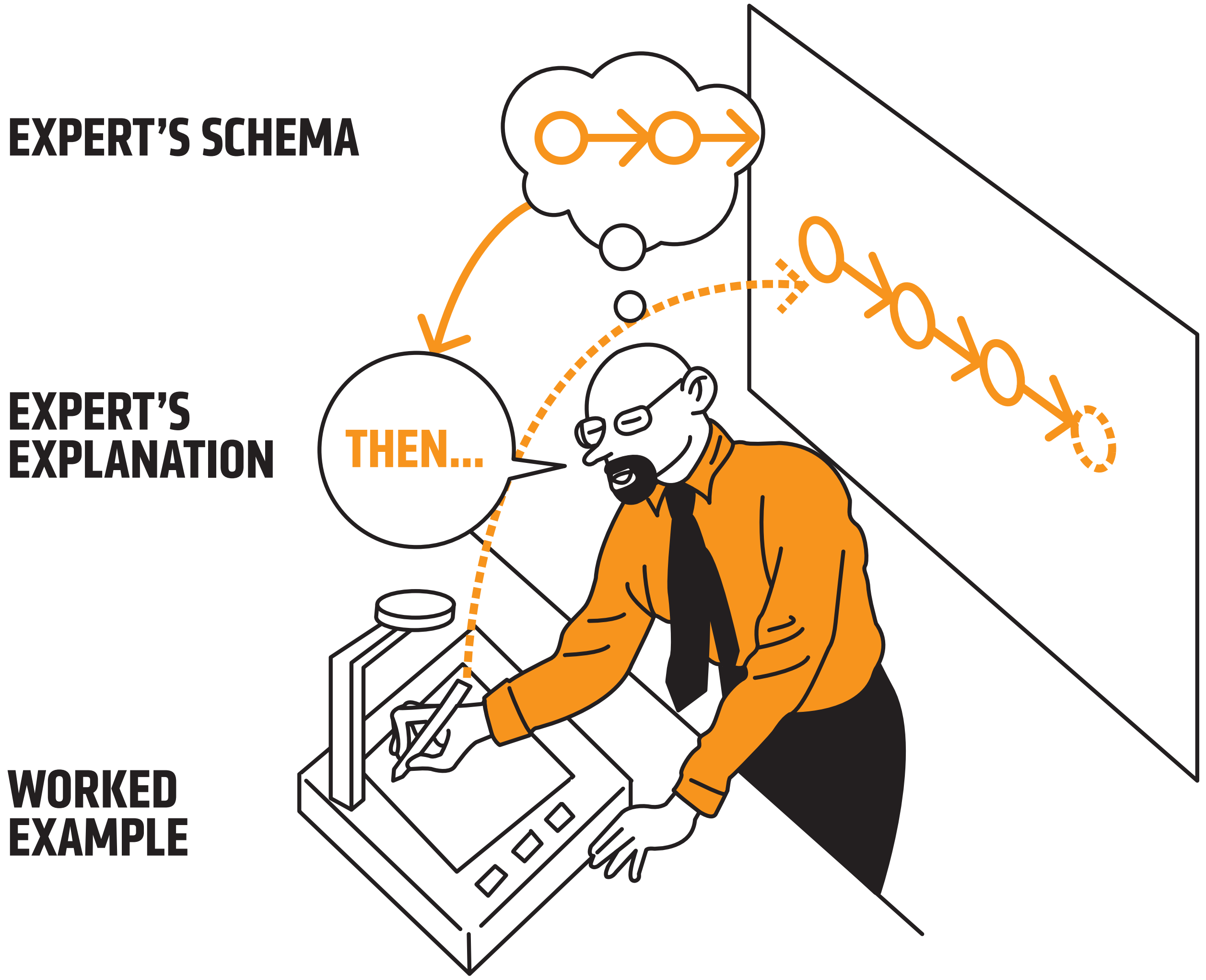
> Studying worked examples provides one of the best, possibly the best, means of learning how to solve problems in a novel domain.



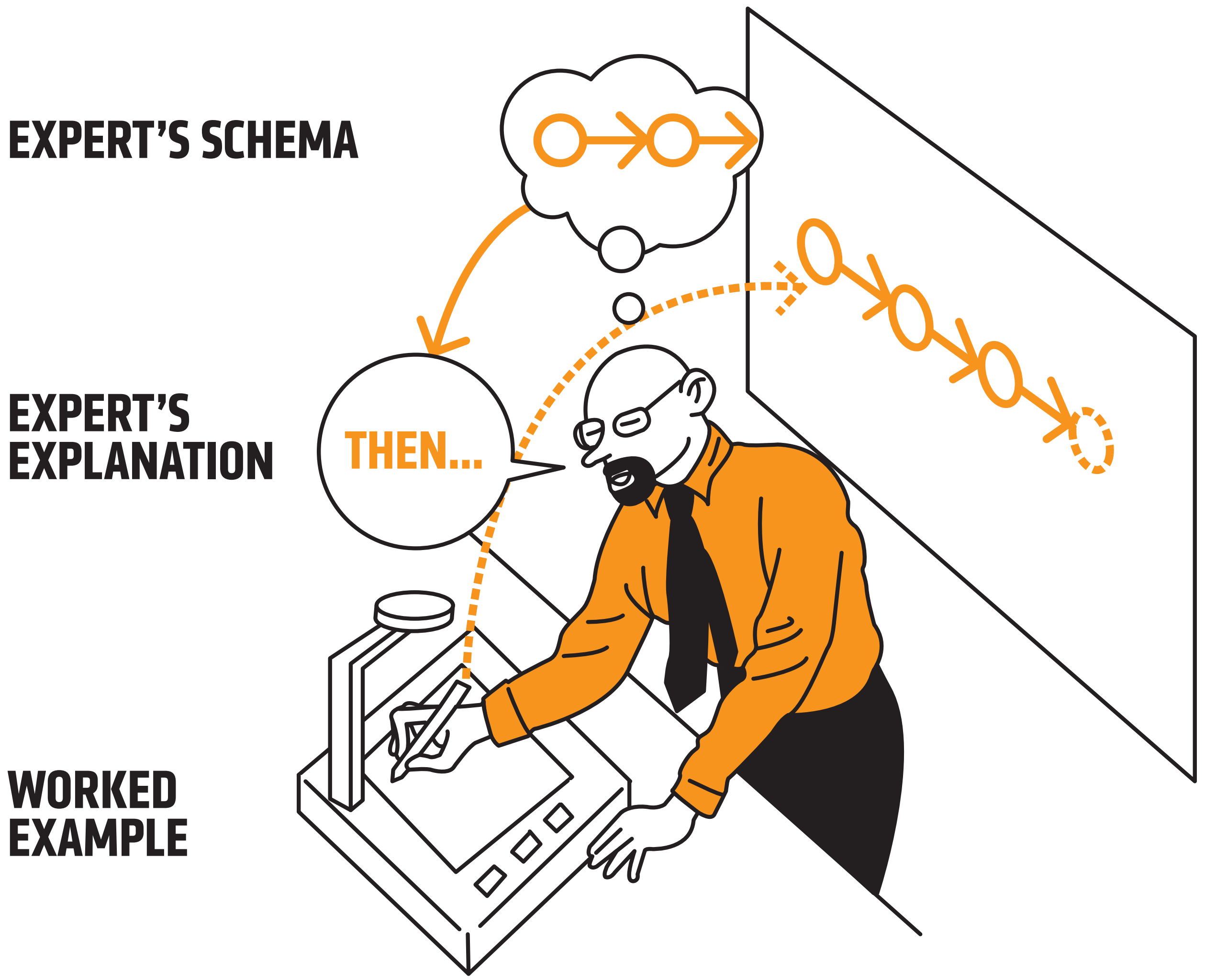
8 The Worked Example and Problem Completion Effect

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

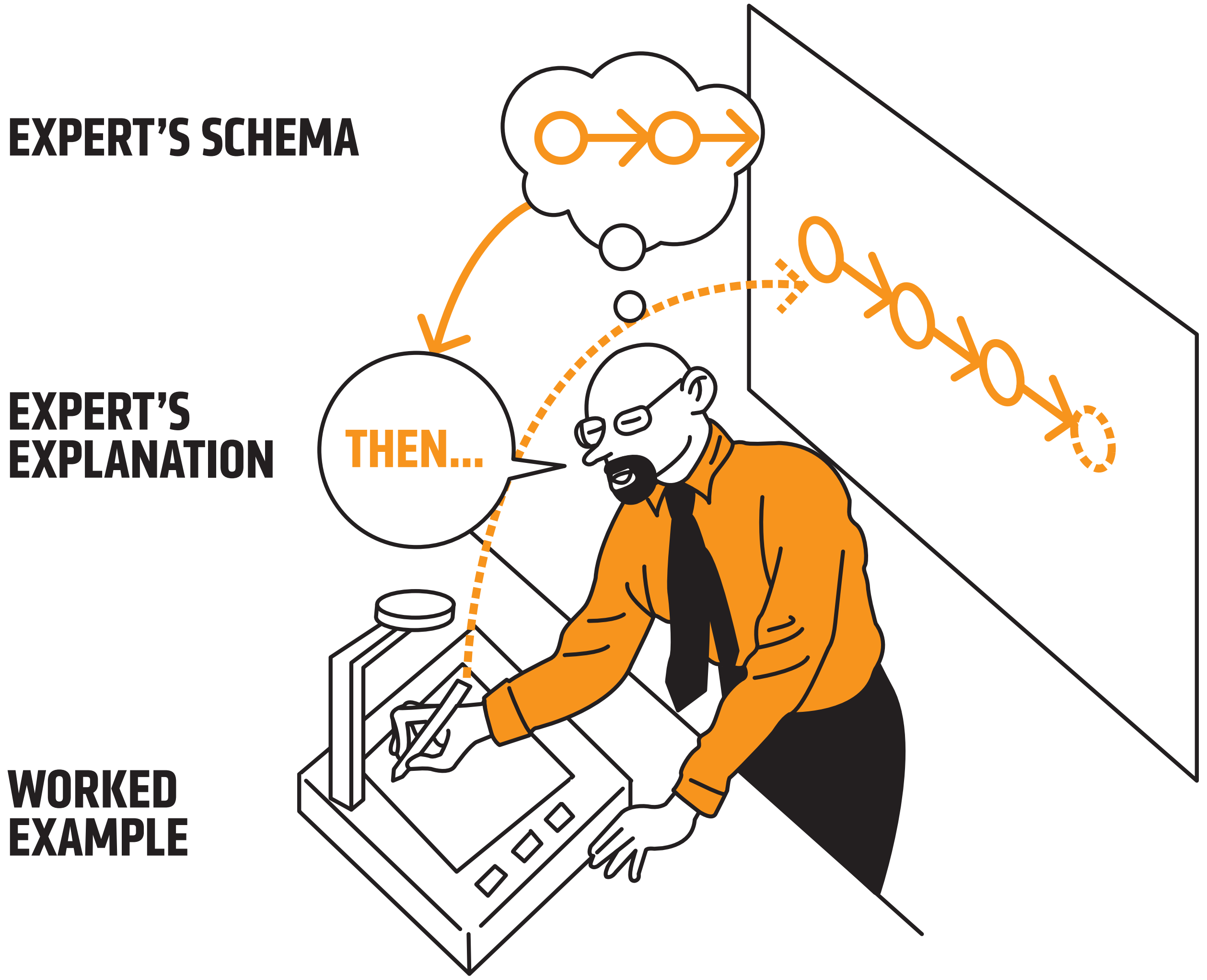
> Worked examples can effectively provide us with problem-solving schemas that need to be stored in long-term memory using the information store principle.



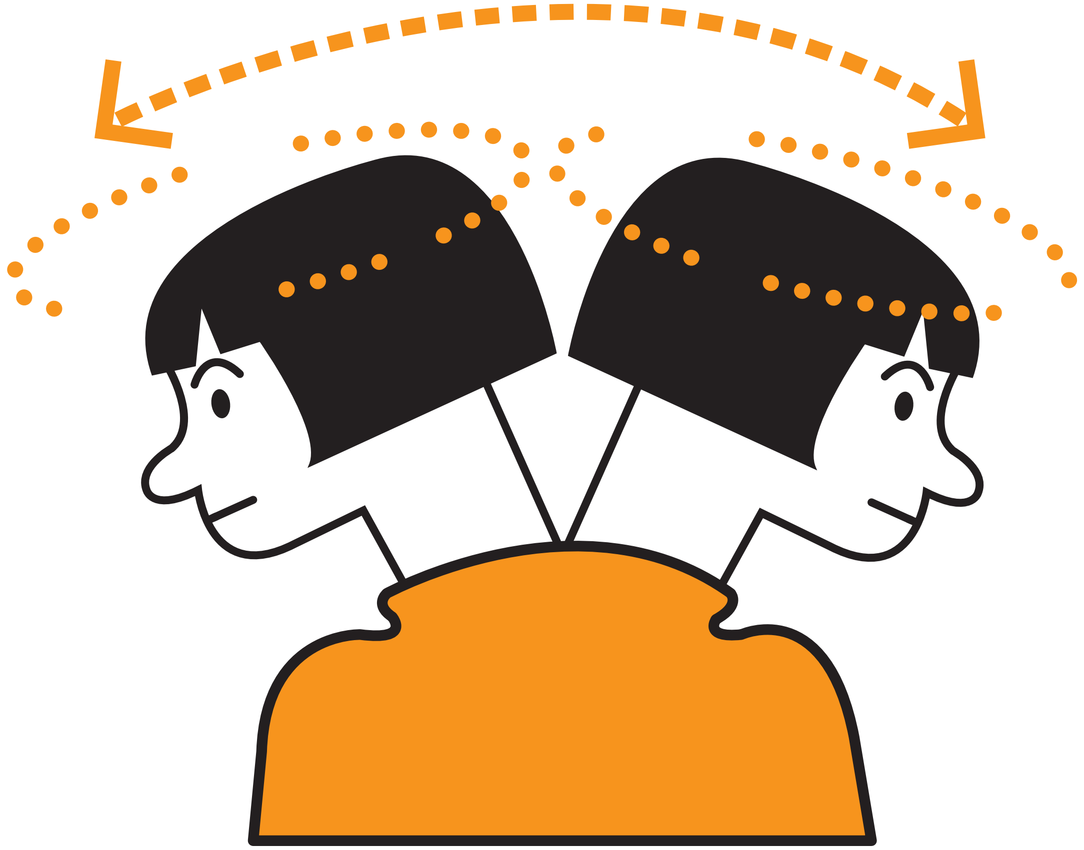
> Worked examples impose a relatively low working memory load…compared to solving problems using means-end search.



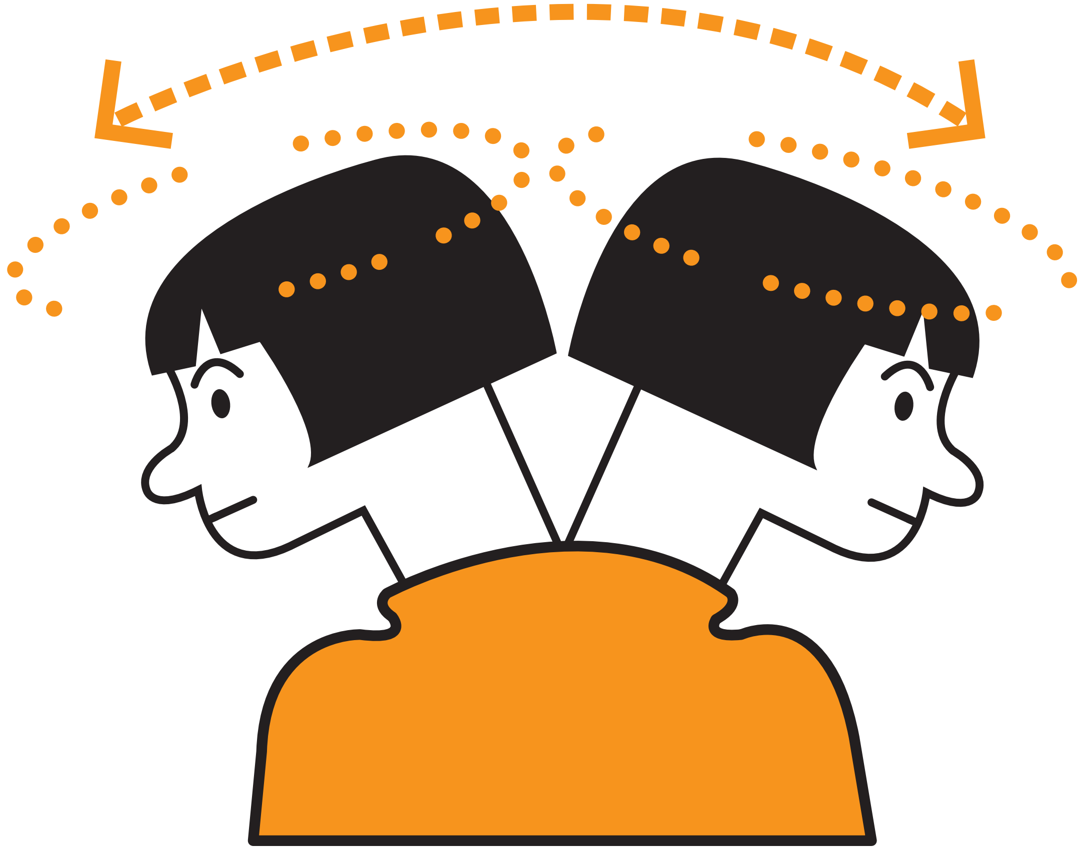
“The most efficient method of studying examples and solving problems was to present a worked example and then immediately follow this example by asking the learner to solve a similar problem.
This is the alternation strategy.



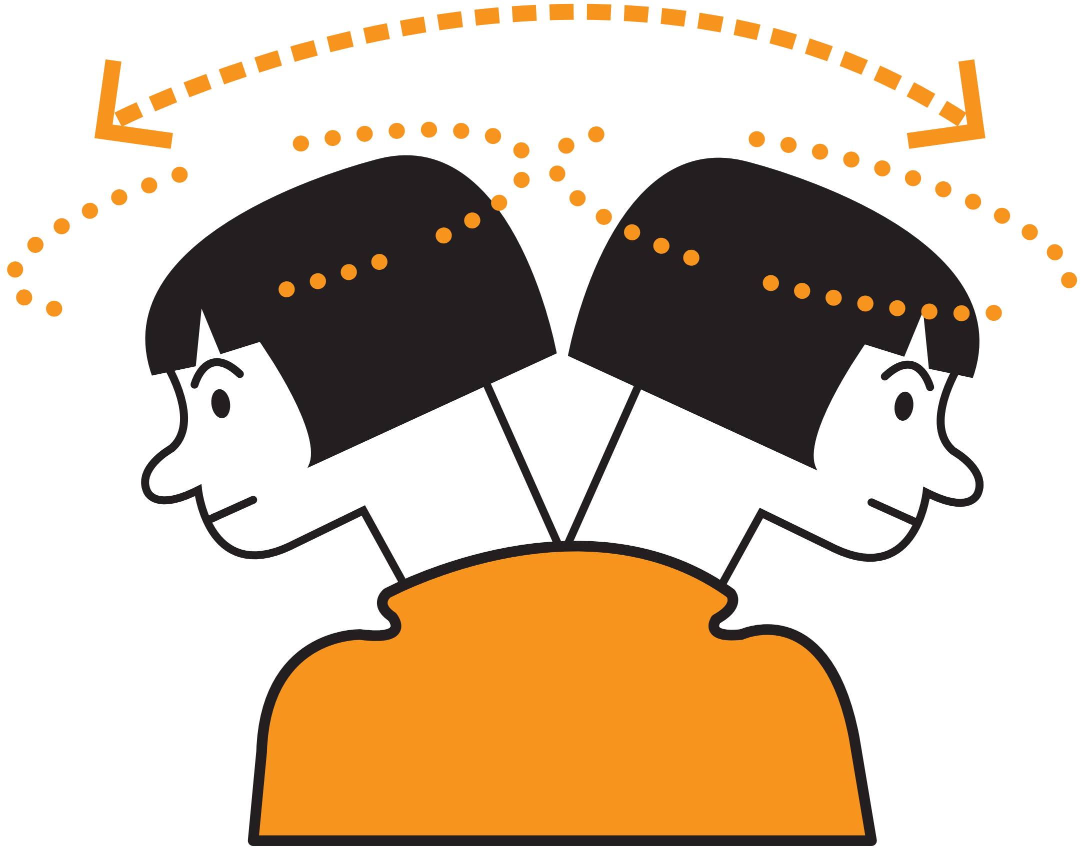
> The split-attention effect occurs when an instructional strategy based on integrated materials leads to better outcomes than one based on split source materials.



> If learners are using working memory resources to integrate disparate sources of information, they may have few resources available to consider the solution.



“ Worked examples have no advantage over conventional problem solving when they were constructed in a split-source presentation format, but had a significant advantage if they were structured according to an integrated approach.



10 The Modality Effect

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

> The amount of information that can be processed using both auditory and visual channels should exceed the processing capacity of a single channel.

10 The Modality Effect

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

> There is evidence that the effect may be eliminated or reversed with relatively more experienced learners.

11 The Redundancy Effect

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

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The redundancy effect occurs when information that includes redundant material results in less learning than the same information minus the redundant material.

The Redundancy Effect

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

“The presence of a concurrent spoken presentation rendered reading comprehension less effective compared with written-only instructions.

> The expertise reversal effect is explained by the need to provide novices with information that is essential for their understanding and in the case of experts, to unnecessarily process that same information that is redundant for more knowledgeable learners.

“ The information or activities that previously were essential may become redundant causing increased levels of extraneous cognitive load.

> The need for experts to establish connections between elements of presented information and their existing knowledge base can interfere with learning.

> One possible means of a smooth transition from worked examples to problem solving practice is the use of completion tasks.

“The gradual reduction of instructional guidance as levels of learner expertise increase has proved to be a more effective instructional procedure than abrupt switches from worked examples to problems.

“ According to the expertise reversal effect, appropriate instructional guidance needs to be presented at the right time, and removed in a timely fashion as learners gradually gain expertise.

14 Facilitating Effective Mental Processes: The Imagination and Self-Explanation Effects

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

“Imagining or self-explaining a procedure can be regarded as form of deliberate practice that requires intentional processing of information in working memory to strengthen schemas held in long-term memory.

"The imagining effect was beneficial only for more knowledgeable learners. The results indicated that the imagining technique was not useful for low-knowledge students because of the heavy working memory load it generated for these learners.

14 Facilitating Effective Mental Processes: The Imagination and Self-Explanation Effects

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

> Switching from studying worked examples to imagining problem solutions may be as effective or even more effective as expertise increases than switching from studying worked examples to solving problems via faded worked examples.

"

The fact that cognitive load effects tend to be obtainable only if intrinsic cognitive load is high is referred to as the element interactivity effect.

15 Emerging Themes in Cognitive Load Theory: The Transient Information and the Collective Working Memory Effects

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

“High levels of element interactivity are a major impediment to learning.

15 Emerging Themes in Cognitive Load Theory: The Transient Information and the Collective Working Memory Effects

COGNITIVE LOAD THEORY: SRINGER, AYRES, KALYUGA, 2001, SPRINGER

“Imagining high element interactivity materials allowed learners to combine the multiple interacting elements of information into a single schema that could be more readily processed in working memory.

> The modular approach reduces element interactivity and intrinsic cognitive load.

“Learning of complex materials can be achieved by reducing element interactivity initially and then carefully progressing to full element interactivity in a simple–to–complex sequence.

> A learner is more likely to integrate new knowledge with old if tasks are completed in small sections.

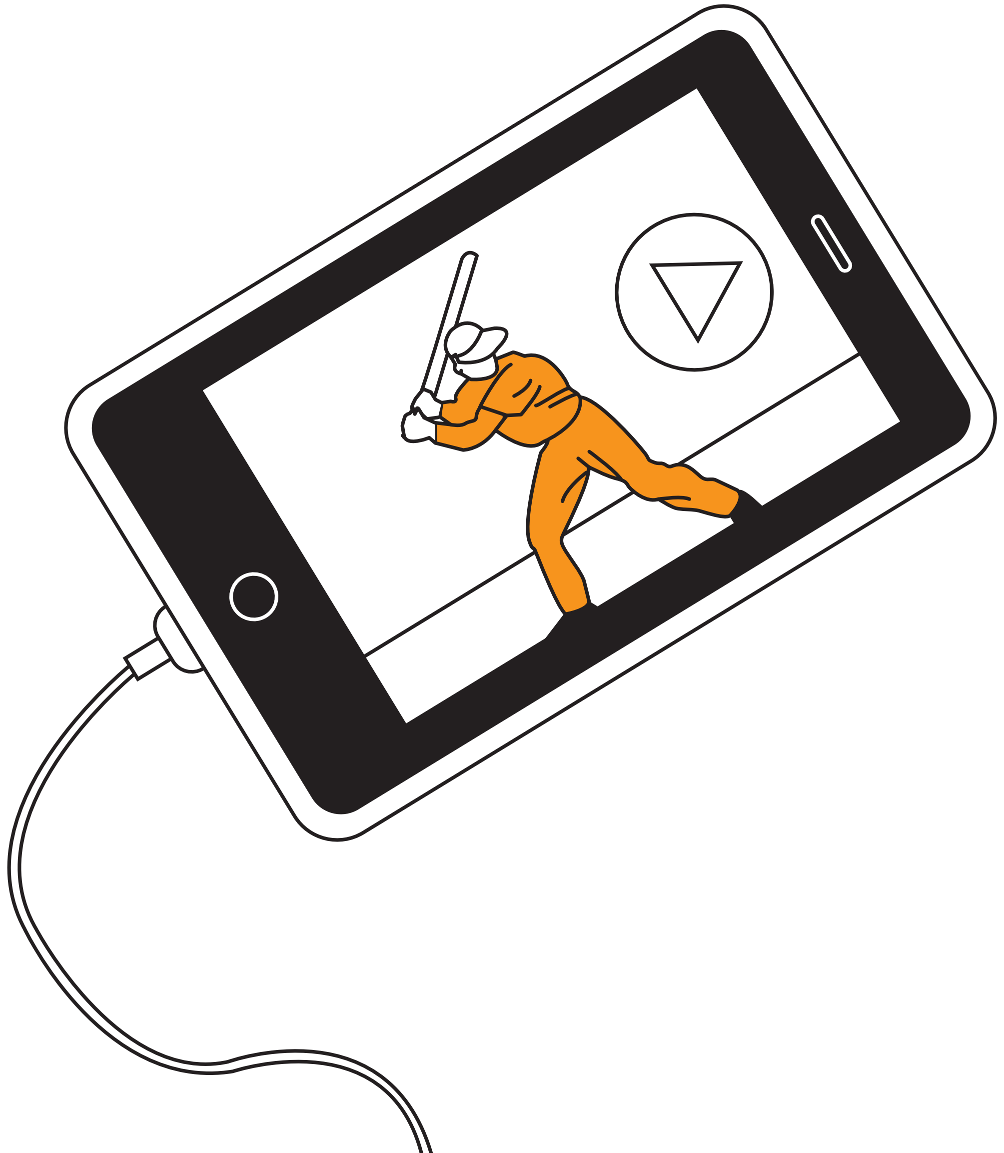
> We define the Transient Information Effect as a loss of learning due to information disappearing before a learner has time to adequately process it.

“Whenever a teacher orally explains something to a class or pupil…the information presented is transient.

Unless it is recorded, any spoken information disappears.

“If it is important information for the learner, then the learner must try to remember it.

> Transience is a particular characteristic of dynamic representations that have ramifications for working memory.



> The transience of animated information may be a key factor in explaining why instructional animations have not produced the consistently positive effects that have been anticipated.