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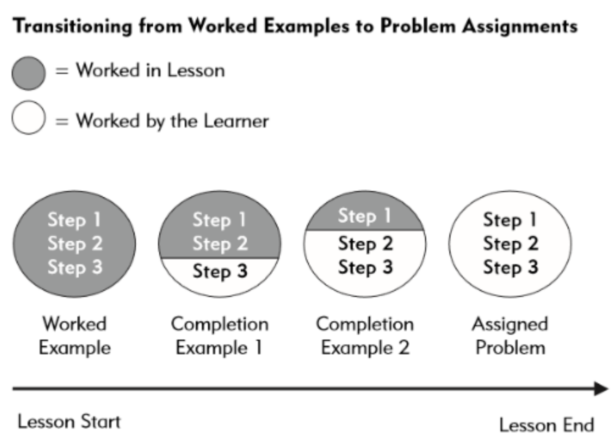
Cognitive Load Theory Effects

There are multiple effects related to CLT that should be considered in the design of the K-5 Integrated product.

The worked example effect

Worked examples are a type of scaffolding provided to novice learners to prevent cognitive overload when learning a new concept. In math, a worked example can be a set of fully solved problems presented to students with detailed explanations. These supports can be gradually faded ("faded worked examples"), requiring the student to gradually do more of the work of solving a problem on their own, until they are removed completely.

Figure 8.5. A Conceptual Model of Backwards Faded Completion Examples.



Although most common in math, the worked example effect can be leveraged in any content area. In the development of K-5 Integrated, we should explore the appropriate use of worked examples to manage cognitive load for students. This will require additional training for teachers to understand the importance of (and research behind) worked examples and their effective use in the classroom.

The split-attention effect

Split attention occurs when multiple sources of information can't be understood at the same time because the sources of the information are not integrated.

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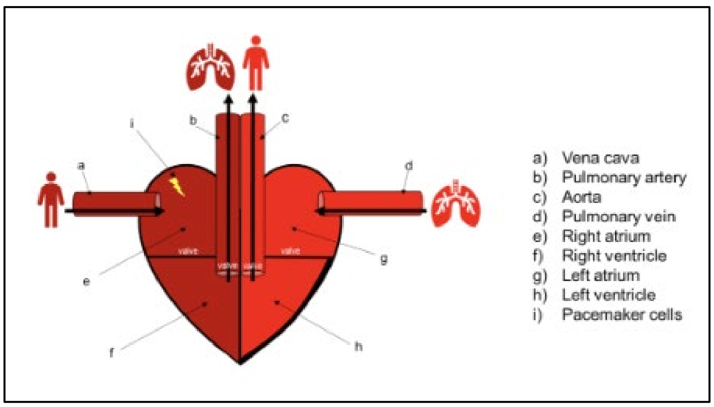
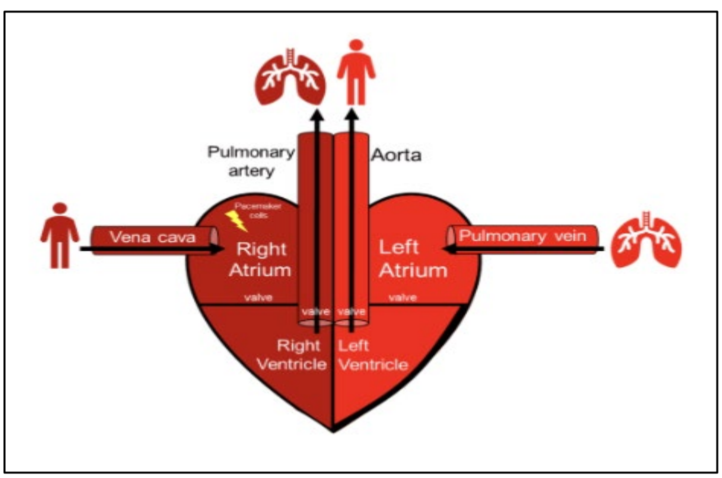
Split attention increases extraneous cognitive load, which reduces students' ability to focus on the task (intrinsic load) and build schema (germane load). If information is not placed together in space and time, students must hold one part of the information in working memory, transfer it through space, then integrate it with the other piece to form a complete picture. This occupies precious "slots" in working memory that should be used to focus on the task.

Consider the diagram of the heart below. The first example is in the "split-attention" format: the diagram of the heart and the relevant labels are separated. This increases extraneous load because there is additional strain on working memory to integrate the image and the labels into one integrated whole.



The second image is in an integrated format: the labels have been brought into the image, creating an integrated whole. This reduces extraneous load because students can simply look at the image and, at the same time, see what each part of the heart is called.



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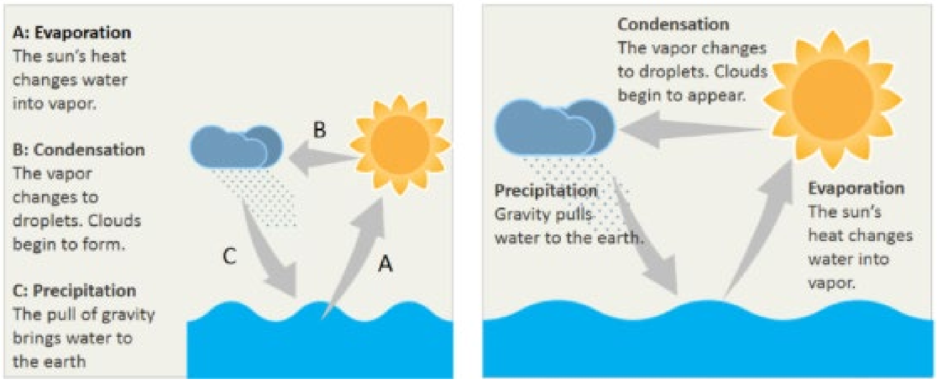
An additional example of a water cycle diagram in a non-integrated format vs. an integrated format is shown below.



In the design of K-5 Integrated, we must pay close attention to the design of maps, diagrams, images, etc. to make sure they are integrated. This helps reduce extraneous load and improves students' ability to engage in schema development.

The redundancy effect

The **redundancy effect** states that providing students with redundant information can have a negative effect on learning. This is because students are required to process multiple sources of information together to make sense of it when they don't need to.

An example from an instructional delivery perspective is when a teacher reads the words exactly as they appear on a PowerPoint slide. Students have to expend space in working memory to evaluate if what the teacher is saying is the same or different than what is on the slide.

From a materials design perspective, materials such as cartoons or unnecessary illustrations are considered redundant. Students must evaluate whether or not the additional information is relevant, and in doing so, expend unnecessary cognitive energy on the process.

When designing K-5 Integrated, we must take care to only include relevant information in materials, slide decks, etc., even if doing so might make the materials seem "bare" in comparison to other elementary instructional materials.

The expertise reversal effect

The **expertise reversal effect** suggests that the effectiveness of cognitive load effects depends on the level of a learner's expertise in a specific domain.

For example, the use of worked examples is most effective for novices with limited knowledge in their long-term memory, but can have the opposite effect when used with experts (since the information is redundant).

A key takeaway from the expertise reversal effect is that teaching strategies should be matched to an individual student's level of expertise to support knowledge acquisition. Novice learners learn best from clear, explicit instructions (such as worked examples) and, as expertise increases, more experienced learners can learn from inquiry-based modes of learning (such as unguided problem solving).

In the design of K-5 Integrated, it is essential to match the type of task to the level of knowledge acquisition. Novice learners should not be learning from "messy problems" or unguided situations where they're expected to "discover" the information they are supposed to learn. As a novice, this type of instruction is inappropriate, increases extraneous cognitive load, and prevents the development of appropriate schema. By contrast, in the development of enrichment/extension activities for more expert learners as part of the "What I Need (WIN) Time"/Integrated Project Time portion of the master schedule, activities that are more problem or project-based **may** be appropriate for more expert learners.

The variability effect

The **variability effect** refers to how exposing learners to varied problem-solving scenarios can enhance learning by promoting deeper schema construction and transferability of knowledge. However, its effectiveness depends on the learner's prior knowledge and the type of cognitive load imposed.

The variability effect occurs when **high-variability practice** (i.e., encountering different problem types, contexts, or solution strategies) increases germane load, encouraging learners to extract deep structures and patterns rather than relying on surface features. This enhances schema instruction and transferability.

However, in alignment with the **expertise reversal effect**, high variability can increase intrinsic and extraneous load, which can overwhelm working memory and hinder learning in novices. Initially, a **low variability** approach can be better when first introducing learners to a new concept.

In the design of K-5 Integrated, the materials should gradually introduce variability, ensuring learners have a strong foundational schema before increasing diversity of tasks.

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References and Resources

Cognitive Load During Problem Solving: Effects on Learning (Sweller, 1988)

Cognitive Load Theory (Sweller, 2011)

Cognitive Load Theory and its Relation to Instructional Design (Asma & Dallel, 2020)

A Little Guide for Teachers: Cognitive Load Theory (Ashman, 2022)

Efficiency in Learning: Evidence-Based Guidelines to Manage Cognitive Load (Clark, Nguyen, Sweller, 2006)

A Meta-analysis of the Worked Examples Effect on Mathematics Performance (Barbieri, et al., 2023)

The Split-Attention Effect as a Factor in the Design of Instruction (Chandler & Sweller, 1992)

Different types of redundancy and their effect on learning and cognitive load (Albers, et al., 2022)

The Expertise Reversal Effect (Kalyuga, et al., 2003)

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