Research Guide
College and Career Competency:
Learning Schema

Definition:

In the context of education, a learning schema is a knowledge structure in a student's long-term memory that helps the student mentally store, locate, or retrieve information in order to solve problems (Donald, 1987; Van Merriënboer & Sweller, 2005; Kalyuga, Ayres, Chandler, & Sweller, 2003; Kalyuga, 2007). Schemas work by helping to organize information that needs to be processed, thereby reducing the limitations of working memory (Van Merriënboer & Sweller, 2005; Kalyuga et al., 2003). Schemas allow each learner to recognize patterns and relate information to their own life, interests, previous learning, or future goals (Cooper, Tindall-Ford, Chandler, & Sweller, 2001; Turner, Warzon, & Christensen, 2011).

Essential Components for Students:

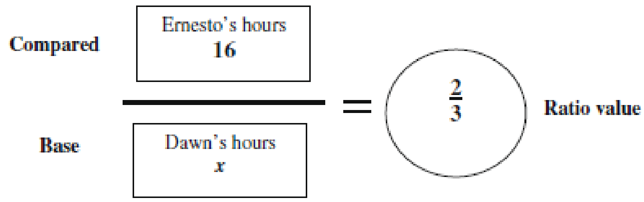
1. Make the connection between new information and your own experiences or previous learning.
2. Retrieve prior knowledge to make sense of new information even if it is ambiguous or incomplete.

Research:

- Cognitive load theory provides the academic foundation for a discussion of learning schema by highlighting two types of memory: working memory and long-term memory. Working memory can be thought of as short-term storage that can be quickly overwhelmed by information, resulting in decreased effectiveness in the processing required to learn or solve problems (Kalyuga et al., 2003).
  - According to cognitive load theory, working memory operates on only two to four elements of information, and information is only retained for a few seconds unless it is refreshed by rehearsal (Van Merriënboer & Sweller, 2005).
  - In contrast, long-term memory contains a large store of organized knowledge structures—or schemas—and has virtually unlimited capacity (Kalyuga, 2007).
- Individuals use their schemas to organize information into generalizable chunks that can be recalled in other situations or environments (Brewer, 2000).
- Schema-based instruction has been shown to be more effective than traditional methods for teaching English to native speakers of other languages (Khodadady, Alavi, Pishghadam, & Khaghaninezhad, 2012).
- Dysfunctional schemas (e.g., incorrect beliefs or knowledge) interfere with learning because new information contrasts with current schemas (Rosen, 1989). Schema-based cognitive behavior therapy has been shown to support individuals in changing their schemas by generalizing change and improving maintenance of behavior changes (Sookman & Steketee, 2007).

- Schema-based instruction can help students develop the learning schemas they need to effectively process new and novel information in working memory (Donald, 1987; Jitendra et al., 2009).
    - See also http://psychology.about.com/od/sindex/g/def_schema.htm
- The level of learner expertise (e.g., experience and prior knowledge in a particular subject) is a major factor in how schemas are constructed and used (Kalyuga, 2007; Van Merriënboer & Sweller, 2005; Kalyuga et al., 2003).
    - The more experience that a learner has in a particular subject, the more schemas the learner will possess and bring into working memory, resulting in lower demands on working memory (Kalyuga et al., 2003).
    - Novice learners, however, will experience higher demands on working memory because they either have to create or use conscious effort to access a schema (Kalyuga et al., 2003).
- External supports like scaffolding can help novice learners build new knowledge structures (Kalyuga, 2007). These supports are essential when novice learners are placed in a complex learning situation; their working memory will be quickly overloaded, resulting in ineffective processing of the new information (Van Merriënboer & Sweller, 2005) and feeling overwhelmed (Van Merriënboer, Kirschner, & Kester, 2003).
- The instructional methods for novice learners can interfere with the performance of high-knowledge learners and actually cause a reversal of expertise (Kalyuga, 2007). For example, using scaffolding for a learner with good knowledge of a subject would detract from their ability to access their already existing knowledge base by adding to their working memory load, thus actually making it harder for them to learn new knowledge within that subject.
- Meaningfulness, defined by Brophy (2008) as “awareness of the role of learning in improving the quality of one’s life” (p. 5) supports schema development by relating content to the students’ future lives. Meaningfulness increases **motivation**, which is positively correlated with increases in students’ academic performance in mathematics (Stipek et al., 1998; Turner et al., 2011).
    - Service learning provides meaningful experiences by connecting students to their communities while simultaneously building academic skills. Service learning has been shown to improve students’ knowledge, grades, and academic **motivation** (Bruce-Davis & Chancey, 2012; Conway, Amel, & Gerwien, 2009).
- The impact of schema training on student performance in mathematics has been examined through numerous experimental studies. In one study, seventh grade students who received a 10-day intervention in the form of instruction on identifying the problem structure (ratio or proportion) and then representing the problem on a schematic diagram, outperformed students who had not received the schema-based instruction (Jitendra et al., 2009). An example of a schematic diagram (Jitendra et al., 2009, p. 257) is shown below.

Ernesto and Dawn worked separately on their social studies projects this weekend. The ratio of the number of hours Ernesto spent on the project to the number of hours Dawn spent on the project was 2:3. If Ernesto spent 16 hours on the project, how many hours did Dawn spend on the project?



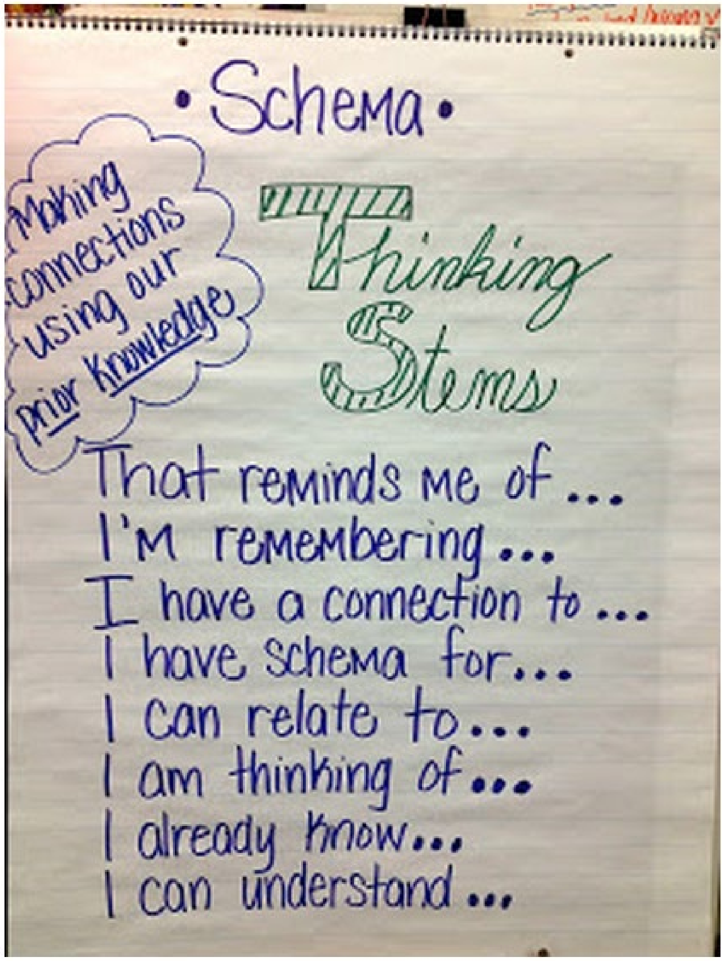
Math	Explanation
	First, I figured this is a ratio problem, because it compared the number of hours that Ernesto worked **to** the number of hours Dawn worked. This is a **part-part ratio** that tells about a **multiplicative relationship** (2:3) between the hours that Ernesto and Dawn worked.
$\frac{\text{16 hours (Ernesto)}}{x \text{ hours (Dawn)}} = \frac{2}{3}$	**Next**, I represented the information in the problem using a ratio diagram and set up the math equation.
	Then, I decided to use the equivalent fractions strategy to solve for number of hours that Dawn worked.
$\frac{\text{16 hours (Ernesto)}}{x \text{ hours (Dawn)}} \leftarrow = \rightarrow \frac{2}{3}$ To solve for x, think: 2 times what number equals 16? The answer is 8 (i.e., 2 * 8 = 16). So 8 times 3 equals x.	**Finally,** I used the equivalent fractions strategy and got 3 * 8 = 24, which is the number of hours Dawn worked on her project. **Answer:** Dawn worked 24 hours on her project.

Assessments

- Many frequently-used techniques in schools assess prior knowledge.
  - Pre-tests administered prior to instruction provide information on students' prior knowledge. Teachers can then modify their instruction based on the students' existing knowledge base.
  - Many reading instructional strategies are designed to assess and build students' schemas. For example, students can make connections by identifying text-to-text, text-to-self, and text-to-world connections. More information is available at http://www.readwritethink.org/professional-development/strategy-guides/making-connections-30659.html.
- Assessments specific to implementing learning schemas are designed to help inform the selection of instructional strategies. These assessments primarily focus on identifying the learner's level of expertise in a given domain so the appropriate level of external supports is provided and the expertise reversal effect avoided (Van Merriënboer & Sweller, 2005).
  - A rapid assessment test has been used successfully to measure the quality of a learner's problem-solving schemas. For example, a student can be asked to report the first step in solving an algebraic problem. Students with more expertise and higher-quality schemas can typically skip steps and start at later steps (Van Merriënboer & Sweller, 2005). See the appendix for an example of how the rapid assessment test can be applied.

Instructional Practices:

- Interdisciplinary instruction, such as units spanning multiple content areas, deepens student learning and builds connections that support students' schema development (Petroelje Stolle & Frambaugh-Kritzer, 2014; Vars, 1993).
- Explicit connections to real world applications of the concept help develop learning schemas (Halloun, 2007). Examples include discussion or answering questions, such as: How might you use this in the future? How is this scientific model portrayed in the real world? How have historical conflicts impacted current economics such as the price of gasoline? How might you approach the conflicts of the protagonist in the story differently? Clearly showing connections to the students' current and future lives helps students organize information.
- K-W-L Charts are designed to activate prior knowledge by asking students to identify what they already know about the topic and what they would like to learn. Later, they reflect on what they learned. More information is available at http://www.readwritethink.org/classroom-resources/printouts/chart-a-30226.html.
- Two-column notes or Cornell notes are designed to support students in making connections with texts or lecture content by reflecting on how the new content fits with what they already know and applying the content to their lives. More information is available at http://lsc.cornell.edu/LSC_Resources/cornellsystem.pdf.
- When novice learners have to learn complex material, a progressive approach, in which isolated elements are presented first and then the interactions among the elements are introduced in a second phase, is much more effective at increasing understanding (Van Merriënboer & Sweller, 2005). The progressive approach helps the novice learner create the necessary schema, which can then be "automated" through practice and rehearsal.
- Providing novice students with completed examples allows them to focus on the problem-solving steps; students then provide self-explanations (e.g., self-talk) as they study the completed examples, which leads to better learning outcomes (Renkl & Atkinson, 2002).
    - Initially, the learner can be provided a completed example with all the solution steps. This complete solution can be followed by partially completed examples with fewer and fewer steps provided, requiring the learner to complete the remaining steps and construct the necessary schema (Van Merriënboer & Sweller, 2005; Van Merriënboer et al., 2003).
        - For example, if students are learning to search for relevant research literature, a completed example could involve giving the learner a research question, a list of articles, and the search terms that were used to generate the articles. The student is then asked to evaluate the quality of the search approach and the list of articles (Van Merriënboer et al., 2003).
        - Another approach would be to provide the student with the research question, an incomplete set of search terms, and the task of generating a list of relevant research articles. The learner is required to complete the task by adding search terms, then searching for and selecting articles (Van Merriënboer et al., 2003).
- This blog posting highlights how a teacher practiced developing schema with an art museum activity in the classroom: http://theartoflearning-bermingham.blogspot.com/2013/01/schema-whats-your-schema.html. An example of prompts is provided below.



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Appendix

Example of rapid assessment test (from Van Merriënboer & Sweller, 2005, p. 167):

The rapid assessment test asked students to indicate their *first* step towards solution of a task. As a simple example, when presented the algebraic problem $(3x - 5)/2 = 5$, students may respond in one of the following ways when asked to report their first step:

- The first step reported is incorrect or the student indicates that (s)he "doesn't know the answer;" this student is categorized as a pre-novice with no relevant schemata.
- $3x - 5 = 10$ is indicated as the first step by a student who first multiplies both sides of the equation by 2; this student is categorized as a novice.
- $3x = 15$ is indicated as the first step by a student who mentally multiplies both sides of the equation by ten and adds 5 to both sides of the equation; this student is categorized as having intermediate ability.
- $x = 15/3$ is indicated as the first step by a student who mentally divides both sides by 3 and immediately writes the final answer; this student is categorized as an advanced student.
- $x = 5$ is indicated as the first step by a student who has automated the whole procedure; this student is categorized as an expert.

The assumption that higher quality schemata allow for the skipping of steps is central to this type of rapid assessment.