Essential instructional design

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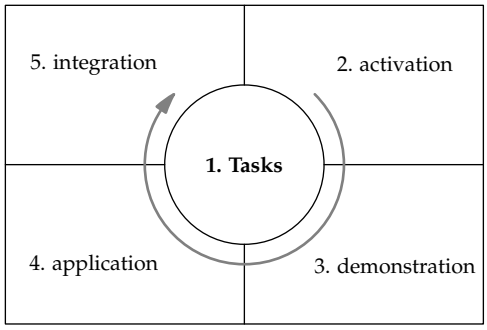
1 First principles of instruction

David Merrill synthesized the key principles common among leading instructional-design frameworks to produce his *first principles of instruction* [3]. Namely, learning is promoted when

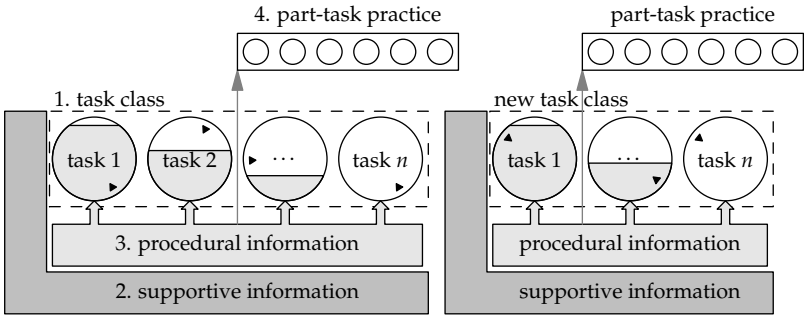


Five principles (adapted from [3]).

1. ...learners solve real-world problems *(task-centered principle [4, 5])*.
2. ...existing knowledge is activated as a foundation for new knowledge *(activation principle)*.
3. ...new knowledge is demonstrated to the learner *(demonstration principle)*.
4. ...new knowledge is applied by the learner, with feedback *(application principle)*.
5. ...new knowledge is integrated into the learner's world *(integration principle)*, providing a base for the next learning cycle of activation, demonstration, ...

2 Four-component instructional design: Implementing the principles

An outstanding framework, consistent with Merrill's principles and based on cognitive-load theory [6], is *four-component instructional design* [2, 7]. Instructional blueprints are described using four basic components, designed in the following order.



Four instructional components (adapted from [2]).

1. *Tasks (circles) grouped in classes*. Instruction is centered on real-world tasks integrating knowledge, skills, and attitudes. Tasks within a class use the same *supportive information* but offer decreasing support (shading) and, for generalization, vary in surface presentation (rotated triangles).
2. *Supportive information (dark shaded L)*. Lectures, print and web materials, feedback, etc. that help students perform nonroutine aspects of the tasks, explaining cognitive strategies and mental models in the knowledge domain. This information, introduced before the first task, is available whenever learners need it.
3. *Procedural information (light gray bar)*. Information on how to perform recurrent skills, ones that are the same in all contexts (e.g., how to read a resistor by its color code, how to use partial fractions for integration). To reduce cognitive load, this information is made available just when needed during task performance (light gray arrows) and is faded.
4. *Part-task practice (small circles)*. Provided for skills that need to be automated (to reduce cognitive load when performing the tasks) but where the tasks alone do not provide enough practice to reach automaticity.

3 ICAP framework: A different category of framework

The preceding frameworks are particularly useful for designing the longer-time-scale portions of a course (or curriculum). Chi's ICAP framework [1] is particularly useful for designing problems and class activities. It refines the distinction between active and passive (P) learning by subdividing active into three levels—active (A), constructive (C), and interactive (I)—each promoting deeper learning than the preceding level.

Cognitive engagement	*Characteristics*	*Depth of learning*
Interactive	dialogue with tutor or another student (e.g., debating conceptual question)	understanding that might create new ideas
Constructive	adding to the information (e.g., drawing a diagram or concept map, self-explaining)	deeper understanding that might transfer
Active	doing something with hands or bodies with the material, but not adding to the information (e.g., highlighting)	shallow understanding
Passive	simply paying attention (e.g., watching lecture or video)	minimal understanding

References and further reading

[1] Michelene T.H. Chi and Ruth Wylie. The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, 49(4):219–243, 2014.

[2] Paul A. Kirschner and Jeroen J. G. van Merriënboer. Ten steps to complex learning: A new approach to instruction and instructional design. In T. L. Good, editor, *21st Century Education: A Reference Handbook*, chapter 26, pages 244–253. Sage, Thousand Oaks, CA, 2008.

[3] M. David Merrill. First principles of instruction. *Educational Technology Research and Development*, 50(3):43–59, 2002.

[4] M. David Merrill. A pebble-in-the-pond model for instructional development. *Performance Improvement*, 41(7):41–44, 2002.

[5] M. David Merrill. A task-centered instructional strategy. *Journal of Research on Technology in Education*, 40(1):5–22, 2007.

[6] John Sweller, Paul Ayres and Slava Kalyuga. *Cognitive Load Theory*, volume 1 of *Explorations in the Learning Sciences, Instructional Systems and Performance Technologies*. Springer, New York, 2011.

[7] Jeroen J.G. van Merriënboer and Paul A. Kirschner. *Ten Steps To Complex Learning: A Systematic Approach To Four-Component Instructional Design*. Routledge, 2012.