Applying learning science findings to instruction

Selected researched-based findings shown to facilitate student learning both in person and online are summarized below. Use this document to generate ideas for incorporating research-based practices in your teaching, and/or to support an application to the MITx Grant Program. General frameworks, links to additional information and how to get assistance at MIT are included at the end.

RESEARCH-BASED FINDINGS

Retrieval practice (the “testing effect”)

Description: The ability to recall and remember knowledge increases if it is periodically retrieved. The act of retrieval solidifies learning, particularly when feedback is provided.

Implications: Administer low-stakes quizzes frequently. Encourage students to test their understanding and remind them that the act of testing themselves not only allows them to know what they don’t know, but enhances their ability to retain what they do know.


Spaced and interleaved practice

Description: Spacing out repetition is more effective for learning than is studying an idea over a single period (even if it is longer than each of the many repetitions). Interleaving the practice of problems types results in greater learning gains than asking students to do the same type of problem over and over (mass practice). Interleaving increases student’s ability to discriminate between different problem types.

Implications: Space how often content/concepts are reviewed or recalled across weeks and months. Administer cumulative problem sets and exams throughout the semester. Review concepts covered in previous class periods/modules at the beginning of class. Rearrange the order of practice problems in problem sets and exams as opposed to ordering problems by type.


Worked and faded examples

Description: When non-experts learn new concepts, it is more effective for them to study solutions to solved problems than to attempt solving problems. Worked examples are most effective when learners self-explain the solutions and when multiple, varied worked examples of the same concept are provided. Worked examples benefit non-experts; experts benefit more from attempting to solve problems than from studying worked examples.

Implications: Provide learners fully worked examples and require them to self explain solutions through asking students follow-up questions (ex: ‘Why was this strategy used?’; ‘What principle is being applied and why?’), annotating solutions, identifying an error in a solution or asking students to compare solutions of two contrasting examples. As learners become more expert, fade support by asking students to attempt solving subsequently more and more steps within a problem.

Pre-/Post-testing
Description: Assessing understanding of the most important concepts and tasks in a course at the beginning and end of the course allows instructors to determine what students know when they start the course and how much they learned in the course. Students’ prior knowledge could be correct, incomplete and/or faulty. If prior knowledge is faulty (misconceptions) students might resist or ignore new information that conflicts with it. Pre-/post-testing also allows instructors to determine what misconceptions students come with and how much conceptual change happens as a result of the course.

Implications: Design and administer the same test at the beginning and end of a module or course. Include questions that will surface common misconceptions students have on the content covered.


FRAMEWORKS

Active learning
Description: Instruction that requires students to engage cognitively and meaningfully with content results in better learning than instruction where students are solely exposed to information passively. Although effective active learning does not require peer-to-peer interactions, activities that deeply engage students in co-generating answers seem to yield the greatest learning gains.

Implications: In class, administer activities that ask students to apply the information presented. Provide opportunities for students to engage cognitively with each other through the use of collaboration and community tools such as collaborative annotators. While demonstrating or providing worked examples, ask probing questions that require explanation of solution steps (see section on ‘Worked and faded examples’).


First principles of instruction:
David Merril synthesized the key principles common among leading instructional design frameworks. Namely, learning is promoted when 1) learners solve real-world problems, 2) existing knowledge is activated as a foundation for new knowledge, 3) new knowledge is demonstrated to the learner, 4) new knowledge is applied by the learner, with feedback and 5) new knowledge is integrated into the learner’s world, providing a foundation for future learning.


Four-component instructional design (4C/ID):
The 4C/ID model is a specific framework, consistent with David Merrill’s principles (see ‘First principles of instruction’), and based on research on the limitations of working memory (cognitive load theory). Instructional blueprints are described using four basic components: 1) tasks, 2) supportive information, 3) procedural information and 4) part-task practice.


Additional info & MIT examples are available here: [https://odl.mit.edu/campus/resources-and-references/](https://odl.mit.edu/campus/resources-and-references/)

For questions and/or assistance, please contact:
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