

ANSWERS from Learning Science

A = Attention: Memory formation requires focused attention

- Multitasking yields up to 50% errors
- Primacy-recency effect: first and last part of class are high impact

N = Novelty: The brain is attracted to novelty

- Novelty increases attention, motivation and interest
- Attention wanes over time, need to take breaks and reset, vary practice
- Multisensory input is better than unisensory – creates additional neural pathways
- Dual encoding (visualize a concept heard verbally or verbalize something only seen)
- Mystery drives novelty (and the corollary: visible lecture notes decrease novelty)

S = Spacing: Do not mass retrieval practice

- Massed practice (including cramming) is ineffective for Long Term Memory (LTM)
- Distributed practice over time (spacing) yields best results
- Mixed practice (interleaving) is effective
- Retrieval practice (including reflection) interrupts the forgetting process

W = Why: Meaning helps retention

- We understand new things in context of what we already know
- High perceived utility increases retention and motivation
- We solve new problems better when we understand the underlying principles and demonstrate true learning with transference (use it in a new application)
- Predicting-and-failing is better than watching a presentation. Make them guess!
- Metamemory (teaching about memory and learning) improves memory and recall

E = Emotions: Memory involves the limbic system, associated with emotions

- Memory is associative. “Fire together, wire together”
- “Affective filter” can impact perception of teacher AND subject matter
- Cortisol (stress) impairs hippocampus function

R = Residue: Memory is the residue of thought

- Learning is effortful and proficiency requires practice
- Short term memory in hippocampus has limited capacity, encoding to LTM involves larger lobes, almost unlimited and more durable
- Chunking creates patterns, patterns are easier to remember – decrease cognitive load

Classroom Strategies: Easily Integrated Changes

- **Laptop banning:** Studies show taking notes on a laptop is less effective for conceptual information and long term learning than taking handwritten notes. The former is analogous to “mindless dictation” while the latter requires processing and deeper engagement with the content.
<http://pss.sagepub.com/content/early/2014/04/22/0956797614524581>
- **Worked examples:** Step-by-step demonstration of how to perform a task or how to solve a problem designed to support initial acquisition of cognitive skills through introducing a formulated problem, solution steps and the final solution.
- **Interactive teaching:** Any of a number of techniques that encourage attention and student participation, including: questions that stimulate response, guided discussion, hands-on experiences and a workshop environment.
- **PBL – Problem-Based Learning:** Engages students with complex, challenging problems that they work collaboratively to solve, connecting disciplinary knowledge to real-world problems and motivation to learn.
- **Nota Bene (MIT):** Web-based collaborative annotation tool that facilitates communication among students and their instructors, centered around better understanding of course reading material. Insights are recorded in lecture-note margins making them available to students at the specific moment those insights are needed.
- **Reflection: Serves as a form of retrieval practice that** encourages long term memory formation, promotes critical analysis, problem-solving, synthesis and evaluation of ideas, identification of patterns and creation of meaning.
- **Activity Before Concept - Concept Before Vocabulary (ABC-CBV):** Engages students with an activity that allows them to derive the desired concept and follows with presentation of relevant vocabulary.



- **Clickers:** An interactive technology that enables instructors to pose questions to students and immediately collect and view the responses of the entire class.

Classroom Strategies: Comprehensive Changes

- **Inquiry learning/POGIL** - Uses guided inquiry , a learning cycle of exploration, concept invention and application, as the basis for students to construct new knowledge. Students develop critical thinking, problem solving, and communication skills by working in small groups with individual roles that ensure all students are fully engaged.
- **Group learning:** Supports two principles of learning—learners construct their own knowledge and learning is an inherently social phenomenon. Working in small groups provides students with opportunities to articulate ideas, uncover assumptions and misconceptions, negotiate with others and discover deeper meaning in the content.
- **PLTL – Peer Led Team Learning:** Undergraduate students who have previously done well in the class are recruited and trained as peer leaders, guiding smalls groups in weekly sessions to work together on problems that are structured to help build understanding and problem-solving skills.
- **Flipped Model:** Reverses typical lecture and homework elements of a course, providing short video lectures viewed by students at home, while in-class time is devoted to exercises, projects, or discussions.
- **Just-in-Time Teaching (JiTT):** Relies on a feedback loop between web-based learning materials and the classroom. Students prepare for class by reading and completing assignments online. The students’ answers are delivered to the instructor a few hours before class starts, allowing the instructor to adapt the lesson as needed, allowing the instructor to create an interactive classroom environment that emphasizes active learning and cooperative problem solving.
- **SCALE-UP:** Student-Centered Active Learning Environment with Upside-down Pedagogies: A student-centered, highly collaborative, hands-on, computer-rich, interactive learning environment for large-enrollment courses.
- **Mastery Learning or Competency-based Learning:** Shifts the focus of instruction to the time required for different students to learn the same material, as opposed to the classic model in which all students are given the same amount of time to learn and the focus is on differences in ability. This flexibility allows students to progress as they demonstrate mastery of academic content, regardless of time.
- **Emporium Model:** Replaces or supplements lectures with a learning resource center model featuring interactive computer software and on-demand personalized assistance.

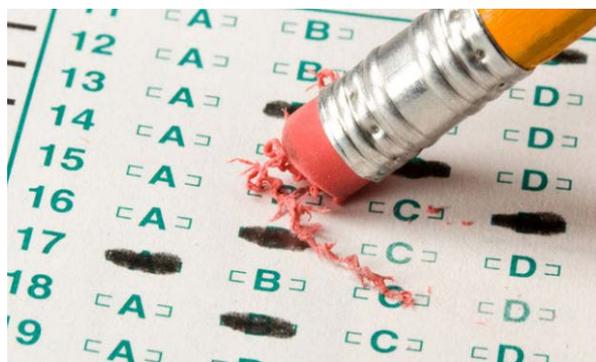


High-Impact Educational Practices

- **First-Year Seminars and Experiences (Academic Foundations):** Small groups of students meet with faculty or staff regularly, ideally, with emphasis on critical inquiry, writing and collaborative learning. These interactions build a sense of community and connectedness in addition to intellectual and practical skills.
- **Common Intellectual Experiences (Common Reader):** A set of required common courses or general education program that combines broad themes with a variety of curricular and co-curricular options for students.
- **Learning Communities:** Students take two or more linked courses as a group and work closely with one another and their professors to encourage integration of learning across courses and to involve students with “big questions” that matter beyond the classroom.
- **Writing Intensive:** Emphasizes writing at all levels of instruction and across the curriculum. Students are encouraged to produce and revise various forms of writing for different audiences in different disciplines.
- **Collaborative Projects:** Students participate in team-based assignments, cooperative projects or study groups to solve problems and increase their own understanding by working with others, especially those with different backgrounds and life experiences.
- **Undergraduate Research:** Engages students with active involvement in systematic investigation and research, connecting key concepts and critical thinking skills with the sense of excitement that comes from working to answer important questions.
- **Global Learning (Global Citizens Project):** Courses and programs that help students explore cultures, life experiences, and worldviews different from their own, frequently augmented by experiential learning in the community and/or by study abroad.
- **Service Learning:** Students apply what they learn in real-world settings by working with community partners, then reflect in a classroom setting on their service experiences, thus providing preparation for citizenship, work, and life.
- **Internships:** Provide students with direct experience in a work setting, usually related to their career interests, as a form of experiential learning that also provides the benefit of mentoring from professionals in the field.
- **Capstone Courses and Projects:** Culminating experiences that require students to create a final project that integrates and applies what they’ve learned.

Assessment

- **Teaching Study Skills:** Do NOT assume your students know how to study. Help students know what needs to be learned and how to learn it by setting clear learning objectives for courses, making regular assignments and emphasizing outlines, mnemonic aids and other such learning devices.
- **Practice testing:** Testing is a form of retrieval practice that has been shown to improve long term memory. Low stakes practice tests improve retention and identify areas of weakness.
- **"What you should know" list or Diagnostic test:** Make it clear from the first day of class what you expect students to already know, either with a test or knowledge inventory. Most effective prior to the drop/add date and in conjunction with a list of resources (online modules or programs, worksheets, etc.) students can use to ameliorate any gaps they identify.
- **Distributed practice or spacing:** Study effort is spread over many brief sessions, as opposed to massed practice (cramming) whereby the student conducts few but long study sessions. It has been proved that distributed practice promotes meaningful learning, whereas massed practice promotes rote learning.
- **Math Adaptive Learning:** Education technology that responds to a student's interactions in real-time by automatically providing the student with individual support. ALEKS - **A**ssessment and **L**earning in **K**nowledge **S**paces, for example. Programs provide adaptive content (a student's specific answer prompts immediate feedback and resources on a specific topic), adaptive sequence (predictive analytics adjust the overall sequence of skills or the type of content a student receives next) and adaptive assessment (difficulty and content changes based on whether a student answers questions correctly or incorrectly).



- **Cumulative everything! Make all quizzes, tests, and final cumulative:** Do not reward massed practice (cramming), which works in the short-term, but does not yield long-term retention. Instead, enforce distributed practice through frequent, cumulative assessments.

Character and Connections

- **Grit (Duckworth):** Five characteristics: courage, conscientiousness, follow through, resilience and excellence, shared by individuals who succeed in the face of obstacles.
https://www.ted.com/talks/angela_lee_duckworth_the_key_to_success_grit?
- **Attachment Theory:** Children who develop secure attachments with caregivers have lower stress, greater overall health and positive interpersonal relationships throughout life.
- **Self-efficacy:** An individual's confidence in the ability to exert control over one's own motivation, behavior, and social environment. This has widespread impact on goal setting, energy expended toward goal achievement, and the likelihood of attaining benchmarks and goals.
- **Growth Mindset (Dweck):** Individuals with a growth mindset believe that intelligence is malleable and are more motivated to learn and exert effort, as opposed to the fixed-mindset in which intelligence is perceived as an inborn trait and deviation from perfection reflects poorly on their inherent intelligence.
- **Soft skills:** Career readiness skills valued by employers including: effective oral and written communication, teamwork and collaboration, problem solving and critical thinking, agility and adaptability, initiative and conflict resolution.
- **Message Students Who _____:** A function of Canvas that allows you to send messages en masse to all students who, for example, scored above or below a specified value on an exam, failed to turn in an assignment or missed a quiz.
- **Guest visitors (also skype or recorded video):** Engages students with “real world” applications of the curricula and provides examples of possible future career paths. Ideal visitors are recent graduates in business and industry that can explain how this course helped them.

