FLASHFEED STUDY GUIDE

Education Theory & Learning Technology

Study guide by FlashFeed

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flashfeedlearningapp.com

Education Theory & Learning Technology: study guide

From Pavlov to Khanmigo: a complete tour of how humans learn — the foundational learning theories (behaviorism, cognitivism, constructivism), Bloom's taxonomy and the 2 Sigma Problem, the cognitive science of memory and flow, instructional-design frameworks, Sal Khan's AI vision, the modern EdTech landscape, and the field's essential vocabulary.

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In the app	flashfeedlearningapp.com/packs/learning-theory

How to use this guide

Take one lesson at a time: read the study guide, then go over any key facts. Where a lesson has a self-test, try it from memory before you check the answer key at the back. Follow the Go deeper links when you want more.

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LESSON 1 OF 10

How Humans Learn

Three modes of learning · The forgetting curve & spaced repetition · Retrieval practice (the testing effect)

WHAT YOU'LL BE ABLE TO DO

- Explain Hebbian learning: how repeated co-activation strengthens synaptic connections
- Distinguish passive, active, and interactive learning, and identify which mode forces the deepest retrieval and schema negotiation.
- Describe Ebbinghaus's forgetting curve and quantify how much unreviewed information is lost within 30 minutes and 24 hours.
- Explain spaced repetition over expanding intervals and how SRS tools like Anki schedule reviews at the optimal moment.
- Explain retrieval practice (the testing effect), cite its key studies, and state the practical implication for frequent low-stakes quizzing.

Three modes of learning

Learning is not a single act but a spectrum of engagement, grounded in biology. Understanding the three modes helps you structure study sessions that actually produce durable knowledge rather than a temporary impression.

Neurons that fire together, wire together

At the cellular level, every skill or memory is a pattern of **synaptic connections** between neurons. The principle, formalized as **Hebbian learning**, is that repeated co-activation makes those connections structurally stronger — the synapse thickens and signals travel faster. This is why passive exposure to material rarely produces mastery: if the neurons encoding new information never fire in the context of retrieval or use, the connection doesn't strengthen. Practice, repetition, and varied application are not motivational advice — they are the literal mechanism by which biological change occurs. **Passive learning** (re-reading, re-watching) keeps activation low and connection-building weak. **Active learning** demands retrieval, which fires the target neurons and begins to wire them.

Exposure, retrieval, application

Effective learning cycles through three distinct stages. **Exposure** introduces the material — a lecture, a reading, a demonstration. On its own, exposure is the weakest of the three. **Retrieval** forces the brain to reconstruct what was stored, which both tests the connection and strengthens it; this is why quizzing yourself outperforms re-studying by a wide margin. **Application** takes the knowledge into increasingly complex, novel contexts — solving problems, teaching others, debating. **Interactive learning** (teaching, debating) demands the deepest retrieval and **schema negotiation**: you must not only recall a fact but integrate it, defend it, and adapt it. That layered demand produces the most robust encoding. The

progression is not linear; strong learners loop back through exposure after encountering gaps during retrieval, and use application failures as diagnostic signals that point to specific knowledge holes.

The forgetting curve & spaced repetition

Memory is not stable storage — it decays on a predictable schedule unless actively maintained. Understanding that schedule is what lets you intervene at the right moment rather than wasting time reviewing material you still know or losing material you've already forgotten.

The forgetting curve (Ebbinghaus, 1885)

In the 1880s, German psychologist **Hermann Ebbinghaus** ran meticulous self-experiments memorizing and testing himself on nonsense syllables. What he found was a consistent exponential decay: without review, popular summaries of his results put the loss at about **50% of new information within 30 minutes** and roughly **75% within 24 hours**. (Those are round, popularised figures. His own relearning-savings measurements were gentler: savings of about 58% after 20 minutes and about a third after a day.) This pattern is the **forgetting curve**. The shape of the curve is important — decay is steepest immediately after learning, which means the first review is most valuable when it happens soon. Ebbinghaus also showed the flip side: each successful review flattens the curve, so the next forgetting episode is slower. The practical implication is that the timing of review matters as much as the duration.

Spaced repetition & SRS

Spaced repetition is the scheduling strategy that exploits the forgetting curve directly: instead of cramming all study into one sitting, you distribute sessions over **expanding intervals**. Reviewing material just before you would forget it produces far stronger retention than the same total time spent in a single block. The mechanism is straightforward — you are forcing retrieval at the moment the memory is weakest, which triggers a more effortful encoding process and resets the decay clock. **SRS (Spaced Repetition Software)** like **Anki** and **SuperMemo** automate this by algorithmically scheduling each card review at the optimal interval — typically based on how confidently you recalled it last time. Easier cards get longer gaps; harder cards are reviewed sooner. The result is that a fixed daily study budget covers far more material at far higher retention than unstructured review.

Retrieval practice (the testing effect)

Re-reading feels productive because the material becomes familiar, but familiarity is not retention. The distinction matters enormously for how you design a study session.

The testing effect

Retrieval practice — actively pulling information out of memory rather than re-exposing yourself to it — produces dramatically stronger long-term retention than passive review. This finding, known as the **testing effect**, is among the most replicated results in cognitive psychology. The key studies: **Karpicke & Roediger (2008)** showed that students who practiced retrieval (self-testing) retained significantly more after one week than those who restudied the same material the same number of times. **Roediger & Butler (2011)** confirmed retrieval practice's critical role in long-term retention across a range of material

types, not just vocabulary. The mechanism is often explained by the **retrieval effort hypothesis**: the effort required to reconstruct an answer — when retrieval is difficult but successful — strengthens the memory trace more than effortless re-reading. Conversely, re-reading only confirms that the information is accessible from the page, not from your own memory. MIT Open Learning draws a direct practical implication: **administer low-stakes quizzes frequently**, because the act of being tested is itself the learning event, not merely an assessment of prior learning.

Retrieval practice is most valuable when it is difficult but successful — easy retrieval produces smaller gains. This is why flashcard systems that retire cards too early, or re-read rather than self-test, fail to capture the full benefit of the effect.

Key terms

Hebbian learning
The principle that synaptic connections between neurons strengthen when they activate together — 'neurons that fire together, wire together.'

Forgetting curve
Ebbinghaus's finding that memory of new information decays exponentially over time without review, losing most of it within a day.

Spaced repetition
Distributing study sessions over expanding intervals, which produces far better retention than the same time spent cramming in one sitting.

SRS (Spaced Repetition Software)
Software like Anki and SuperMemo that algorithmically schedules each review at the moment of maximum forgetting — the optimal interval.

Retrieval practice
Strengthening memory by actively recalling information rather than re-exposing yourself to it; the mechanism behind the testing effect.

Key concepts

Passive learning

- The weakest of the three modes of engagement, it keeps the brain only lightly activated.
- Its typical activities are re-reading a chapter or re-watching a lecture.
- Because the target neurons never fire during retrieval or use, the synaptic connection barely strengthens.

Active learning

- This mode sits above the weakest one because it demands effortful mental work.
- It requires the learner to reconstruct stored information rather than re-expose themselves to it.
- By forcing retrieval, it fires the target neurons and begins to wire them together.

Interactive learning

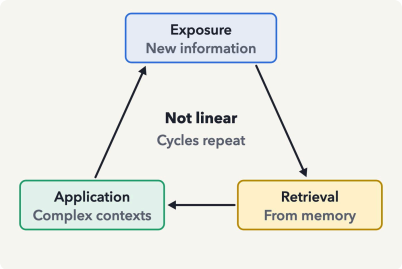
- The deepest of the three modes, it produces the most robust encoding.
- Its signature activities are teaching others and debating.
- It demands 'schema negotiation' — you must integrate, defend, and adapt a fact, not merely recall it.

Hebbian learning

- This principle works at the cellular level, describing how a skill or memory physically takes hold.
- It holds that repeated co-activation thickens the synapse so signals travel faster.
- It is famously summed up as 'neurons that fire together, wire together.'

Key facts

> **Neurons that fire together, wire together**
>
> Learning is biological. At the cellular level, acquiring knowledge means forming and strengthening **synaptic connections** between neurons — the principle summarized as *"neurons that fire together, wire together,"* known as **Hebbian learning**.



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> **Exposure, retrieval, application**
>
> Effective learning requires three stages of engagement: **exposure** to new information, **retrieval** of that information from memory, and **application** in progressively complex contexts. It isn't linear — strong learning cycles through these repeatedly.

> **Re-reading Isn't Studying**
>
> Re-reading a chapter you've already highlighted counts as passive learning, not active or interactive — flashcards count as active retrieval, while teaching or debating the material counts as interactive.

> **Synapses Thicken With Practice**
>
> When repeated co-activation strengthens a learned pattern, the change is physical: the synapse connecting the neurons thickens and the signal between them travels faster.

> **Weak Wiring Without Recall**
>
> A student who rewatches a lecture five times but never quizzes herself builds only weak connections — without retrieval, the relevant neurons never fire, so the wiring stays weak.



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The forgetting curve (Ebbinghaus, 1885)

German psychologist **Hermann Ebbinghaus** was among the first to study memory decay scientifically. Without review, we forget about **50% of new information within 30 minutes** and **70–80% within 24 hours**. This exponential decay is the **forgetting curve**.

> ### The First 30 Minutes
>
> Without any review, roughly half of what you just learned is gone within 30 minutes — the steep opening plunge of the forgetting curve.

> ### A Day Without Review
>
> Left unreviewed, about 75% of newly learned information is gone within 24 hours — the forgetting curve's decay continues well past the first half hour.



AI-generated (gpt-image-1.5)

Time Your First Review

Because the forgetting curve drops fastest right after learning, your first review is most valuable when it happens soon afterward — timing matters as much as total study time, and it's the basis for spaced repetition's expanding intervals.



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Beat Cramming With Timing

Reviewing material right before you'd forget it beats cramming the same amount of time in, because retrieving a memory at its weakest point forces more effortful encoding and resets the decay clock.

> ### MIT's Low-Stakes Quiz Rule
>
> MIT Open Learning draws a simple, practical implication from the testing effect: give students frequent low-stakes quizzes, since each one triggers retrieval and helps solidify learning.

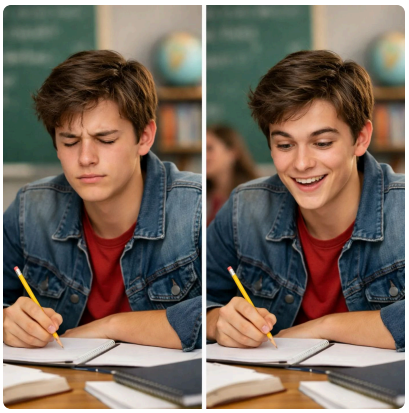


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A Week Later, Retrieval Wins

Karpicke and Roediger's 2008 study found that students who practiced retrieval retained significantly more material a week later than students who simply restudied the same material the same number of times.

> **Retrieval Works Everywhere**
>
> A 2011 study by Roediger and Butler confirmed that retrieval practice plays a critical role in long-term retention across a wide range of material types, not just vocabulary.



AI-generated (gpt-image-1.5)

The Sweet Spot for Recall

Under the production effect, retrieval practice produces its biggest memory gains when the recall is difficult but ultimately successful — easy retrieval builds far weaker memory traces.

By the numbers

Share of new information forgotten within 30 minutes, without review

50 %

Share of new information forgotten within 24 hours, without review

75 %

Matched pairs

Each item on the left goes with the one on the right.

Passive learning → Observing, watching, reading — weak for retention

Active learning → Recalling, practicing, testing — reinforces neural pathways

Interactive learning → Teaching, debating, contributing — the deepest retrieval

Anki / SuperMemo → SRS apps that schedule reviews at the optimal interval

Roediger & Butler (2011) → Retrieval practice's critical role in long-term retention

Karpicke & Roediger (2008) → Science paper: the critical importance of retrieval for learning

Step by step

Schedule spaced-repetition reviews after first learning something

1. Study the material once, actively, on day 0.
2. Review after 1 day.
3. Review again after 3 days.
4. Review again after 7 days.
5. Review again after 14 days, extending intervals as recall strengthens.

Each review slows the forgetting curve. SRS apps automate this by timing reviews to the optimal interval — the moment you're about to forget.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Which principle states that synaptic connections between neurons strengthen when those neurons activate together?

A Piagetian assimilation
B Skinnerian shaping
C Hebbian learning
D Pavlovian conditioning

2. At the cellular level, what physically changes when repeated co-activation strengthens a learned pattern?

A The neuron is replaced and a new one takes over the pattern
B The cell body enlarges and holds the pattern itself
C The firing threshold rises and signals slow down
D The synapse thickens and signals travel faster

3. Why does passive exposure to material rarely produce mastery, according to the Hebbian account?

A The neurons encoding it fire in the wrong order, so each exposure weakens the connection instead
B The neurons encoding it never fire during retrieval or use, so the connection doesn't strengthen
C The neurons encoding it fire too often during exposure, so the synapse fatigues and cannot strengthen
D The neurons encoding it fire in isolation, so there is no partner neuron for a synapse to form

4. Which is NOT an accurate statement about practice and repetition in the Hebbian view?

A. Practice and repetition are merely motivational advice
B. Repeated co-activation makes connections structurally stronger
C. Varied application helps strengthen connections
D. Passive learning keeps activation low and connection-building weak

5. A student re-watches a lecture five times but never quizzes herself. Applying Hebbian learning, what best predicts her outcome?

A. Weak connection-building, because activation stays low without retrieval
B. Strong mastery, because each re-watch fires the encoding neurons again
C. Gradual mastery, because exposure strengthens synapses as reliably as retrieval
D. No lasting trace, because each re-watch overwrites the previous encoding

6. Which pair of activities defines the interactive mode of learning?

A. Recalling and practicing
B. Re-reading and re-watching
C. Listening and observing
D. Teaching and debating

7. Recalling, practicing, and self-testing are the defining behaviors of which mode of learning?

A. Interactive learning
B. Passive learning
C. Active learning
D. Exposure learning

8. Which activity belongs to passive learning rather than active or interactive learning?

A. Quizzing yourself with flashcards you wrote
B. Re-reading a chapter you already highlighted
C. Debating a claim with a classmate who disagrees
D. Teaching the concept to a peer who missed class

9. Ranked from weakest to strongest for retention, what is the correct order of the three modes?

A. Interactive → active → passive
B. Interactive → passive → active
C. Passive → active → interactive
D. Active → passive → interactive

10. What extra demand does interactive learning place on the learner beyond simply recalling a fact?

A. Spaced repetition — resting, recalling, and re-testing the fact
B. Chunking — splitting, grouping, and relabeling the fact
C. Dual coding — visualizing, verbalizing, and pairing the fact
D. Schema negotiation — integrating, defending, and adapting the fact

11. The forgetting curve decays steepest immediately after learning. What does Ebbinghaus's finding imply for how you should review?

A. Later reviews should come closer together as each one slows the decay
B. The first review is most valuable when it happens soon after learning
C. A review adds the most once the material has decayed to a stable floor
D. Each review works best when spaced at the same interval as the last

12. Roughly what share of new information is lost within 30 minutes when it is never reviewed?

A) 50%
B) 90%
C) 75%
D) 25%

13. Without any review, approximately how much new information is gone after 24 hours?

A) About 50%
B) About 75%
C) About 30%
D) About 95%

14. Which researcher established the forgetting curve, and using what material?

A) Hermann Ebbinghaus, using nonsense syllables
B) Hermann Ebbinghaus, using foreign-language vocabulary
C) Henry Roediger, using nonsense syllables
D) Henry Roediger, using foreign-language vocabulary

15. According to Ebbinghaus, how does the rate of forgetting change across the first day after learning?

A) It starts slow for several hours, then accelerates sharply
B) It rises steadily and peaks around the end of the first day
C) It holds one constant pace from the first minute onward
D) It is steepest right after learning and slows thereafter

16. Spaced repetition distributes study sessions over what kind of intervals?

A) Contracting intervals
B) Uniform intervals
C) Expanding intervals
D) Randomized intervals

17. Why does reviewing material just before you would forget it beat the same total time spent cramming?

A) Retrieval at the memory's weakest point lets the old trace lapse and stores the answer as a brand-new memory
B) Waiting until the memory is nearly gone shrinks the amount that has to be re-encoded, so each pass is cheaper
C) Retrieval at the memory's weakest point forces effortful encoding and resets the decay clock
D) Spacing lets each trace consolidate before the next exposure, so passive re-reading lands on a settled memory

18. Which pair of tools is named as SRS (Spaced Repetition Software)?

A) Anki and Quizlet
B) SuperMemo and Duolingo
C) Duolingo and Quizlet
D) Anki and SuperMemo

19. On what basis does an SRS typically decide when to schedule a card's next review?

A) How confidently you recalled it last time
B) How long you spent answering it last time
C) How recently the card was added to the deck
D) How many other cards in the deck share its topic

20. You recall a card easily and another only with great difficulty. How should an SRS schedule them?

A Sooner review for the easy card, longer gap for the hard one
B Longer gap for the easy card, sooner review for the hard one
C Same gap for both cards, with the hard one shown first next session
D Sooner review for both cards, until each is recalled twice in a row

21. What practical implication does MIT Open Learning draw from the testing effect?

A Administer low-stakes quizzes frequently
B Weight every quiz heavily in the final grade
C Replace short quizzes with guided re-reading
D Keep quiz questions easy for everyone

22. Retrieval practice is defined as strengthening memory by doing what?

A Re-reading until it feels familiar rather than stopping after one pass
B Actively recalling information rather than re-exposing yourself to it
C Highlighting key passages on each pass rather than reading every line
D Spacing exposure across sessions rather than massing it into one block

23. What did Karpicke & Roediger (2008) show about students who practiced retrieval versus those who restudied?

A Restudiers retained significantly more after one week
B Both groups retained roughly the same amount after one week
C Retrieval practicers retained significantly more after one week
D Restudiers retained significantly more after one day

24. Which study confirmed retrieval practice's critical role in long-term retention across a range of material types?

A MIT Open Learning (2019)
B Karpicke & Roediger (2008)
C Ebbinghaus (1885)
D Roediger & Butler (2011)

25. When does retrieval practice produce its largest memory gains?

A When retrieval is quick and successful
B When retrieval is difficult but successful
C When retrieval is difficult but unsuccessful
D When retrieval is quick and unsuccessful

26. Per the testing effect, how often should low-stakes quizzes be given?

A Frequently — the testing itself drives learning
B Rarely, so quizzes stay high-stakes
C Never; re-reading works just as well
D Only once, right before the final

27. Why does frequent testing (not just re-reading) drive learning gains, per the testing effect?

A Testing only works when high-stakes and graded
B Quizzes mainly motivate through fear of failure
C Frequent testing eliminates need for spaced repetition
D Being tested is itself the learning event

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LESSON 2 OF 10

Learning Theories: Behaviorism to Constructivism

Behaviorism · Cognitivism · Constructivism

WHAT YOU'LL BE ABLE TO DO

- Identify behaviorism's founders (Skinner, Pavlov, Watson) and match each to their stimulus-response contribution.
- Explain operant conditioning and how shaping reinforces successive approximations toward a target behavior.
- Distinguish assimilation, accommodation, and equilibration as Piaget's schema-change processes, and why mild surprise aids memory.
- Define a schema and explain how chunking works within George Miller's 7±2 working-memory limit.
- Explain constructivism through the Zone of Proximal Development, scaffolding, and the roles of Vygotsky and Dewey.

Behaviorism

The oldest major learning theory treats the mind as a black box and focuses entirely on what can be observed: inputs, outputs, and the consequences that connect them. Its logic runs through almost every modern training system, often without acknowledgment.

Behaviorism

Behaviorism holds that learning is observable behavior change produced by **stimulus-response** conditioning. Its early-20th-century founders — **B.F. Skinner**, **Ivan Pavlov**, and **John Watson** — argued that internal mental states (beliefs, feelings, attention) are unmeasurable and therefore scientifically irrelevant. Pavlov demonstrated **classical conditioning** with dogs: pair a bell with food enough times and the bell alone triggers salivation. Watson extended this to humans, treating all behavior as conditioned reflexes. The framework was radical and productive: it forced researchers to specify observable outcomes rather than theorize about invisible minds.

Behaviorism, gamified

B.F. Skinner introduced **operant conditioning**: behavior is shaped by its consequences — **reinforcement** increases a behavior, **punishment** decreases it. Unlike Pavlov's passive conditioning, operant conditioning involves the learner's own actions. Skinner's key insight was that *when* a reward arrives matters as much as whether it arrives — different **reinforcement schedules** produce different response rates and extinction curves. This mechanics is directly behind modern **gamification**: Duolingo's streaks, badges, leaderboards, and immediate-feedback loops are applied Skinnerian schedules. The

ADDIE instructional-design model — still the dominant military and corporate training framework — has direct roots in this operant tradition.

The behaviorist toolkit

Behaviorism produced a precise vocabulary for intervention design. **Shaping** rewards successive approximations toward a target behavior, which lets instructors teach complex skills by reinforcing small steps rather than waiting for the whole performance. **Stimulus generalization** describes how a learned response transfers to stimuli that resemble the original — useful when you want training to carry over to real-world contexts. **Discrimination** is the flip side: learning to respond only to the correct stimulus, not its neighbors. Together these concepts give designers handles for sequencing difficulty, calibrating feedback timing, and planning transfer. The limitation behaviorism never escaped is that it cannot explain latent learning, language acquisition, or anything that happens between stimulus and response.

Cognitivism

Where behaviorism refused to look inside the skull, cognitivism made the mind's internal processes the whole subject. The shift, crystallizing in the 1950s–70s, reframed learning as information processing rather than behavior shaping.

Cognitivism

Cognitivism put the mind back in the picture. **Jean Piaget**, **Jerome Bruner**, **Albert Bandura**, and **George Miller** studied the internal machinery: how people attend, encode, store, and retrieve information. The mind is not a passive receiver of stimuli but an active system that *constructs* understanding. **George Miller**'s landmark 1956 paper established that **working memory** holds roughly **7 ± 2** chunks of information at once — a hard capacity limit that shapes every instructional design decision since. **Chunking** exploits this limit: grouping raw items into meaningful units (the digits 1-4-9-2 become "1492") reduces the number of slots occupied and dramatically improves encoding.

Piaget gave cognitivism its richest vocabulary for knowledge structure. A **schema** is a cognitive framework — a stored pattern of understanding — used to interpret new information. When new information fits an existing schema it is absorbed through **assimilation**: the schema stays intact. When it contradicts the schema, the learner must revise it through **accommodation** — a more effortful process that produces genuine conceptual change. The tension between old schemas and new experience creates **disequilibrium**; the drive to resolve it is **equilibration**, Piaget's engine of cognitive development. Equilibration is why mildly surprising information tends to be better remembered than information that simply confirms what you already know.

Cognitivism's practical legacy is large: it underlies spaced repetition, worked-example research, dual-coding theory, and the entire cognitive load tradition that shapes modern instructional design. Its weakness is that it sometimes treats the individual mind in isolation, downplaying social and cultural context — the opening that constructivism moved through next.

Constructivism

Constructivism argues that knowledge is not transmitted from teacher to student but actively built by the learner through experience, reflection, and social interaction. It is less a single theory than a family sharing one core claim: meaning-making is the learner's job.

Constructivism

Constructivism holds that knowledge is *built*, not delivered. Context, culture, and collaboration shape what is learned and how durable it is. Three poles define the tradition. **Piaget** (cognitive constructivism) emphasized the individual mind's encounter with the physical world — schemas built through direct manipulation and exploration. **Lev Vygotsky** (social constructivism) argued that higher mental functions arise first between people before they become internal — learning is inherently social. **John Dewey** (pragmatic constructivism) insisted that genuine learning requires "learn by doing": authentic problems, real consequences, reflection on action. All three converge on the idea that passive reception of information is the least reliable route to durable understanding. Constructivist classrooms emphasize projects, problems, and discussion over lecture.

Scaffolding and fading

Vygotsky's most influential concept is the **Zone of Proximal Development (ZPD)**: the gap between what a learner can do *independently* and what they can achieve *with guidance* from a **more knowledgeable other** — a teacher, peer, or structured tool. Learning is most efficient when a task falls inside this zone: too easy and no growth occurs; too hard and frustration blocks progress. **Scaffolding** is the practical application — temporary instructional support (hints, prompts, models, worked examples, partially completed problems) that allows a learner to operate in the ZPD. The critical design constraint is that scaffolding must be **temporary by design**: as competence grows, support is progressively withdrawn through **fading**. Scaffolds that are never removed create dependency rather than independence. This fading principle distinguishes effective scaffolding from simply making a task easier and explains why well-designed AI tutors gradually reduce the hints they offer as a learner's accuracy improves.

Key terms

Operant conditioning

Skinner's principle that behavior is shaped by its consequences — reinforcement and punishment — rather than by internal mental states.

Schema

A cognitive framework or category used to organize and interpret information.

Assimilation

Integrating new information into an existing schema without changing the schema itself.

Accommodation

Modifying an existing schema to incorporate contradictory new information.

Equilibration
The drive to balance assimilation and accommodation, resolving the tension between old schemas and new information.

Chunking
Breaking complex information into smaller, more manageable units to reduce cognitive load and improve encoding.

Zone of Proximal Development (ZPD)
Vygotsky's gap between what a learner can do independently and what they can achieve with guidance from a 'more knowledgeable other'.

Scaffolding
Temporary instructional support — hints, prompts, models, worked examples — that helps a learner progress through their ZPD, withdrawn as competence grows.

Key concepts

Schema

- Piaget gave cognitivism its richest vocabulary for knowledge structure, and this is its basic building block.
- It is a cognitive framework — a stored pattern of understanding — used to interpret new information.
- New information that fits one is absorbed intact; information that clashes forces the learner to revise it.

Assimilation

- One of Piaget's two complementary processes for fitting new information to an existing mental framework.
- It is the easier of the pair: the incoming information already fits, so the framework stays intact.
- When new digits slot neatly into a pattern you already hold, that effortless absorption is this process.

Accommodation

- This is the more effortful of Piaget's two adaptation processes.
- It kicks in when new information contradicts an existing schema.
- The learner must revise the framework itself, producing genuine conceptual change rather than a simple fit.

Equilibration

- Piaget called this the engine of cognitive development.
- It is the drive to resolve the tension between an outdated framework and a new, conflicting experience.
- This balancing process pushes a learner from mental conflict back toward a stable, updated understanding.

Key facts

Behaviorism

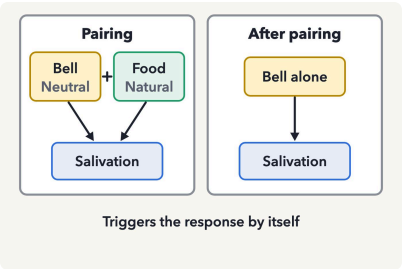
Behaviorism holds that learning is observable behavior change produced by stimulus-response conditioning, reinforcement, and punishment. Its early-20th-century champions — **B.F. Skinner**, **Ivan Pavlov**, and **John Watson** — treated internal mental states as irrelevant: only what you can see and measure counts.

The behaviorist toolkit

Beyond reinforcement, behaviorism gave us **reinforcement schedules** (when rewards arrive), **shaping** (rewarding successive approximations toward a target behavior), and **stimulus generalization** (a response learned to one stimulus transfers to similar ones).

Skinner: Operant Conditioning

B.F. Skinner is behaviorism's pioneer of operant conditioning — the principle that behavior is shaped by its consequences, distinct from Pavlov's classical conditioning or Watson's early behaviorism.



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Pavlov's Bell and Drool

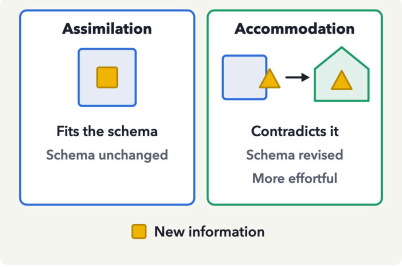
Pavlov paired a bell with food until dogs salivated at the bell alone — demonstrating classical conditioning, in which a neutral stimulus paired with a natural one comes to trigger the response by itself.

Cognitivism

Cognitivism put the mind back in the picture. Where behaviorism saw a black box, cognitivists — **Jean Piaget**, **Jerome Bruner**, **Albert Bandura**, **George Miller** — studied the internal processes: schemas, attention, encoding, storage, retrieval. The mind actively *constructs* understanding.

Assimilation: Same Old Schema

When a child who already knows 'dog' sees a new breed and simply calls it a dog too, that's assimilation — fitting new information into an existing schema without changing it.



FlashFeed original diagram · CC-BY-4.0

Accommodation: Schema Under Revision

Accommodation is the opposite move: when new information contradicts an existing schema, the schema itself gets revised to fit it — a more effortful process than simply assimilating.

Working Memory's Hard Limit

George Miller's landmark 1956 paper established that working memory holds only about 7 plus-or-minus 2 chunks at once — a hard capacity limit that has shaped instructional design ever since.

Four Digits Become One Chunk

Turning the digits 1-4-9-2 into the single meaningful unit '1492' is chunking: it frees up working-memory slots by grouping raw items into one chunk instead of several.

Constructivism

Constructivism holds that knowledge is *built* by the learner through active experience, not transmitted by a teacher. Context, culture, and social interaction shape what is learned. Its three poles: **Piaget** (cognitive), **Lev Vygotsky** (social), and **John Dewey** (pragmatic).

Scaffolding and fading

Good scaffolding is **temporary by design**. As competence grows, the support is progressively withdrawn — a process called **fading**. Learning is optimized when a task falls *within* the ZPD: hard enough to need support, not so hard it causes frustration.

The More Knowledgeable Other

In Vygotsky's zone of proximal development, a 'more knowledgeable other' — a teacher, parent, or more capable peer — supplies the scaffolding that lets a learner accomplish more than they could alone.

Dewey: Learn By Doing

John Dewey's pragmatic constructivism is defined by 'learn by doing' — authentic problems, real consequences, and reflection on action.

Vygotsky vs. Piaget

Vygotsky's social constructivism holds that higher mental functions first arise between people and only later become internal — learning is inherently social, unlike Piaget's focus on the individual's encounter with the physical world.

Matched pairs

Each item on the left goes with the one on the right.

B.F. Skinner → Operant conditioning

Ivan Pavlov → Stimulus-response conditioning

John Watson → Early behaviorism

George Miller → Chunking / 7±2 rule

Lev Vygotsky → Zone of Proximal Development

John Dewey → Learn by doing

Step by step

Order Piaget's four stages of cognitive development

1. Sensorimotor
2. Preoperational
3. Concrete Operational
4. Formal Operational

Piaget's framework established that learners aren't passive recipients but active constructors of knowledge.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Which behaviorism founder is correctly paired with his contribution?

- A Ivan Pavlov — conditioned reflexes in humans
- B B.F. Skinner — operant conditioning
- C John Watson — classical conditioning with dogs
- D Ivan Pavlov — reinforcement schedules

2. Pavlov paired a bell with food until the bell alone triggered salivation in dogs. What did this demonstrate?

- A Operant conditioning
- B Stimulus generalization
- C Classical conditioning
- D Stimulus discrimination

3. Which school of learning theory counts John Watson among its founders?

- A Cognitivism
- B Connectivism
- C Constructivism
- D Behaviorism

4. How did behaviorism's founders regard internal mental states such as beliefs and attention?

- A As unmeasurable and therefore scientifically irrelevant
- B As unmeasurable yet still central to explaining learning
- C As measurable yet too unreliable to be worth studying
- D As measurable and therefore fit for scientific study

5. A trainer treats all human behavior as conditioned reflexes, extending a method first shown with dogs to people. Whose stance is this?

- A Ivan Pavlov's
- B Albert Bandura's
- C B.F. Skinner's
- D John Watson's

6. In the behaviorist toolkit, what does shaping describe?

A. Learning to respond to the correct stimulus alone and disregard its neighbors
B. Reinforcing successive approximations toward a target behavior
C. Pairing a neutral stimulus with a reward until it alone triggers the response
D. Transferring a learned response to new stimuli that resemble the original

7. How does operant conditioning define what drives behavior change?

A. Behavior is shaped by its consequences — reinforcement and punishment
B. Behavior is built between people, then within — culture and collaboration
C. Behavior changes as mental schemas adjust — assimilation and accommodation
D. Behavior is evoked by paired stimuli — a neutral cue and a natural one

8. A coach rewards a beginner first for gripping the bat correctly, then for a partial swing, then for full contact. Which principle is this?

A. Pairing
B. Fading
C. Shaping
D. Chunking

9. What was Skinner's key insight about reinforcement schedules?

A. A behavior persists as well without its rewards as with them
B. Rewarding only a finished skill works as well as rewarding its steps
C. Punishment strengthens a behavior as much as reinforcement does
D. When a reward arrives matters as much as whether it arrives

10. What most clearly distinguishes Skinner's operant conditioning from Pavlov's conditioning?

A. Operant conditioning begins with the learner's reflex to a cue
B. Operant conditioning hinges on the learner's own actions
C. Operant conditioning tracks the learner's beliefs and attention
D. Operant conditioning relies on the learner's social interaction

11. In Piaget's account, why is mildly surprising information often remembered better than information that merely confirms what you already know?

A. It compresses into a single meaningful chunk, and the freed working-memory slots make it easier to recall
B. It overloads working memory's limited slots, and the strain of rehearsing it etches the material in deeper
C. It contradicts an existing schema, and the drive to resolve that disequilibrium forces effortful accommodation
D. It fits an existing schema, and the ease of assimilating it into place leaves a stronger memory trace

12. A child who knows 'dog' sees a new breed and calls it a dog without changing what 'dog' means. Which process is this?

A. Assimilation
B. Accommodation
C. Disequilibrium
D. Equilibration

13. Which Piagetian process involves modifying an existing schema to incorporate contradictory new information?

A Accommodation
B Equilibration
C Assimilation
D Disequilibrium

14. In Piaget's account, what is equilibration?

A The tension between a stored schema and new experience that contradicts it
B The stored pattern that assimilation preserves and accommodation revises
C The effortful revision of a schema so that surprising new experience fits it
D The drive to balance assimilation and accommodation and resolve schema tension

15. Which sequence correctly orders Piaget's engine of cognitive development?

A New information fits a schema → assimilation → equilibration then drives accommodation
B New information conflicts with a schema → disequilibrium → equilibration drives accommodation
C Accommodation revises a schema → disequilibrium → assimilation restores the original pattern
D Equilibration produces a schema → new information contradicts it → disequilibrium drives assimilation

16. Which best describes what a schema is?

A A reinforcement schedule or timing pattern that governs response rate and extinction
B A grouping of raw items into meaningful units that occupy fewer memory slots
C A cognitive framework or category used to organize and interpret information
D A temporary support or prompt that is withdrawn as the learner's competence grows

17. George Miller's landmark 1956 paper established what capacity for working memory?

A Roughly 3 ± 1 chunks
B Roughly 7 ± 2 chunks
C Roughly 9 ± 3 chunks
D Roughly 5 ± 2 chunks

18. Why does turning the digits 1-4-9-2 into '1492' help memory?

A It reduces the number of working-memory slots occupied by grouping items into one meaningful unit
B It sends the digits straight to long-term storage by skipping working memory altogether
C It raises working memory's capacity by training it to hold more chunks at once
D It lowers the cognitive load of each digit by spreading the four across separate slots

19. A diner handles an unfamiliar restaurant using a stored pattern — be seated, read the menu, order, pay. What is that stored pattern called?

A A chunk
B A stimulus
C A schema
D A scaffold

20. Which is NOT an accurate description of chunking?

A. It lets each occupied slot carry far more meaning than a raw item
B. It sharply reduces the number of slots occupied and improves encoding
C. It always groups multiple raw items into larger meaningful units
D. It permanently raises the number of chunks working memory can hold

21. In Vygotsky's ZPD, which source of guidance lets a learner exceed what they could do alone?

A. A peer at the same level
B. Unaided trial and error
C. A less experienced novice
D. A more knowledgeable other

22. According to Vygotsky, learning is most efficient when a task sits where?

A. Inside the gap between independent ability and guided ability
B. Inside the gap between a peer's ability and a trained teacher's ability
C. Just beyond what a more knowledgeable other could guide the learner through
D. Inside the range the learner already handles confidently on their own

23. What design constraint separates effective scaffolding from simply making a task easier?

A. Scaffolds must be increased step by step as the learner's accuracy improves
B. Scaffolds must be pitched at the level the learner already reaches alone
C. Scaffolds must be temporary and progressively withdrawn through fading
D. Scaffolds must be supplied by a trained teacher acting as the more knowledgeable other

24. Which theorist is matched with 'learn by doing' — authentic problems, real consequences, and reflection on action?

A. Albert Bandura
B. John Dewey
C. Lev Vygotsky
D. Jean Piaget

25. How does Vygotsky's social constructivism differ from Piaget's cognitive constructivism?

A. It emphasizes the individual mind's encounter with the physical world through exploration
B. It treats reflection on authentic problems with real consequences as the engine of learning
C. It holds that higher mental functions arise between people before becoming internal
D. It holds that higher mental functions mature within the individual before they are shared socially

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/learning-theory/learning-theories-behaviorism-to-constructivism

STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

LESSON 3 OF 10

Bloom's Taxonomy & Mastery Learning

Bloom's taxonomy · The verb ladder · The 2 Sigma Problem & mastery learning

WHAT YOU'LL BE ABLE TO DO

- Explain Bloom's Taxonomy and the 2001 revision, including the renaming to verbs and the Synthesis→Create swap at the summit.
- Identify the five levels of Bloom's affective domain (Receiving, Responding, Valuing, Organizing, Characterizing).
- Match the revised Bloom levels to their action verbs and identify Create as the highest level.
- Explain the 2 Sigma Problem and mastery learning, including why the result was economically unscalable and how a student's failure is reframed.
- Rank Bloom's alterable instructional variables by effect size, from one-to-one tutoring down to classroom morale.

Bloom's taxonomy

Bloom's Taxonomy is the most widely used framework for classifying cognitive learning objectives. Understanding both the original 1956 structure and the 2001 revision — including its less-discussed affective companion — is essential for anyone designing instruction or assessments.

Bloom's Taxonomy

Benjamin Bloom and colleagues at the University of Chicago published the **Taxonomy of Educational Objectives: Cognitive Domain** in **1956**, sorting cognitive skills into **six hierarchical levels**: Knowledge, Comprehension, Application, Analysis, **Synthesis**, and **Evaluation**. The hierarchy runs from lower-order thinking (simple recall) to higher-order thinking (complex judgment). Its enduring value is operational: once you attach a level to a learning objective, you know what kind of task to assign and what kind of assessment to write. The taxonomy gave educators a shared vocabulary that persists in virtually every curriculum-design conversation today.

The 2001 Revision

In **2001**, **Lorin Anderson** (a former student of Bloom) and **David Krathwohl** published a revised taxonomy. Two structural changes matter most. First, the level names became **verbs** — *Remember, Understand, Apply, Analyze, Evaluate, Create* — making them directly actionable when drafting objectives. Second, the top two levels were **swapped**: **Synthesis** (1956) became **Create** (2001) and moved to the summit; **Evaluation** (1956) became **Evaluate** (2001) and dropped one rung. The verb shift is not cosmetic — saying "the student will *analyze*" forces a clearer choice of evidence than "the student will demonstrate Analysis."

The Affective Domain

The cognitive taxonomy gets most of the attention, but Bloom's team also produced a second handbook in **1964** covering the **affective domain** — the realm of attitudes, values, emotions, and motivations. Its five levels are **Receiving, Responding, Valuing, Organizing,** and **Characterizing**. Receiving is simply attending to a stimulus; Characterizing means a value system has become integrated into a person's identity. Edtech tends to sideline this framework, but engagement design — whether someone bothers to open the app — operates squarely in the affective domain. Ignoring it means optimizing cognition while the motivational preconditions go unaddressed.

The 2 Sigma Problem & mastery learning

In 1984 Benjamin Bloom published the most provocative benchmark in educational research: individual tutoring outperforms conventional classroom instruction by a full two standard deviations. He called it a problem because no one could afford the solution.

The 2 Sigma Problem

In **1984**, Bloom reported a controlled comparison of three instructional conditions: conventional classroom teaching, **mastery learning** in a classroom, and **one-to-one tutoring** with mastery techniques. The tutored group scored **two standard deviations** higher than the conventional group — meaning the average tutored student outperformed roughly **98%** of the control class. Mastery learning alone produced about **1 sigma** gain. Bloom labelled this the **"2 Sigma Problem"** because the solution was economically unscalable: hiring a personal tutor for every student is fantasy. The challenge he issued to the field: find a group-based method that replicates the tutored result.

His paper also catalogued **alterable variables** — instructional inputs a teacher can actually change — ranked by effect size. **One-to-one tutorial instruction** topped the list at **2 sigma**. **Reinforcement** came second at **1.2 sigma**. **Mastery learning with feedback-corrective cycles** and **student time on task** each reached **1 sigma**. **Cooperative learning** and **graded homework** landed at **0.8 sigma**. **Classroom morale** contributed **0.6 sigma**. The ranking matters because it tells practitioners where to spend limited effort.

Mastery learning — developed earlier by John Carroll and expanded by Bloom — holds that most students can achieve a high threshold of mastery if given sufficient time and corrective feedback. When a student falls short, that outcome is treated as an **instructional gap to correct**, not a fixed student deficit. The diagnosis shifts from "this student can't" to "this unit wasn't taught effectively enough yet." That reframing has concrete consequences: re-teaching is the response, not remediation-as-punishment. The 2 Sigma result demonstrated what happens when mastery logic is taken to its logical extreme with unlimited one-to-one attention.

Key terms

Bloom's Taxonomy

A hierarchy of six cognitive skill levels, from lower-order to higher-order: in the revised version, Remember, Understand, Apply, Analyze, Evaluate, Create.

The 2 Sigma Problem

Bloom's 1984 challenge: one-to-one mastery tutoring lifts achievement by about two standard deviations, but is too costly to scale — so find a group method that matches it.

Mastery learning

An approach where students must reach a threshold (e.g. 90% on a test) before advancing; failures are treated as instructional gaps to correct, not student deficits.

Key concepts

Remember

- The lowest rung of Bloom's six-level cognitive hierarchy.
- It represents lower-order thinking — the simple recall of information.
- In the 1956 original this bottom level was called 'Knowledge'; the 2001 revision renamed it with an action verb.

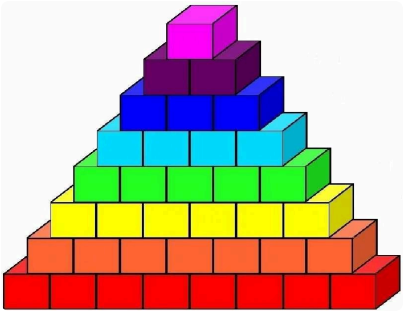
Evaluate

- This is one of the two highest levels in Bloom's revised taxonomy.
- It concerns complex judgment, near the summit of higher-order thinking.
- In the 2001 revision it was knocked down one rung, surrendering the top spot to the level about creating.

Create

- This occupies the very summit of Bloom's revised taxonomy.
- It sits at the top of higher-order thinking, above the level concerned with judgment.
- In the 1956 original it was called 'Synthesis'; the 2001 revision renamed it and promoted it to the peak.

Key facts



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Bloom's Taxonomy

Bloom's Taxonomy (Benjamin Bloom and colleagues, University of Chicago, **1956**) sorts cognitive skills into **six levels**, from lower-order recall up to higher-order thinking. It's the backbone of how we write learning objectives, design assessments, and calibrate difficulty.

The 2001 Revision

In **2001**, Lorin **Anderson** and David **Krathwohl** revised Bloom's Taxonomy. They turned the noun levels into **verbs** (Knowledge became *Remember*), swapped the top two, and moved **Create** to the summit. The verbs make objectives and assessments far more actionable.

The Affective Domain

A second handbook (1964) covered the **affective domain** — attitudes, values, and motivations — across five levels: **Receiving, Responding, Valuing, Organizing, Characterizing.** Less discussed in edtech than the cognitive domain, but central to engagement design.

The Original 1956 Taxonomy

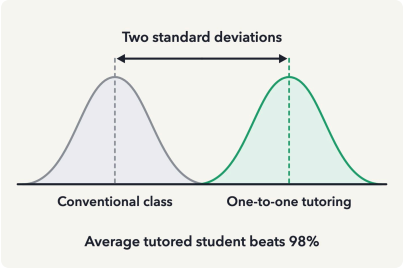
Benjamin Bloom and colleagues at the University of Chicago published the original Taxonomy of Educational Objectives: Cognitive Domain in 1956, decades before the 2001 revision led by Anderson and Krathwohl.



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Bloom's Original Summit

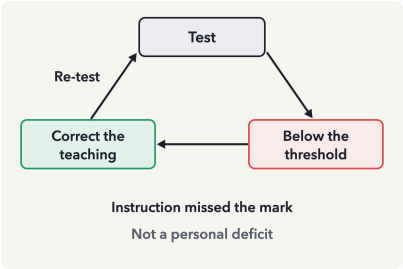
In the 1956 taxonomy, Evaluation sat at the very top of the hierarchy, following Synthesis. The 2001 revision swapped the order, dropping Evaluate one rung below the new top level, Create.



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The 2 Sigma Problem

In **1984**, Bloom reported that students tutored **one-to-one** with mastery techniques scored **two standard deviations** higher than conventionally taught peers — the average tutored student beat **98%** of the control class. The catch: 1:1 tutoring doesn't scale.



FlashFeed original diagram · CC-BY-4.0

Instructional Gap, Not Deficit

In mastery learning, a student who doesn't reach the threshold is treated as evidence the instruction missed the mark, not as a personal deficit — the fix is to correct the teaching and re-test.

> **Before Bloom: John Carroll**
>
> Mastery learning wasn't Bloom's original idea — John Carroll developed the model first, and Bloom later expanded it.

> **Reinforcement's 1.2 Sigma**
>
> Among Bloom's ranked alterable variables, reinforcement placed second at 1.2 sigma — well behind one-to-one tutoring's top effect size of 2 sigma.

> **Two Ways to 1 Sigma**
>
> Two of Bloom's alterable variables each produced a 1-sigma effect: mastery learning built on feedback-corrective cycles, and simply increasing a student's time on task.

By the numbers

Effect size of one-to-one tutorial instruction (Bloom's alterable variables)
2 sigma

Effect size of reinforcement (Bloom's alterable variables)
1.2 sigma

Effect size of mastery learning, feedback-corrective (Bloom's alterable variables)
1 sigma

Effect size of student time on task (Bloom's alterable variables)
1 sigma

Effect size of cooperative learning (Bloom's alterable variables)
0.8 sigma

Effect size of graded homework (Bloom's alterable variables)
0.8 sigma

Effect size of classroom morale (Bloom's alterable variables)
0.6 sigma

Matched pairs

Each item on the left goes with the one on the right.

Knowledge (1956) → Remember (2001)

Comprehension (1956) → Understand (2001)

Synthesis (1956) → Create (2001)

Evaluation (1956) → Evaluate (2001)

Remember → define, list, recall, identify

Apply → use, execute, implement, solve

Create → design, produce, construct, invent

Step by step

Climb Bloom's revised (2001) cognitive ladder from lowest to highest order

1. Remember — recall facts and basic concepts
2. Understand — explain ideas in your own words
3. Apply — use knowledge in a new situation
4. Analyze — break material into parts and see how they relate
5. Evaluate — judge, defend, or critique against criteria
6. Create — combine parts into something new and original

The 2001 revision swapped the top two levels and put Create — not Evaluate — at the summit.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Who published the original Taxonomy of Educational Objectives: Cognitive Domain, and in what year?

(A) Lorin Anderson and David Krathwohl, 1956
(B) Lorin Anderson and David Krathwohl, 2001
(C) Benjamin Bloom and colleagues, 2001
(D) Benjamin Bloom and colleagues, 1956

2. Which mapping from a 1956 level to its 2001 counterpart is correct?

A Knowledge to Understand
B Analysis to Evaluate
C Synthesis to Create
D Comprehension to Apply

3. What did the 2001 revision do to the number of levels in the cognitive taxonomy?

A It cut the taxonomy from six levels to five
B It kept the taxonomy at its original six levels
C It kept the taxonomy at its original five levels
D It expanded the taxonomy from five levels to six

4. In the original 1956 taxonomy, which level sat at the very top of the hierarchy?

A Evaluation
B Application
C Synthesis
D Analysis

5. An instructor rewrites 'the student will demonstrate Analysis' as 'the student will break down the argument.' Which 2001 change does this reflect?

A The affective domain was folded in, making attitudes a cognitive level
B The top two levels were swapped, making judgment the final rung
C Level names became verbs, making objectives directly actionable
D The hierarchy was flattened, making every level equally rigorous

6. Which set of five levels belongs to Bloom's affective domain?

A Receiving, Responding, Valuing, Organizing, Characterizing
B Imitation, Manipulation, Precision, Articulation, Naturalization
C Knowledge, Comprehension, Application, Analysis, Synthesis
D Analyzing, Designing, Developing, Implementing, Evaluating

7. Which is the lowest level of Bloom's affective domain — simply attending to a stimulus?

A Responding
B Receiving
C Organizing
D Valuing

8. In the affective domain, which level describes a value system that has become integrated into a person's identity?

A Organizing
B Responding
C Valuing
D Characterizing

9. Which of these is one of the five levels of Bloom's affective domain?

A Feeling
B Valuing
C Believing
D Trusting

10. In what year did Bloom's team publish the second handbook covering the affective domain?

A 1964
B 2001
C 1956
D 1984

11. What is the highest level of the revised (2001) Bloom's Taxonomy?

A Evaluate
B Analyze
C Remember
D Create

12. Which set of action verbs belongs to the Apply level?

A design, produce, construct, invent
B recognize, describe, summarize, explain
C use, execute, implement, solve
D define, list, recall, identify

13. An objective reads 'the student will design and produce an original experiment.' Which revised level do those verbs place it at?

A Create
B Analyze
C Evaluate
D Apply

14. The verbs 'define, list, recall, identify' correspond to which revised Bloom level?

A Analyze
B Apply
C Understand
D Remember

15. In the revised taxonomy, which level sits directly below the summit?

A Create
B Evaluate
C Remember
D Analyze

16. Which level was moved to the summit of the revised Bloom's Taxonomy?

A Evaluate
B Understand
C Create
D Analyze

17. Which verb-level ranks highest in the 2001 Bloom's revision, above Evaluate?

A Remember
B Analyze
C Apply
D Create

18. Why did Bloom frame the two-sigma result as a 'problem'?

A The design lacked a conventional-classroom control
B One-to-one tutoring is economically unscalable
C The tutored gain appeared only among strong students
D Mastery learning in classrooms fell well short of a sigma

19. In mastery learning, how is a student's failure to reach the threshold treated?

A As an instructional gap to correct, not a student deficit
B As a bar set too high, not a student unable to clear it
C As a need for more time on task, not more re-teaching
D As a flaw in the unit's sequencing, not in its teaching

20. In Bloom's 1984 study, the average tutored student outperformed roughly what share of the conventionally taught control class?

A) 50%
B) 84%
C) 98%
D) 68%

21. Which three instructional conditions did Bloom compare in his 1984 study?

A) Classroom mastery learning, cooperative learning, and peer tutoring in pairs
B) Conventional teaching, programmed instruction, and computer-assisted drill
C) Lecture-based teaching, small-group seminars, and peer tutoring in pairs
D) Conventional teaching, classroom mastery learning, and one-to-one tutoring

22. Mastery learning was developed earlier by whom, before Bloom expanded it?

A) David Krathwohl
B) Lorin Anderson
C) John Carroll
D) Robert Gagne

23. Which alterable variable topped Bloom's list with the largest effect size?

A) Cooperative learning in small groups
B) One-to-one tutorial instruction
C) Feedback-corrective mastery learning
D) Reinforcement in the classroom

24. What effect size did Bloom report for reinforcement?

A) 1.2 sigma
B) 1.0 sigma
C) 0.8 sigma
D) 2.0 sigma

25. Which two alterable variables each reached 1 sigma?

A) One-to-one tutorial instruction, and student time on task
B) Mastery learning with feedback-corrective cycles, and student time on task
C) Cooperative learning, and one-to-one tutorial instruction
D) Reinforcement, and mastery learning with feedback-corrective cycles

26. What effect size did Bloom assign to classroom morale?

A) 0.6 sigma
B) 0.8 sigma
C) 1.2 sigma
D) 1 sigma

27. Which list ranks alterable variables correctly from largest effect size to smallest?

A) Time on task, reinforcement, graded homework
B) Mastery learning, reinforcement, cooperative learning
C) Reinforcement, cooperative learning, classroom morale
D) Classroom morale, graded homework, time on task

28. Among Bloom's alterable instructional variables, which tops the ranking by effect size?

A) Reinforcement
B) Cooperative learning
C) Mastery learning, feedback-corrective
D) One-to-one tutorial instruction

29. What effect size did one-to-one tutorial instruction reach in Bloom's ranking?

A 1.2 sigma
B 2 sigma
C 1 sigma
D 0.6 sigma

30. Which alterable variable sits at the bottom of Bloom's effect-size ranking?

A Student time on task
B Cooperative learning
C Classroom morale
D Graded homework

31. What effect size does classroom morale contribute, per Bloom's ranking?

A 0.6 sigma
B 2 sigma
C 0.8 sigma
D 1.2 sigma

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/learning-theory/bloom-s-taxonomy-and-mastery-learning

STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

LESSON 4 OF 10

The Cognitive Science of Learning

Flow & dual coding · Connectivism & Gagné's events · UDL & memory techniques · Cognitive load

WHAT YOU'LL BE ABLE TO DO

- Explain flow and the challenge-skill balance — including boredom, anxiety, autotelic engagement, and its 1975 origin.
- Explain Paivio's Dual Coding Theory and its two interconnected verbal and visual memory systems.
- Explain Sweller's Cognitive Load Theory: working memory's limit, the three load types of the 1998 formulation, and the 2010 recasting of germane load.
- Explain connectivism's 'know-where' claim and the gap it named, plus Gagné's five learning outcomes and first event of instruction.
- Explain UDL's three principles and the mnemonic techniques (Method of Loci, Keyword Method) that exploit dual coding.

Flow & dual coding

Two cognitive principles — one about emotional engagement, one about memory architecture — explain why the same learner can absorb material effortlessly in one context and struggle in another.

The challenge-skill balance

Mihaly Csikszentmihalyi described **flow** in 1975 as a state of complete psychological immersion: intense focus, effortless concentration, intrinsic enjoyment. The condition for reaching it is precise — task **challenge must match the learner's skill**. Tip the balance too far either way and flow collapses: too easy produces **boredom**; too hard produces **anxiety**. When the match is right, the activity becomes **autotelic** — rewarding in itself, not for any external payoff. Practically, this means calibrating difficulty in real time: a fixed syllabus delivered identically to every learner leaves most people in the wrong zone.

Dual Coding Theory, proposed by **Allan Paivio in 1971**, adds a second lever. Paivio's model holds that humans operate with two interconnected memory systems — **verbal** (language, text, narrative) and **visual** (imagery, spatial layout). Each system can encode information independently, but when both are engaged simultaneously, learning improves. A diagram paired with an explanation encodes in two channels; a wall of text encodes in one. Mnemonic images — vivid, concrete pictures linked to what you're trying to remember — are a deliberate exploitation of this dual-channel architecture.

Flow and dual coding are complementary: flow governs the motivational conditions under which learning happens at all; dual coding governs how information is encoded once attention is secured. Together they argue for lessons that are emotionally calibrated *and* multimodal.

Connectivism & Gagné's events

Two frameworks from opposite ends of the 20th-to-21st century transition — one a structured instructional sequence from the pre-digital era, one a network theory built for the internet age — together map the full range of what teaching has to manage.

Know-where beats know-that

Connectivism, developed by **George Siemens and Stephen Downes in 2004–05**, is sometimes called "the learning theory for the digital age." Its core move: learning is the process of creating **connections between nodes in a network** — people, books, databases, tools, AI systems. What you currently know matters less than **knowing where to find information** and being able to evaluate it critically. Older theories (behaviorism, cognitivism, constructivism) were built around learning stored inside the human mind; connectivism argued they failed to account for learning that occurs **outside the mind, distributed across systems**. In the AI era, the theory reads as prescient: educational value increasingly shifts **toward know-where** — accessing and evaluating sources — rather than memorizing content that's a search away.

Five kinds of learning outcome

Robert Gagné's *Conditions of Learning* (first published in 1965, with later editions) made a claim that sounds obvious once stated: different outcomes require different instruction. He named five categories — **verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes** — and insisted each demands its own teaching approach. His **Nine Events of Instruction** operationalized this into a lesson sequence; the first event is to **gain attention** before any content is delivered, because unattended information is not encoded. Gagné's framework remains a backbone of instructional design precisely because it is modular: designers diagnose which outcome type a lesson targets and then select the corresponding event sequence, rather than applying a one-size method.

Together, Connectivism and Gagné span the theoretical and the procedural — what learning is, and how instruction should be built.

UDL & memory techniques

Curriculum design and memory encoding are often treated as separate concerns. They aren't — how a course is built determines whether students can access it, and how information is encoded determines whether it survives past the lesson.

Why vivid images stick

Mnemonic images — concrete, vivid mental pictures tied to target information — are far more durable in memory than abstract verbal representations. The reason connects back to Paivio: a vivid image activates the **visual memory system** while the linked word or concept activates the **verbal system**, encoding the item in two channels simultaneously. That is **dual coding in action**.

Two classic techniques exploit this. The **Method of Loci** (Memory Palace) originated in **ancient Greece and Rome** and works by placing items to be memorized at specific locations along a familiar mental

route — a walk through your home, a commute. Retrieval is spatial: you walk the path and the items appear in sequence. The mechanism it exploits is **spatial-episodic memory**, a system humans evolved for navigation and that is exceptionally robust. The **Keyword Method** is a language-learning mnemonic that links a foreign word's sound to a memorable image which then bridges to its translation — "fork" in French is *fourchette*; picture a four (quatre) on a fork. Both methods work for the same reason: concrete, narrative, spatial material sticks; abstract lists don't.

Universal Design for Learning (UDL), developed by David Rose at **CAST**, addresses the access side. UDL is a neuroscience-based curriculum framework that builds flexibility in from the outset rather than retrofitting accommodations. Its three principles are **Representation** (how content is delivered), **Action & Expression** (how learners demonstrate knowledge), and **Engagement** — the principle that addresses the **why** of learning: motivation, relevance, and sustained effort. UDL treats variability as the norm, not the exception.

Cognitive load

Lesson 2 introduced working memory's capacity limit and chunking. **Cognitive Load Theory (CLT)** turns that limit into rules for designing instruction, and its central terms have been revised since they were first set out.

Sweller's theory

John Sweller gave the first full description of **Cognitive Load Theory** in a 1988 *Cognitive Science* article, "Cognitive Load During Problem Solving: Effects on Learning." He argued that **schemas** held in long-term memory are what separate experts from novices, and that conventional problem solving uses so much processing capacity that little is left for acquiring them. The theory's premise is that novel information is first processed by a **working memory** limited in capacity and duration, then stored in an unlimited **long-term memory**; once stored, those limits effectively disappear. **George Miller**'s 1956 paper estimated working memory at about 7 ± 2 chunks. **Nelson Cowan** (2001) reviewed later evidence and argued that the limit averages nearer **four chunks**, so the exact figure remains debated.

Three types of load (the 1998 formulation)

In 1998, Sweller, van Merriënboer and Paas set out three categories of cognitive load in *Educational Psychology Review*. **Intrinsic load** comes from the complexity of the information itself: how many elements must be processed together, which also depends on what the learner already knows. Better presentation cannot reduce it; only changing what is to be learned, or the learner's expertise, can. **Extraneous load** comes from how information is presented and what the instruction makes the learner do, so redesign can cut it. Most of the theory's instructional effects, such as studying **worked examples** instead of solving conventional problems, work by reducing extraneous load. **Germane load** was defined as the mental resources devoted to building and automating schemas. In this classic formulation, germane load counted toward the total, and the prescription was to reduce extraneous load first, then promote germane load while keeping total load within working memory's limits.

The revision

Sweller revised the account in 2010. He argued that **element interactivity**, the number of elements that must be processed together, underlies extraneous load as well as intrinsic load, and that germane load can be defined in terms of intrinsic load. In the current formulation (Sweller, van Merriënboer and Paas, 2019), germane load is not a separate load that adds to the total. It refers to the working-memory resources devoted to intrinsic load rather than extraneous load, so only intrinsic and extraneous load remain as basic categories. The design advice survives in revised form: the more working memory extraneous load takes up, the less is left for the material's intrinsic complexity, and the less is learned.

Key terms

Flow

An optimal experience of complete psychological immersion in a task, marked by intense enjoyment and effortless concentration.

Autotelic activity

An activity that is intrinsically rewarding — done for its own sake, not for an external payoff. Central to Csikszentmihalyi's concept of flow, the peak state of full absorption when challenge matches skill.

Dual Coding Theory

Paivio's idea that humans have two interconnected memory systems — verbal and visual — and learning improves when both are engaged at once.

Connectivism

Siemens and Downes's 'learning theory for the digital age': learning is the process of creating connections between nodes in a network.

Universal Design for Learning (UDL)

A neuroscience-based curriculum framework (Rose, CAST) that builds flexibility into learning from the outset rather than adding accommodations afterward.

Method of Loci (Memory Palace)

An ancient technique that places items to be memorized at spatial locations along a familiar mental journey; walking the path retrieves them in sequence.

Keyword Method

A language-learning mnemonic that links a foreign word's sound to a memorable image which bridges to the translation.

Cognitive Load Theory

Sweller's theory (1988) that working memory has limited capacity, so instruction must manage how much mental load the material imposes.

Intrinsic load

The load that comes from the material's inherent complexity, which also depends on the learner's prior knowledge; design cannot remove it.

Extraneous load

Cognitive load created by poor instructional design — unnecessary complexity that should be eliminated.

Germane load

In CLT's 1998 formulation, mental resources devoted to building schemas, the load to promote; Sweller later recast it as resources spent on intrinsic load.

Key concepts

Allan Paivio

- This researcher's 1971 theory explains why a diagram paired with an explanation beats a wall of text.
- He proposed that humans run two interconnected memory systems — one verbal, one visual.
- His dual-coding model says engaging both channels at once improves learning; mnemonic images exploit it.

Stephen Downes

- This thinker co-created a framework billed as 'the learning theory for the digital age.'
- Working with a collaborator in 2004-05, he cast learning as forming connections between nodes in a network.
- His theory prized 'know-where' — locating and evaluating information — over memorizing content a search away.

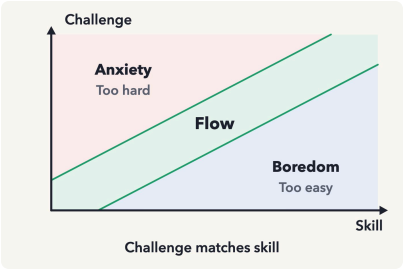
Robert Gagné

- This theorist's 1965 book argued that different learning outcomes each need a different teaching approach.
- He named five outcome categories — verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes.
- His 'Nine Events of Instruction' start by gaining attention before any content is delivered.

David Rose

- This researcher built a neuroscience-based curriculum framework at an organization called CAST.
- His approach designs in flexibility from the outset instead of retrofitting accommodations, treating learner variability as normal.
- Universal Design for Learning — Representation, Action & Expression, and Engagement — is his framework.

Key facts



FlashFeed original diagram · CC-BY-4.0

The challenge-skill balance

Mihaly **Csikszentmihalyi** described flow in 1975. Its condition is precise: task **challenge must match the learner's skill**. Too easy breeds **boredom**; too hard breeds **anxiety**; the balance produces flow.

Flow Is Autotelic

Flow theory calls an activity 'autotelic' when it's pursued purely because doing it is rewarding, with no outside payoff — like a student who keeps practicing piano long after the assignment is finished, simply because playing itself feels good.

Dual Coding's Origin

Allan Paivio proposed Dual Coding Theory in 1971 — distinct from Sweller's later Cognitive Load Theory (1988) and Gagné's earlier Conditions of Learning (1965).

Verbal Plus Visual

Dual Coding Theory holds that humans operate with two interconnected memory systems: a verbal system for language, text, and narrative, and a visual system for imagery and spatial layout.

Know-where beats know-that

Connectivism holds that **knowing where to find information** matters more than what you currently know. Knowledge is **distributed across networks** — people, books, databases, AI — not stored only in one mind. Prescient for the LLM era.

Five kinds of learning outcome

Gagné's *Conditions of Learning* named five outcome categories: **verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes**. His point — each kind requires a different type of instruction.

Learning Outside the Mind

Connectivism's founders argued that behaviorism, cognitivism, and constructivism all locate learning inside the individual mind — missing the learning that happens in networks, organizations, and digital systems.

Gagné's First Event

Gagné's Nine Events of Instruction open by gaining the learner's attention, before informing them of objectives — the sequence ends by building retention and transfer.

Connectivism's Two Founders

George Siemens and Stephen Downes developed connectivism, 'the learning theory for the digital age,' around 2004–05 — after Gagné's 1965 Conditions of Learning and Sweller's 1988 load theory.

Why vivid images stick

Mnemonic images — concrete, vivid mental pictures — are far easier to recall than abstract words. Linking a target word to a similar-sounding or similar-meaning image fires both the verbal and visual systems at once: **dual coding in action**.

The Why of Learning

Universal Design for Learning organizes its three principles around what (Representation), how (Action & Expression), and why (Engagement) — the why being learner motivation and interest.

Loci and Spatial Memory

The method of loci works by exploiting the brain's strong spatial-episodic memory — placing facts along a familiar mental route, which is how memory champions manage to memorize thousands of digits.

The Keyword Method

The Keyword Method is a language-learning mnemonic that links a foreign word's sound to a bridging image — for example, picturing a four (quatre) on a fork to remember the French word fourchette.

An Ancient Memory Trick

The method of loci, or memory palace, originated in ancient Greece and Rome, where orators used it to hold long speeches in sequence — long before its Renaissance revival.

By the numbers

Roughly how many chunks can working memory hold at once, per Miller's 1956 paper?

7 chunks

Matched pairs

Each item on the left goes with the one on the right.

Allan Paivio (1971) → Dual Coding Theory

Siemens & Downes (2004–05) → Connectivism

Robert Gagné → Nine Events of Instruction

Representation (UDL) → The 'what' — multiple means of presenting content

Action & Expression (UDL) → The 'how' — multiple ways to demonstrate knowledge

Engagement (UDL) → The 'why' — multiple means of motivation and interest

Ancient Greece and Rome → Origin of the method of loci

Step by step

Run Gagné's Nine Events of Instruction in order

1. Gain attention (reception)
2. Inform learners of objectives (expectancy)
3. Stimulate recall of prior learning (retrieval)
4. Present the content (selective perception)
5. Provide learning guidance (semantic encoding)
6. Elicit performance (responding)
7. Provide feedback (reinforcement)
8. Assess performance (retrieval)
9. Enhance retention and transfer (generalization)

Gagné's nine events read like a design checklist for a well-architected tutoring session — each can be orchestrated by an LLM tutor at scale.

Self-test

Answer each question from memory, then check your work against the answer key.

1. In flow theory, what happens when a task's challenge far exceeds the learner's skill?

A Apathy
B Control
C Anxiety
D Boredom

2. Mihaly **Csikszentmihalyi** described flow in ___. Its condition is precise: task **challenge must match the learner's skill**. Too easy breeds **boredom**; too hard breeds **anxiety**; the balance produces flow.

A 1975
B 1985
C 1971
D 1980

3. A student keeps practicing piano long after the assignment is finished, purely because playing itself is rewarding. Flow theory calls this kind of activity:

A Vicarious
B Exotelic
C Habitual
D Autotelic

4. In flow theory, what results when a task's challenge falls far below the learner's skill?

A Anxiety
B Boredom
C Burnout
D Autotelic engagement

5. Which state does Csikszentmihalyi's flow theory link to a task that is too easy?

A Cognitive load
B Anxiety
C Autotelic reward
D Boredom

6. Who proposed Dual Coding Theory, and in what year?

A Robert Gagné, 1965
B Allan Paivio, 1971
C John Sweller, 1988
D George Siemens, 2004

7. Dual Coding Theory holds that humans operate with which two interconnected memory systems?

A Episodic and semantic
B Implicit and explicit
C Verbal and visual
D Working and long-term

8. In Paivio's Dual Coding Theory, how do the verbal and visual memory systems relate to each other?

A Interconnected, with each able to encode information on its own
B Interconnected, with just the verbal system able to encode alone
C Interconnected, with just the visual system able to encode alone
D Interconnected, with both required to encode any information

9. A lesson pairs a labeled diagram with a spoken explanation. Under Dual Coding Theory, why does this pairing help learning?

A It encodes the material through both memory channels at once
B It merges the two channels into one stronger trace
C It splits the material so each channel encodes only half
D It encodes the material in the two channels one after the other

10. Per Dual Coding Theory, which of these encodes information in only ONE channel?

A A captioned photograph
B A wall of unbroken text
C A labeled anatomy diagram
D A mnemonic image for a word

11. In Cognitive Load Theory's classic 1998 formulation, which type of load should designers try to INCREASE?

A Germane load
B Intrinsic load
C Extraneous load

12. Cognitive Load Theory — that working memory's limited capacity must be managed by instruction — was proposed by whom, and when?

A Allan Paivio, 1971
B George Miller, 1956
C John Sweller, 1988
D Robert Gagné, 1965

13. In Miller's classic 1956 estimate, roughly how many items can working memory hold at once?

A 4
B 14
C 7
D 10

14. A slide is crammed with decorative animations and off-topic text that make the point harder to find. Which kind of cognitive load has the designer added?

A Intrinsic load
B Germane load
C Perceptual load
D Extraneous load

15. In Cognitive Load Theory, what sets the amount of intrinsic load a topic carries?

A The effort a learner spends building schemas
B The inherent complexity of the material
C The capacity of the learner's working memory
D The quality of the instructional design

16. Which technique exploits working memory's limit by grouping raw items into meaningful units?

A Chunking
B Scaffolding
C Spaced repetition
D Method of Loci

17. Working memory's hard capacity limit is counted in which units?

A Schemas
B Nodes
C Channels
D Chunks

18. Per connectivism, where does educational value shift in the AI era?

A Toward know-why — explaining the causes behind each fact
B Toward know-where — accessing and evaluating information
C Toward know-how — building skills that transfer across tools
D Toward know-that — retaining facts a model might get wrong

19. What gap did connectivism claim older theories failed to address?

A Learning that occurs outside the human mind, in networks and systems
B Learning that arises from emotion, in feelings and motivation
C Learning that is carried in the body, in movement and gesture
D Learning that stays tacit, in habits too automatic to describe

20. Which is one of Gagné's five categories of learning outcomes?

A Perceptual abilities
B Verbal reasoning
C Cognitive strategies
D Interpersonal skills

21. What is the first of Gagné's Nine Events of Instruction?

A Present content
B Gain attention
C State objectives
D Stimulate recall

22. Connectivism, 'the learning theory for the digital age,' was developed by which pair, and in what year?

A Siemens & Downes, 2004
B Anderson & Krathwohl, 2001
C Gagné & Briggs, 1965
D Sweller & Chandler, 1988

23. Per connectivism, what matters most in the AI era compared to memorized facts?

A Memorizing more facts than before
B Relying solely on classroom instruction
C Avoiding AI tools during study
D Knowing where to find and evaluate information

24. What gap did Siemens and Downes say older learning theories missed?

A How motivation affects retention
B The difference between short- and long-term memory
C Learning that happens outside the mind, across networks
D The role of feedback in classroom instruction

25. Gagné's Conditions of Learning named five outcome categories. Which is one?

A Mastery learning
B Autotelic engagement
C Motor skills
D Dual coding

26. What is the very first step in Gagné's Nine Events of Instruction?

A Provide learning guidance
B Gain attention
C Assess performance
D Enhance retention and transfer

27. Which UDL principle addresses the 'why' of learning?

A Engagement
B Retention
C Representation
D Action & Expression

28. What memory strength does the method of loci exploit?

A Phonological working memory
B Procedural motor memory
C Verbal-semantic memory
D Spatial-episodic memory

29. Which of these is NOT one of UDL's three principles?

A Action & Expression
B Engagement
C Representation
D Reinforcement

30. What does the Keyword Method have a learner do?

A Link a foreign word's sound to an image that bridges to its translation
B Match a task's difficulty to the learner's current skill so focus holds
C Place each item at a spot along a familiar mental route and walk it to recall
D Group a long list of words into a few meaningful units so working memory copes

31. Where did the Method of Loci (Memory Palace) originate?

A Ancient Babylon and Assyria
B Ancient Greece and Rome
C Ancient India and China
D Ancient Egypt and Persia

32. The Keyword Method links a foreign word's sound to which of these to aid recall?

A. A grammar conjugation pattern
B. A rote repetition drill
C. A vivid image that bridges to the translation
D. A spatial route through a familiar building

33. Which example illustrates the Keyword Method for learning a French word?

A. Repeating the word aloud ten times
B. Walking a familiar route to recall items in order
C. Picturing a four on a fork to remember "fourchette"
D. Pairing a diagram with a spoken explanation

Go deeper

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STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

LESSON 5 OF 10

Instructional Design Frameworks

The ADDIE model · ID frameworks & the Socratic method

WHAT YOU'LL BE ABLE TO DO

- Identify ADDIE's origin and sequence its five phases, matching Analyze, Design, and Develop to their functions.
- Explain how the Evaluate phase threads through all of ADDIE rather than acting as a final gate.
- Match the major instructional-design frameworks (Dick & Carey, SAM, Merrill, UbD) to their defining approach.
- Distinguish backward design (Wiggins & McTighe's UbD) from Cathy Moore's Action Mapping.
- Explain the Socratic method and how Khanmigo embodies it through guided questioning rather than direct answers.

The ADDIE model

ADDIE is the bedrock framework of **instructional systems design (ISD)** — a structured, repeatable process that has shaped how training is built across military, corporate, and academic settings for fifty years.

Where ADDIE came from

ADDIE was developed in **1975** at **Florida State University's** Center for Educational Technology, commissioned by the **U.S. Army** to bring engineering-style rigor to training production. The acronym maps to five sequential phases: **Analyze**, **Design**, **Develop**, **Implement**, and **Evaluate**. In the Analyze phase you identify goals, audience, prior knowledge, and constraints. Design is where you define objectives, assessment strategy, sequencing, and modalities. Develop is the build phase — you produce the actual content, activities, and assessments. Implement is delivery; Evaluate is the continuous quality check. Crucially, **Evaluate is not a final gate** — it threads through all phases, surfacing problems early rather than waiting until after delivery.

The rigidity criticism

ADDIE's dominant critique is that its linear structure is **too rigid** for the rapid, AI-enabled content cycles that modern teams run. Moving sequentially through five phases can mean weeks pass before any learner interaction surfaces a design flaw. That friction is exactly what pushed the field toward more iterative alternatives — most notably **SAM** (Successive Approximation Model), which shortens feedback loops by cycling through prototyping and revision earlier. ADDIE still dominates when stakes are high and thorough documentation is required — government and compliance training, for example — but for shorter-horizon projects the rigidity cost is real. Knowing the critique matters: it tells you which context ADDIE fits and which calls for something faster.

ID frameworks & the Socratic method

Beyond ADDIE, the instructional design field has produced a cluster of influential frameworks — each a different answer to "what should drive the design process?" — and the Socratic method offers a contrasting philosophical anchor for how learning actually happens.

Khanmigo, by design

Sal Khan built **Khanmigo** to operationalize Socratic principles at scale: the AI tutor guides students *through* problems with probing questions rather than surfacing the answer directly. That design choice is not aesthetic — it reflects a well-supported constructivist finding: **knowledge a learner constructs through guided questioning encodes more durably than knowledge merely received**. The Socratic method, formally, is teaching through strategic questions that force the learner to surface and examine their own reasoning, yielding the insight independently. Khanmigo is one of the clearest recent attempts to embed that dynamic in an AI product.

The broader landscape of ID frameworks the quizzes draw from:

- **Dick & Carey Model (1978)** — a systems view that treats instruction as nine interacting components rather than phases.
- **SAM (2012)** — Michael Allen's iterative counterpoint to ADDIE; rapid prototyping, short cycles.
- **Merrill's Principles of Instruction (2002)** — **task-centered "first principles"** of effective design: problem-centered, activation, demonstration, application, integration.
- **Understanding by Design / UbD (1998)** — Wiggins and McTighe's **backward design** approach: start from the desired learning outcomes, then work back to assessments, then to instruction.
- **Action Mapping (2008)** — Cathy Moore's performance-focused method that strips out "nice to know" content and designs entirely around what learners must *actually do* on the job.

The clearest differentiator to hold: **backward design** belongs to Wiggins and McTighe's UbD; **Action Mapping** belongs to Cathy Moore.

Key terms

ADDIE

An instructional systems design framework structured as five phases: Analyze, Design, Develop, Implement, and Evaluate.

Backward design

Wiggins and McTighe's approach in Understanding by Design: start from the desired learning outcomes, then work back to assessments and instruction.

Action Mapping

Cathy Moore's 2008 performance-focused method that strips out 'nice to know' content and designs around what learners must actually do.

The Socratic method

Teaching through guided, probing questions rather than direct answers, so the learner constructs the insight independently — yielding deeper encoding.

Key concepts

SAM (Successive Approximation Model)

- Michael Allen built this framework in 2012 as a direct counterpoint to a decades-old linear model.
- It attacks the rigidity of phase-by-phase design by cycling through prototyping and revision far earlier.
- Its entire selling point is rapid prototyping and short, repeated feedback loops.

Dick & Carey Model

- This 1978 framework takes a systems view of instruction.
- Rather than sequential phases, it treats instruction as a set of interacting components.
- Precisely, it models instruction as nine interacting components working together as a system.

Merrill's Principles of Instruction

- Published in 2002, this framework distills effective teaching into a short set of 'first' fundamentals.
- It is task-centered and problem-centered at its core.
- Its five pillars: problem-centered, activation, demonstration, application, and integration.

Understanding by Design (UbD)

- Wiggins and McTighe introduced this framework in 1998.
- Its signature move is 'backward design': begin from the desired learning outcomes.
- You work back from target outcomes to assessments, and only then to the instruction itself.

Action Mapping

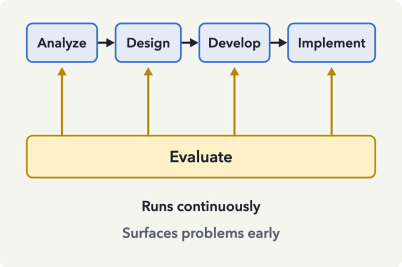
- Cathy Moore introduced this performance-focused method in 2008.
- It ruthlessly strips out 'nice to know' content.
- It designs a course entirely around what learners must actually do on the job.

Key facts

> **Where ADDIE came from**
>
> **ADDIE** was developed in **1975** at **Florida State University's** Center for Educational Technology — for the **U.S. Army**. Decades later it remains the dominant **instructional systems design (ISD)** framework worldwide. The name is just an acronym for its five phases.

The rigidity criticism

ADDIE's main knock: some consider it **too rigid** for the rapid, AI-enabled content cycles teams now run. The linear roots show. That critique is exactly what spawned faster, more iterative alternatives like **SAM**.



FlashFeed original diagram · CC-BY-4.0

Evaluate Never Stops

ADDIE's Evaluate phase isn't a final gate — it runs continuously through Analyze, Design, Develop, and Implement, surfacing problems early instead of waiting until after delivery.

ADDIE Starts With Analyze

ADDIE's front-end Analyze phase is where a team identifies goals, audience, prior knowledge, and constraints — before Design sets objectives, assessment, and sequencing.

ADDIE's Build Phase

In ADDIE's Develop phase, a team produces the actual videos, activities, and quiz items planned during Design — turning objectives and sequencing into finished material.



AI-generated (gpt-image-1.5)

Khanmigo, by design

Sal Khan built **Khanmigo** to embody Socratic principles: it guides students *through* their learning rather than just handing over answers. That operationalizes a constructivist insight — knowledge a learner builds is more durable than knowledge merely received.

Start From the End

Understanding by Design (Wiggins & McTighe, 1998) is the framework built on 'backward design' — starting from the outcomes learners should achieve and working back from there.



AI-generated (gpt-image-1.5)

ADDIE's Agile Answer

SAM — Michael Allen's Successive Approximation Model (2012) — is the iterative counterpoint to ADDIE, built on rapid, agile prototyping and short revision cycles.

> **Merrill's First Principles**
> Merrill's Principles of Instruction (2002) offer task-centered 'first principles' of design — problem-centered, activation, demonstration, application, and integration — rather than a systems view of instruction.

> **Nine Parts, Not Phases**
> The Dick & Carey Model (1978) treats instruction as nine interacting components rather than a set of sequential phases, making it a more prescriptive systems view than ADDIE.

Matched pairs

Each item on the left goes with the one on the right.

Analyze (ADDIE) → Identify goals, audience, prior knowledge, and constraints

Design (ADDIE) → Define objectives, assessment, sequencing, and modalities

Develop (ADDIE) → Build the content, activities, and assessments

Dick & Carey Model (1978) → Systems-theory approach; more prescriptive than ADDIE

SAM (2012) → Rapid, agile prototyping; explicitly iterative

Merrill's Principles (2002) → Task-centered 'first principles' of effective design

Understanding by Design (1998) → Backward design — start from desired outcomes

Step by step

Work through the five ADDIE phases in order

1. Analyze — identify learning goals, audience, existing knowledge, and constraints.
2. Design — define objectives, assessment strategy, content sequencing, and modalities.
3. Develop — build the actual content, activities, and assessments.
4. Implement — deliver the instruction to learners.
5. Evaluate — assess effectiveness, both during development and after delivery.

In modern practice, evaluation feeds back into every other phase rather than waiting until the end.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Where and in what year was ADDIE developed?

- A University of Pittsburgh's Learning Research and Development Center, 1985
- B Indiana University's Department of Instructional Systems Technology, 1978
- C Syracuse University's Center for Instructional Development, 1972
- D Florida State University's Center for Educational Technology, 1975

2. Which organization commissioned the work that produced ADDIE?

- A The U.S. Army
- B The Marine Corps
- C The Air Force
- D The U.S. Navy

3. Which ADDIE phase is where you identify goals, audience, prior knowledge, and constraints?

- A Design
- B Develop
- C Analyze
- D Implement

4. A team has just finished ADDIE's Analyze phase. Which phase comes next, and what does it involve?

- A Design — produce the content, activities, and assessments
- B Design — define objectives, assessment strategy, sequencing, and modalities
- C Develop — define objectives, assessment strategy, sequencing, and modalities
- D Develop — produce the content, activities, and assessments

5. A team has finished planning objectives and sequencing, and is now producing the actual videos, activities, and quiz items. Which ADDIE phase is this?

- A Analyze
- B Design
- C Develop
- D Implement

6. How does the Evaluate phase function in the ADDIE model?

A. It threads through all five phases, surfacing problems early rather than only at the end
B. It replaces the Analyze phase in modern iterative versions
C. It is optional and usually skipped for high-stakes compliance training
D. It is a single final gate performed only after the course is delivered

7. What is the main benefit of running ADDIE's Evaluate phase continuously?

A. The five phases blend into one cycle rather than a sequence
B. Learner delivery starts earlier rather than after the build phase
C. Thorough documentation becomes optional rather than required
D. Design flaws surface early rather than after delivery

8. Which of ADDIE's five phases is described as the continuous quality check rather than a discrete step?

A. Develop
B. Evaluate
C. Analyze
D. Implement

9. A team builds a full course and collects no feedback of any kind until after launch day. Which ADDIE principle did they violate?

A. Evaluate should thread through every phase, not act as a final gate
B. Implement should run as a continuous loop, not as a discrete delivery step
C. Develop should begin before objectives are set, not wait for Design
D. Analyze should repeat at the end of every phase, not run once up front

10. How does ADDIE's Evaluate differ from a conventional final quality gate?

A. It is cumulative, carrying its findings forward into the next project
B. It is continuous, feeding findings back into the earlier phases
C. It is prototype-led, testing rough drafts with learners before the build
D. It is front-loaded, scoping audience and constraints before any design

11. Which framework is defined by rapid, agile prototyping and explicitly iterative cycles?

A. UbD (1998)
B. ADDIE (1975)
C. ARCS (1987)
D. SAM (2012)

12. Merrill's Principles of Instruction (2002) is best described as which of the following?

A. Performance-focused design that strips out 'nice to know' content
B. Systems-based view of instruction as interacting components
C. Task-centered 'first principles' of effective design
D. Prototype-driven process built on rapid, short revision cycles

13. Which framework treats instruction as nine interacting components rather than a set of phases?

A Moore's Action Mapping
B Dick & Carey Model
C Merrill's Principles
D Understanding by Design

14. A team wants to begin from the outcomes learners should achieve, then work back to assessments and only then to instruction. Which framework fits?

A Merrill's First Principles
B Dick and Carey Model
C Understanding by Design
D Successive Approximation Model

15. Which framework-to-approach pairing is NOT correct?

A SAM (2012) — a linear, phase-by-phase process built for thorough documentation
B Merrill's Principles (2002) — a task-centered process built on first principles of effective design
C Understanding by Design (1998) — a backward-design process built back from desired outcomes
D Dick & Carey Model (1978) — a systems process built from nine interacting components

16. Which framework is built on 'backward design'?

A First Principles of Instruction (Merrill)
B Systematic Design of Instruction (Dick & Carey)
C Successive Approximation Model (Allen)
D Understanding by Design (Wiggins & McTighe)

17. Action Mapping (2008) is the work of which designer?

A Cathy Moore
B Michael Allen
C Grant Wiggins
D Robert Gagné

18. Which describes Action Mapping's defining move?

A Cycle through 'successive approximations' of a prototype in short, repeated loops
B Build every lesson on task-centered 'first principles' of effective design
C Strip out 'nice to know' content and design around what learners must do on the job
D Start from desired learning outcomes and work 'backward' to assessments, then instruction

19. A designer names the outcomes learners should achieve, then writes the assessments that would prove them, then plans the lessons. Which approach is this?

A Performance-led design
B Prototype-led design
C Task-centered design
D Backward design

20. Which statement correctly distinguishes the two approaches?

A. Backward design starts from on-the-job performance; Action Mapping starts from desired learning outcomes

B. Backward design starts from desired learning outcomes; Action Mapping starts from on-the-job performance

C. Backward design starts from rapid prototypes; Action Mapping starts from nine interacting components

D. Backward design starts from nine interacting components; Action Mapping starts from rapid prototypes

21. The Socratic method teaches primarily by which means?

A. Collaborative projects in which learners negotiate a shared interpretation

B. Worked examples that model expert reasoning before learners attempt their own

C. Reflective journals in which learners record and revisit their own reasoning

D. Strategic questions that make learners surface and examine their own reasoning

22. Who built Khanmigo to operationalize Socratic principles at scale?

A. Nick Pelling

B. David Rose

C. Sal Khan

D. John Warner

23. How is Khanmigo designed to respond when a student is stuck on a problem?

A. Set a similar problem for them to attempt on their own

B. Guide them through it with probing questions

C. Show the worked solution, then let them retry it unaided

D. Let them pick a hint, an example, or the full answer

24. Khanmigo's question-first design reflects which constructivist finding?

A. Knowledge constructed through guided questioning encodes more durably than knowledge merely received

B. Learners retain more when content matches their preferred modality

C. Giving answers immediately lowers cognitive load and so improves retention

D. Retention depends mainly on total time spent on task

25. Which is NOT characteristic of the Socratic method?

A. Pressing the learner with a run of pointed, strategic questions

B. Making the learner reach the insight through their own effort

C. Delivering the conclusion directly so the learner can memorize it

D. Forcing the learner to expose the gaps in their own reasoning

Go deeper

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LESSON 6 OF 10

Brave New Words: AI & Education

Khan's vision · Khanmigo & the debate

WHAT YOU'LL BE ABLE TO DO

- Explain the personalization problem that Khan argues AI tutoring can finally solve.
- Match Khan's three sci-fi inspirations to their educational vision and identify the work that is NOT an inspiration.
- Explain Khanmigo — its GPT-4/OpenAI basis, Socratic design, and the 'conmigo' pun behind its name.
- Recognize the book's stakes beyond K-12 and John Warner's contrarian critique of technology optimism.

Khan's vision

Salman Khan's 2024 book reframes AI not as an academic integrity crisis but as the first credible answer to a problem education has never solved: how do you give every student the benefits of a personal tutor?

Brave New Words

Brave New Words: How AI Will Revolutionize Education (and Why That's a Good Thing) (2024) is part memoir, part technology manifesto. Khan, who built **Khan Academy** from YouTube math tutorials, argues that conversational AI is not a threat to learning but potentially its greatest democratizing force. The book's title signals its thesis: the disruption is real, but the direction is positive. Khan opens with three works of speculative fiction that shaped his thinking — each imagining a world where personalized, adaptive instruction is available to any child regardless of wealth.

After November 2022

When **ChatGPT** launched in **November 2022**, the dominant response among educators was panic about cheating. Khan's reframing challenges that reaction directly. Rather than a weapon for academic dishonesty, he frames conversational AI as a patient, available-at-midnight tutor capable of following a student's reasoning, asking Socratic questions, and adjusting to their pace. The technology doesn't replace the teacher's judgment; it fills the hours between classes that previously went unsupported. The cheating panic, Khan argues, misidentifies the threat because it misidentifies the opportunity.

AI as equity engine

The deepest claim in the book concerns **equity**. Wealthy families have always been able to purchase one-on-one tutoring; students in under-resourced communities have not. This gap is not a minor inefficiency — Benjamin Bloom's **2 Sigma Problem** (1984) demonstrated that individually tutored students outperform classroom peers by two standard deviations. No systemic intervention has closed that gap at scale. Khan argues that AI can: a tutor that understands where a specific learner is, what they

know, how they learn, and what engages them has historically been available only through expensive private instruction. Making that tutor free and ubiquitous is, in his framing, the most consequential thing technology could do for human potential. Khan's three literary touchstones — *The Diamond Age* (an AI tutor transforms a poor girl's life), *Ender's Game* (challenge-driven simulation learning), and Asimov's *The Fun They Had* (a future child finds a classroom of peers exotic) — each illuminate a different facet of this vision. Notably, *Snow Crash* does **not** appear as an inspiration in the book's opening.

Khanmigo & the debate

Khan didn't just write about AI tutors — he built one. The second half of the book's argument lives in the product, the scope beyond K-12, and a genuinely mixed critical reception that reveals the fault lines in today's edtech debates.

Khan + conmigo

Khanmigo fuses "Khan" with the Spanish word **conmigo** — "with me." The name encodes the pedagogical stance: a tutor that accompanies rather than lectures. Built on **GPT-4** in partnership with **OpenAI**, Khanmigo serves as proof of concept for the book's thesis: a conversational AI that guides students toward answers through Socratic dialogue rather than supplying them directly. The design choice is deliberate and philosophically important — a system that gives the answer on demand would undermine the productive struggle that makes learning stick. Khanmigo is meant to provoke thinking, not replace it.

Beyond K-12

Brave New Words refuses to limit the argument to school-age children. Khan extends the case for AI-assisted personalized learning to **college admissions** (navigating essays, fit, and financial aid), the **workplace** (continuous upskilling without the friction of formal enrollment), and **civic participation** (an informed citizenry able to engage complex policy). The framing treats AI tutoring as **infrastructure** — not a school feature but a lifelong utility, the way electricity or the internet are not just for students. This broadens the book's stakes considerably beyond what most edtech writing attempts.

The ethical framework

Khan is not uncritical of the technology. He explicitly names the risks his own tool inherits: **hallucination** (AI generating confident falsehoods), **bias** (training data embedding historical inequities), and **privacy** (sensitive student data flowing through third-party models). His response is an argument for **responsible deployment** — transparency, human oversight, ongoing evaluation — rather than a call to wait until the risks disappear. He positions this as the same bargain educators made with earlier technologies: imperfect tools adopted carefully, not avoided indefinitely.

The contrarian review

Reception was split. **John Warner**, in *Engaged Education*, argues the book "makes no real attempt to grapple with the implications of its own argument." His critique is that Khan substitutes **technology optimism** for rigorous pedagogical evidence — believing transformation will happen because the tools are impressive, not because controlled research shows they produce learning gains. Warner's review

is not uniformly enthusiastic; it is a pointed challenge. The tension he names — between what edtech promises and what it demonstrably delivers — remains unresolved and is the central argument of the field.

Key terms

The personalization problem

Great education requires understanding where a specific learner is, what they know, how they learn, and what engages them — historically only possible with expensive private tutors. Khan argues AI can democratize this at scale.

Khanmigo

An AI tutoring assistant built on GPT-4 in collaboration with OpenAI. The name plays on "Khan" and the Spanish "conmigo" ("with me"). It uses the Socratic method, guides step-by-step, and never simply delivers answers.

Key concepts

The Diamond Age

- One of three works of speculative fiction Khan credits with shaping his vision of personalized instruction for any child.
- In its story, an AI tutor transforms the life of a poor girl.

Ender's Game

- One of three speculative-fiction works Khan names as inspiration for his 2024 book on AI and learning.
- He cites it for its vision of challenge-driven simulation learning, where students grow through immersive trials.

The Fun They Had

- An Isaac Asimov short story Khan lists among the fiction that shaped his vision of universal tutoring.
- In it, a future child finds a classroom full of human peers exotic and strange.

Key facts

> **Brave New Words**
>
> **Brave New Words: How AI Will Revolutionize Education (and Why That's a Good Thing)** (2024) by **Salman Khan** is part memoir, part technology manifesto. It frames AI not as a cheating threat but as the most powerful potential equalizer in education history — a way to give every student a world-class personal tutor.

After November 2022

When **ChatGPT** launched in **November 2022**, many educators' first response was panic about cheating. Khan's reframing runs against that reaction: rather than a threat to academic integrity, he casts conversational AI as a tutor that can finally personalize learning for everyone.



AI-generated (gpt-image-1.5)

AI as equity engine

Khan argues AI can address historical education inequity by giving students in under-resourced communities access to individualized tutoring equivalent to what wealthy families buy in private instruction. This directly targets **Bloom's 2 Sigma Problem** — the gap between tutored and classroom learners.



AI-generated (gpt-image-1.5)

What a Tutor Must Know

Khan argues an effective tutor must understand four things about a learner: where they are, what they know, how they learn, and what engages them.

Personalization's Price Tag

Historically, the kind of individual attention a great tutor provides was only available through expensive private tutoring — affordable for wealthy families but out of reach for most students.



AI-generated (gpt-image-1.5)

Khan + conmigo

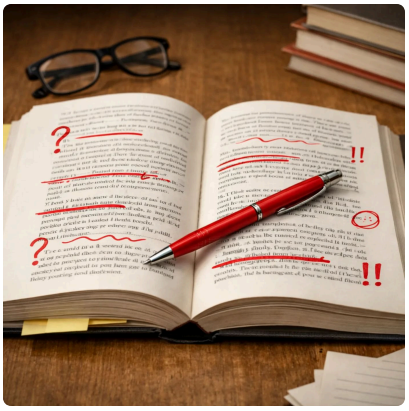
Khanmigo is a play on "Khan" and the Spanish word **conmigo** — "with me." The pun captures the pitch: a tutor that learns alongside the student rather than lecturing at them. It was built on **GPT-4** with OpenAI as Khan Academy's proof of concept.

Beyond K-12

Khan does not confine the argument to schools. **Brave New Words** explores AI's implications for **college admissions**, the **workplace**, and **civic participation** — treating personalized AI as infrastructure for learning across a whole life, not just the K-12 years.

The ethical framework

Khan does not pretend the technology is finished. He explicitly acknowledges current AI's limits — **hallucination**, **bias**, and **privacy** risks — and argues for a responsible deployment approach rather than uncritical adoption.



AI-generated (gpt-image-1.5)

The contrarian review

Reception was mixed. **John Warner**, writing in *Engaged Education*, argues the book "makes no real attempt to grapple with the implications of its own argument" — leaning on faith in technology rather than rigorous evidence. The tension between **technology optimism** and **pedagogical rigor** sits at the center of today's edtech debates.



AI-generated (gpt-image-1.5)

Built on GPT-4

Khanmigo was built on GPT-4 in partnership with OpenAI, serving as Khan Academy's proof of concept for the book's thesis.

Matched pairs

Each item on the left goes with the one on the right.

The Diamond Age (Neal Stephenson)
→ An AI tutor for a poor girl becomes her greatest educational resource

Ender's Game → Personalized, challenge-driven simulation learning

Asimov's "The Fun They Had" → A child finds a classroom of other children an exotic concept

conmigo → Spanish for "with me" — the root of Khanmigo's name

Self-test

Answer each question from memory, then check your work against the answer key.

1. According to Khan, what four things must an effective tutor understand about a learner?

- A Their grade level, test scores, attendance, and school district
- B Their reading speed, memory span, motivation, and screen time
- C Where they are, what they know, how they learn, and what engages them
- D Their IQ, learning style, family income, and career goals

2. Historically, why has the personalization problem gone unsolved for most students?

- A That level of individual attention required expensive private tutors
- B That level of individual attention arrived only with adaptive software
- C That level of individual attention was cheap but confined to elite boarding schools
- D That level of individual attention exceeded what even wealthy families could buy

3. Benjamin Bloom's 1984 finding, which Khan invokes, showed individually tutored students outperform classroom peers by how much?

- A Half a standard deviation
- B Two standard deviations
- C One standard deviation
- D Three standard deviations

4. Which is NOT part of Khan's argument about AI and the personalization problem?

- A AI can make individualized tutoring free and ubiquitous
- B AI can fill the unsupported hours between classes
- C The tutoring gap is an equity problem, not a minor inefficiency
- D AI tutoring should replace the teacher's professional judgment

5. A district gives every student 24/7 access to an AI tutor that adapts to their pace. In Khan's framing, this most directly attacks which problem?

- A The gap between what learners know and what tests can measure
- B The gap between what tutored and classroom learners achieve
- C The gap between what schools teach and what employers later need
- D The gap between what parents expect and what schools report home

6. Which of the three works opening Brave New Words imagines an AI tutor transforming a poor girl's life?

- A Snow Crash
- B Ender's Game
- C The Diamond Age
- D The Fun They Had

7. In Neal Stephenson's The Diamond Age, what educational vision inspired Khan?

- A An AI tutor becomes a poor girl's greatest educational resource
- B A gifted boy hones his strategic talent through escalating simulated battles
- C A shared virtual classroom lets children from every district learn together
- D A girl schooled by a machine at home marvels at the idea of a classroom

8. Which work supplies Khan's image of personalized, challenge-driven simulation learning?

- A The Diamond Age
- B "The Fun They Had"
- C Snow Crash
- D Ender's Game

9. Asimov's "The Fun They Had" contributes which idea to Khan's opening?

- A A future child attends a school built inside a shared virtual world
- B A future child is lifted from poverty by a machine tutor
- C A future child finds a classroom of other children exotic
- D A future child finds a gift for command through simulated battles

10. What do all three of Khan's literary touchstones have in common?

- A Each imagines personalized, adaptive instruction available to any child
- B Each imagines a child's gifts drawn out by a devoted human mentor
- C Each imagines instruction that a whole community shapes together
- D Each imagines adaptive instruction tuned to a whole class rather than one child

11. Which work is explicitly named as NOT one of Khan's three sci-fi inspirations in Brave New Words' opening?

- A The Diamond Age
- B "The Fun They Had"
- C Ender's Game
- D Snow Crash

12. Khanmigo's name fuses "Khan" with a Spanish word meaning what?

- A "Come along"
- B "With me"
- C "My friend"
- D "Teach me"

13. Khanmigo was built on which model, and with which partner?

- A Gemini, in partnership with Google
- B GPT-4, in partnership with Google
- C Gemini, in partnership with OpenAI
- D GPT-4, in partnership with OpenAI

14. Which teaching method does Khanmigo use by design?

- A Anki-style spaced repetition — scheduling each review at an expanding interval
- B Direct instruction — modelling answers through worked examples
- C The Socratic method — guiding toward answers through questions
- D The flipped classroom — assigning lessons at home and problems in class

15. Why does Khanmigo deliberately refuse to hand students the answer on demand?

A. It would undermine the productive struggle that makes learning stick
B. It would deprive the teacher of the correction that fixes a misconception
C. It would reward the quickest students at the expense of the rest
D. It would push students past the pace that their mastery data supports

16. A student asks Khanmigo for the solution to an equation. Consistent with its design, it should do what?

A. Let the student pick either a hint or the full worked solution
B. Ask a question that moves the student toward the next step
C. Walk the student through the full solution one step at a time
D. Swap in an easier equation the student can solve on their own

17. In his contrarian review, critic John Warner argues that Brave New Words is flawed because it...

A. treats hallucination, bias, and privacy as risks already engineered away
B. substitutes technology optimism for rigorous pedagogical evidence
C. urges educators to wait out the risks instead of adopting tools carefully
D. narrows the case for AI tutoring to schoolchildren and their classrooms

18. Beyond K-12, Brave New Words extends the case for AI-assisted learning to which three domains?

A. Adult literacy, immigrant integration, and jury service
B. Trade apprenticeships, the gig economy, and public health
C. College admissions, the workplace, and civic participation
D. Graduate study, professional licensing, and local government

19. Khan frames AI tutoring as "infrastructure." What does that framing claim?

A. It is an invisible background layer, like plumbing or wiring — not a visible tool
B. It is a base that other tools build on, like a power grid — not an end product
C. It is a collective investment, like highways or dams — not a private venture
D. It is a lifelong utility, like electricity or the internet — not a school feature

20. Khan answers the risks he names with a case for responsible deployment. Which three practices does that case rest on?

A. Transparency, human oversight, and ongoing evaluation
B. Informed consent, algorithmic fairness, and open access
C. Teacher autonomy, gradual rollout, and open-source models
D. Data minimization, content filtering, and equity audits

21. Warner's central charge is that Khan trades on technology optimism. Which evidence would most directly answer that charge?

(A) Peer-reviewed benchmarks showing the underlying model aces hard exams

(B) Longitudinal usage data showing students return to the tutor daily

(C) An independent survey finding students rate the tutor as helpful

(D) Controlled research showing students using the AI tutor learn more

Go deeper

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LESSON 7 OF 10

The Modern EdTech Landscape

The AI platform taxonomy · Platform deep-dives · Does AI tutoring work? · The adaptive-learning market

WHAT YOU'LL BE ABLE TO DO

- Classify AI-in-education products into the seven functional categories by what each actually does.
- Describe how the flagship platforms work — Khanmigo's Socratic method and scale, Duolingo BirdBrain, Synthesis's origin — and define adaptive learning.
- Evaluate the RCT evidence for AI tutoring, comparing LearnLM, human-tutor, and static-hint success rates and who benefits most.
- Quantify the adaptive-learning market and the major 2025 EdTech deals and investment.
- Match each named platform (Khanmigo, Duolingo, MagicSchool, Synthesis, NotebookLM) to its edtech category.

The AI platform taxonomy

The AI-in-education space has fragmented into at least seven distinct functional categories — and which category a product belongs to matters more than any surface-level "AI tutor" label.

Mapping the AI-in-education space

The easiest way to cut through the hype is to ask what a product actually *does* rather than what it claims to be. The seven categories break down by audience and function. **AI Tutors** (Khanmigo, Synthesis, LearnLM) offer adaptive, conversational 1:1 instruction — the closest digital analog to a personal teacher. **Teacher Tools** (MagicSchool, Diffit) target lesson planning, rubric generation, and administrative reduction, keeping the human educator central. **Language Learning** (Duolingo, Lingokids) uses adaptive vocabulary sequencing and conversation practice to replace rote flashcards and grammar drills. **Research Assistants** (NotebookLM, Perplexity) perform document synthesis and multi-source knowledge retrieval — Google NotebookLM is the canonical example in this category. **Enterprise / Workforce** platforms (Sana, Coursera, Udemy, Multiverse) focus on upskilling and corporate training where measurable job-readiness matters to the buyer. **Assessment & Analytics** tools (Gradescope, Eedi, MagicQuizzes) handle progress tracking and formative assessment, surfacing where a class is collectively lost. **Micro / Game Learning** (Kahoot, Blooket, Synthesis Teams) delivers game-based, challenge-driven engagement — primarily as a consolidation or motivation layer rather than primary instruction. Knowing which bucket a tool belongs to tells you what evidence to demand before adopting it, because each category has different quality benchmarks, failure modes, and instructional design assumptions.

Platform deep-dives

Five platforms illustrate the range of bets being placed on AI in education — from a Socratic K-12 tutor to a document-synthesis tool that anyone can wire into a custom learning assistant.

Khanmigo

Khanmigo is Khan Academy's AI tutor, powered by **GPT-4**. Its defining pedagogical choice is the **Socratic method**: the system is deliberately designed to refuse direct answers, instead responding with guiding questions that push students to construct understanding themselves. This approach aligns with decades of evidence that retrieval and generation outperform passive answer-reading. It's the only AI tool integrated with Khan Academy's full content library across math, humanities, coding, and social studies, and by the 2024–25 academic year it was serving **700,000 K-12 students**. Khan Academy is explicit that Khanmigo is positioned as a teacher *assistant*, not a replacement.

Duolingo: BirdBrain and Max

Duolingo's proprietary **BirdBrain** model is an adaptive learning system — software that adjusts content, sequence, and difficulty in real time based on each learner's performance history. BirdBrain orchestrates the full lesson experience; the freemium **Duolingo Max** tier (GPT-4 powered) sits on top of it, adding roleplay scenarios, an 'Explain My Answer' feature, and a **Lily** chat mode for open conversation practice. The strategic payoff beyond personalization is throughput: AI lets Duolingo expand its language library without hitting the human-content bottleneck that constrained older courseware companies.

MagicSchool AI

MagicSchool AI is a teacher-tools platform that reached **2+ million educators** and 4,000+ schools within its first year of operation — fast adoption relative to most edtech cycles. A **$45M Series B** (2025) is funding the transition from a loose "collection of tools" into a **connected teaching system**, with Studio Mode, MagicQuizzes, Class Writing Feedback, and a Knowledge layer forming the backbone. Its competitive differentiation comes from safety and district-level trust: the integrations with LMS platforms and alignment to district policies are what get it through procurement, not just feature count.

Synthesis

Synthesis was built for the SpaceX employee school and founded by Chrisman Frank. It is an adaptive **K-6 math** platform with a voice-guided interface and visual math representations, deliberately favoring conceptual understanding over rote drilling. A family subscription runs **~99/year**. By 2025 it was on pace for **10M+ in revenue**, with subscribed students up **4.5x year-over-year** — growth that suggests strong retention, not just trial-driven spikes. The SpaceX origin is notable because it explains Synthesis's design DNA: the platform was built around problem-solving and collaboration, not test prep.

Google NotebookLM

NotebookLM occupies the **Research Assistants** category. It ingests documents — PDFs, YouTube videos, web pages — and builds a source-grounded knowledge base that users can query for synthesis, chat, and multi-modal output including text summaries, audio podcasts, and slide outlines. The key technical characteristic is that responses are **grounded in the provided sources**, which substantially reduces hallucination risk compared to general-purpose LLM chat for domain-specific work. Builders use

it to spin up custom learning assistants around proprietary material without needing to fine-tune a model — making it unusually accessible for institutions that can't afford custom AI development.

Does AI tutoring work?

The evidence base is growing faster than it can be properly synthesized — but three rigorous studies from 2024–2026 and one broad meta-analysis give the clearest picture so far.

What the meta-analysis shows

Broad meta-analyses of **adaptive AI systems** find that they can cut learning time by **30–50%** while improving outcomes by **15–25%** compared with traditional instruction. Some analyses report larger gains where adaptive systems can switch representation formats, which a single teacher presenting to thirty students cannot easily do, though evidence that matching instruction to a learner's preferred style helps is weak. The important caveat: most underlying studies are short-term and subject-specific. The long-term effects of AI tutoring on **motivation, metacognition, and transfer learning** — whether students can apply skills in new contexts — remain open questions that current research does not yet establish.

The LearnLM RCT

In a 2025 **randomized controlled trial** run by Google and Eedi Labs, 165 students aged 13–15 were assigned to one of three conditions: a human tutor, an AI tutor (Google's **LearnLM**), or static hints. Human tutors reviewing LearnLM's responses approved **76.4%** with little or no edits — a quality signal. On subsequent harder topics, LearnLM students achieved a **66% success rate**, compared with **61%** for the human-tutor group and **56%** for the static-hints group. An **intelligent tutoring system** — software that models both the subject and the learner's evolving understanding to deliver individualized feedback — is what makes this performance possible.

Stanford's Tutor CoPilot

Stanford's 2024 **Tutor CoPilot** RCT took a different lever: instead of replacing human tutors, it coached them in real time. Across 900 tutors and 1,800 K-12 students, those whose tutors received AI assistance were **4 percentage points** more likely to reach topic mastery. The effect was not uniform — students paired with **lower-rated tutors** saw gains of **9 percentage points**. The mechanism is meaningful: AI coaching raised the floor of tutor quality, compressing the skill gap between novice and experienced tutors. The study suggests the highest ROI from AI may be in *human augmentation* rather than human replacement.

The Brookings finding

A **2026 Brookings Institution** analysis found that students using an AI tutor achieved **more than double** the learning gains relative to their pre-test baseline compared with the control group — a large effect by educational research norms. This aligns with a 2025 *Scientific Reports* RCT in which AI tutoring outperformed in-class **active learning** at an effect size of **0.73**, which is high by the standards of education research (where effects above 0.4 are typically considered meaningful). Together the

Brookings and Scientific Reports results suggest the signal is not limited to a single study design or subject area.

The adaptive-learning market

Beneath the product demos is a capital market making large directional bets — and the size and shape of 2025 funding reveals which problems investors think are real.

The adaptive-learning market

The **adaptive learning platform market** was valued at **1.72 billion in 2025** and is projected to reach **5.47 billion by 2032** — roughly a 3× expansion over seven years. That growth rate implies sustained double-digit annual expansion, which historically requires either a persistent technology unlock (AI plausibly qualifies) or a regulatory mandate driving adoption. Global **EdTech investment** hit **$2.6 billion in 2025**, up roughly **11%** over 2024. The growth is not broad-based: capital is concentrating in AI-enabled products and workforce-aligned platforms, while traditional courseware companies without clear AI integration are finding the fundraising environment tighter.

Where the 2025 money went

By deal volume, 2025 EdTech investment split across four segments: **workforce training 38%**, **K-12 36%**, **post-secondary 22%**, and **early childhood 4%**. The two largest deals of the year illustrate the workforce-training dominance. Workday acquired **Sana** for **1.1 billion**, embedding an AI-native learning platform directly into the enterprise HR stack — the clearest sign that corporate upskilling is converging with the broader HCM software market. In December 2025, **Coursera** agreed to acquire **Udemy** in an all-stock deal that values the combined company at about **2.5 billion**, creating a combined platform with **290 million learners** and **18,000 enterprise customers**.

The 2026 outlook

Capital in 2026 is expected to stay **disciplined**, shifting away from raw engagement metrics toward products that demonstrate **measurable outcomes** — completion rates, job placement, skill-assessment gains. The architectural preference is for **workflow-embedded, agentic AI**: tools that sit inside the systems people already use (LMSs, HCMs, IDE-style environments) rather than standalone apps requiring separate logins. The long backdrop is substantial: **Owl Ventures** projects the global education market will surpass **$10 trillion by 2030**, which means even a small share of a digitized, AI-mediated slice of that market represents a large absolute opportunity and justifies the current platform-building sprint.

Key terms

Adaptive learning system

Software that adjusts the content, sequence, and difficulty of instruction in real time based on each learner's performance history.

Intelligent tutoring system

A computer system that delivers individualized instruction and feedback, modeling both the subject and the learner's evolving understanding to guide them like a one-on-one tutor.

Key concepts

Khanmigo

- An AI tutor deliberately built to refuse direct answers, instead responding with guiding questions that push students to construct understanding.
- Powered by GPT-4, it is integrated with a full K-12 content library spanning math, humanities, coding, and social studies.
- Positioned as a teacher assistant, not a replacement, by 2024–25 it was serving 700,000 K-12 students.

Duolingo

- A popular language-learning app whose proprietary adaptive model orchestrates the entire lesson experience.
- That adaptive engine is called BirdBrain; a GPT-4-powered premium tier adds roleplay and an 'Explain My Answer' feature.
- Its premium tier, Max, includes a 'Lily' chat mode for open-ended conversation practice.

MagicSchool AI

- A teacher-tools platform for lesson planning, rubric generation, and cutting administrative work, keeping the educator central.
- It reached over 2 million educators and 4,000+ institutions within its first year — fast adoption by edtech standards.
- A $45M Series B in 2025 funds its shift from a loose collection of tools into a connected teaching system, winning procurement via safety and district-policy alignment.

Synthesis

- An adaptive K-6 math platform with a voice-guided interface that favors conceptual understanding over rote drilling.
- Founded by Chrisman Frank, it was originally built for the SpaceX employee school.
- A ~$99/year family subscription; by 2025 it was on pace for $10M+ revenue, with subscribed students up 4.5x year-over-year.

Google NotebookLM

- The canonical example of the 'Research Assistants' category in the AI-in-education taxonomy.
- It ingests documents — PDFs, YouTube videos, web pages — to build a source-grounded knowledge base you can query.
- Because its answers stay grounded in your provided sources, builders use it to spin up custom learning assistants without fine-tuning; outputs include audio podcasts and slide outlines.

Key facts

Research Assistants category

Google NotebookLM ingests documents to build a research-grounded knowledge base, placing it in the Research Assistants category alongside Perplexity.

Teacher Tools category

MagicSchool and Diffit lead the Teacher Tools category, which keeps the human educator central by handling lesson planning, rubric generation, and administrative reduction.

Enterprise/Workforce learning platforms

Sana, Coursera, Udemy, and Multiverse are named players in the Enterprise / Workforce category, which focuses on upskilling and corporate training where measurable job-readiness matters to the buyer.

AI Tutors category

AI Tutors is the category defined as adaptive, conversational one-to-one instruction — the closest digital analog to a personal teacher.

MagicSchool AI

MagicSchool AI reached **2+ million educators** and 4,000+ schools within its first year, backed by a **$45M Series B** (2025). It is evolving from a 'collection of tools' into a 'connected teaching system' — Studio Mode, MagicQuizzes, Class Writing Feedback, and Knowledge. Safety, district alignment, and LMS integrations are its core differentiators.

Synthesis

Synthesis was built for the SpaceX employee school and founded by Chrisman Frank. It's an adaptive **K-6 math** platform with a voice-guided interface and visual math representations, favoring conceptual understanding over rote drilling. A family subscription runs **~99/year**. It's on pace for **10M+ revenue** in 2025, with subscribed students up **4.5x** year-over-year.

Google NotebookLM

NotebookLM ingests documents — PDFs, YouTube, web pages — and builds a research-grounded knowledge base for chat, synthesis, and multi-modal output (text, audio podcasts, slides). Its key trait: outputs are **grounded in the provided sources**, which reduces hallucination for domain-specific synthesis. Builders use it to spin up custom learning assistants without fine-tuning a model.

What the meta-analysis shows

Broad meta-analysis finds that adaptive AI systems can **cut learning time by 30–50%** while **improving outcomes by 15–25%** versus traditional instruction. Visual and kinesthetic learners show the most substantial gains. The big caveat: most studies are short-term and subject-specific — long-term effects on motivation, metacognition, and transfer are still open questions.

The LearnLM RCT

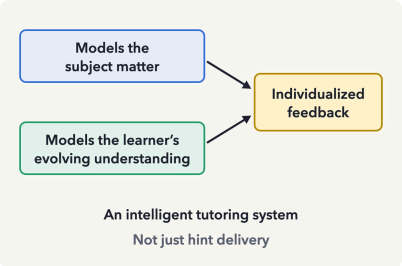
In Google/Eedi Labs' 2025 randomized trial, 165 students aged 13–15 were assigned to a human tutor, an AI tutor (**LearnLM**), or static hints. Human tutors approved 76.4% of LearnLM's responses with little or no edits. LearnLM students hit a **66% success rate** on subsequent harder topics — versus **61%** (human tutor) and **56%** (static hints).

Stanford's Tutor CoPilot

Stanford's 2024 **Tutor CoPilot** RCT put an AI tool coaching 1,000 elementary students' human tutors in real time. Students with AI-assisted tutors were **4 percentage points** more likely to reach topic mastery — and gains rose to **9 points** for students paired with less-experienced tutors. The AI raised the *floor* of tutor quality.

The Brookings finding

A 2026 Brookings Institution analysis reported that students using the AI tutor achieved **more than double** the learning gains relative to the pre-test baseline compared with the control group. Pair this with a 2025 Scientific Reports RCT where AI tutoring outperformed in-class active learning at an effect size of 0.73 — high by educational standards.



FlashFeed original diagram · CC-BY-4.0

Intelligent tutoring's dual model

An intelligent tutoring system distinguishes itself from a simple hint-delivery tool by modeling both the subject matter and the learner's evolving understanding, enabling individualized feedback.

The adaptive-learning market

The adaptive learning platform market was valued at **1.72 billion in 2025** and is expected to reach **5.47 billion by 2032**. Global EdTech investment hit **$2.6 billion in 2025**, up roughly 11% over 2024, with capital concentrating in AI-enabled products and workforce-aligned platforms.

Where the 2025 money went

By deal volume, 2025 EdTech investment split: **workforce training 38%**, **K-12 36%**, **post-secondary 22%**, and **early childhood 4%**. Notable deals: Workday acquired Sana for 1.1B, and Coursera's 2.5B all-stock acquisition of Udemy created a combined platform of 290 million learners and 18,000 enterprise customers.

The 2026 outlook

Capital in 2026 is expected to stay disciplined — favoring **workflow-embedded, agentic AI** and solutions that deliver **measurable outcomes** over raw engagement. Owl Ventures projects the global education market will surpass **$10 trillion by 2030**, the long backdrop against which today's AI-platform race is playing out.

> **EdTech investment hits $2.6B**
> Global EdTech investment reached $2.6 billion in 2025, up roughly 11% over 2024, with capital concentrating in AI-enabled and workforce-aligned products.

> **2025's two headline deals**
> The year's two biggest EdTech deals were Workday's 1.1 billion acquisition of Sana and Coursera's 2.5 billion all-stock acquisition of Udemy.

By the numbers

K-12 students using Khanmigo in the 2024–25 academic year
700000 students

LearnLM students' success rate on harder follow-up topics (2025 RCT)
66 %

Human-tutor group's success rate in the LearnLM RCT
61 %

Static-hints group's success rate in the LearnLM RCT
56 %

Value of the adaptive learning platform market in 2025
1720000000 USD

Projected adaptive learning platform market value by 2032
5470000000 USD

Total global EdTech investment in 2025
2600000000 USD

Price Workday paid to acquire Sana
1100000000 USD

Value of the Coursera–Udemy all-stock acquisition (Dec 2025)
2500000000 USD

Matched pairs

Each item on the left goes with the one on the right.

AI Tutors → Adaptive, conversational 1:1 instruction (Khanmigo, Synthesis, LearnLM)

Teacher Tools → Lesson planning, rubric generation, admin reduction (MagicSchool, Diffit)

Language Learning → Adaptive vocabulary and conversation practice (Duolingo, Lingokids)

Research Assistants → Document synthesis, multi-source knowledge (NotebookLM, Perplexity)

Enterprise / Workforce → Upskilling and corporate training (Sana, Coursera+Udemy, Multiverse)

Assessment & Analytics → Progress tracking, formative assessment (Gradescope, Eedi, MagicQuizzes)

Micro / Game Learning → Game-based, challenge-driven learning (Kahoot, Blooket, Synthesis Teams)

Duolingo BirdBrain → Proprietary AI that sequences and personalizes lessons from performance history

Self-test

Answer each question from memory, then check your work against the answer key.

1. Which function defines the Teacher Tools category, whose leading players include MagicSchool and Diffit?

- A Document synthesis, source grounding, and knowledge retrieval
- B Lesson planning, rubric generation, and admin reduction
- C Progress tracking, formative assessment, and class analytics
- D Adaptive dialogue, one-to-one tutoring, and pace adjustment

2. Sana, Coursera, Udemy, and Multiverse are the named players in which category?

- A Enterprise / Workforce
- B Micro / Game Learning
- C Assessment & Analytics
- D Research Assistants

3. Which three products fall in the AI Tutors category — adaptive, conversational 1:1 instruction?

- A Duolingo, Lingokids, and Kahoot
- B Gradescope, Eedi, and MagicQuizzes
- C Khanmigo, Synthesis, and LearnLM
- D MagicSchool, Diffit, and Perplexity

4. What function does the Assessment & Analytics category (Gradescope, Eedi, MagicQuizzes) serve?

- A Adaptive vocabulary sequencing that replaces rote grammar drills
- B Game-based challenges that consolidate lessons after instruction
- C Document synthesis that grounds answers in the provided sources
- D Progress tracking that surfaces where a class is collectively lost

5. A school adopts Kahoot and Blooket for quick, competitive review rounds after direct instruction. Which category is that, and what role does it serve?

- A AI Tutors — a primary instruction and adaptive dialogue layer
- B Teacher Tools — a lesson-planning and admin-reduction layer
- C Micro / Game Learning — a consolidation and motivation layer
- D Enterprise / Workforce — a job-readiness and upskilling layer

6. What teaching approach does Khanmigo use?

- A Direct explanation with immediate answers
- B The Socratic method of questioning
- C Worked examples followed by graded drills
- D The jigsaw method of peer teaching

7. Where did Synthesis originate?

A Built for the SpaceX employee school
B Spun out of the Khan Academy content team
C Developed inside a Google research lab
D Grown from a Duolingo internal project

8. How many K-12 students was Khanmigo serving by the 2024–25 academic year?

A 250,000
B 2,000,000
C 1,500,000
D 700,000

9. Which of these is handled by Duolingo's proprietary BirdBrain model rather than by the GPT-4-powered Max tier?

A Explaining why a learner's submitted answer was right or wrong
B Running open conversation practice through a chat character
C Staging roleplay scenarios for situational language practice
D Sequencing and personalizing lessons from performance history

10. Which definition matches an adaptive learning system?

A Software that drafts lesson plans, rubrics, and quizzes to cut a teacher's administrative load
B Software that scores work, tracks progress, and shows where a class is collectively lost
C Software that adjusts content, sequence, and difficulty in real time from performance history
D Software that grounds every answer in user-supplied documents and returns summaries or audio

11. What is the name of Duolingo's proprietary adaptive learning model?

A Lily
B BirdBrain
C LearnLM
D Max

12. What does Duolingo's BirdBrain system primarily do?

A Adjusts content, sequence, and difficulty in real time
B Grades essays against a rubric
C Generates audio podcasts from documents
D Provides roleplay scenarios via GPT-4

13. Synthesis, the K-6 math platform, was originally built for which organization's employee school?

A OpenAI
B Khan Academy
C SpaceX
D Google

14. Who founded Synthesis, the K-6 math platform?

A Martin Dougiamas
B Nick Pelling
C Salman Khan
D Chrisman Frank

15. Who benefited most from Stanford's Tutor CoPilot?

A Students paired with less-experienced tutors
B Students paired with the most experienced tutors
C Students working with the AI tutor on their own
D Students whose tutors were coached only after sessions

16. In the 2025 Google/Eedi Labs RCT, what success rate did LearnLM students reach on subsequent harder topics?

A 61%
B 66%
C 56%
D 76%

17. In the LearnLM RCT, what did the 76.4% figure measure?

A LearnLM responses human tutors approved with little or no edits
B Students who completed the full trial
C Students who preferred the AI tutor to a human tutor
D Questions LearnLM answered without a factual error

18. What distinguishes an intelligent tutoring system from a simple hint-delivery tool?

A It routes each learner's question to a human tutor and stores the reply
B It models the subject and infers each learner's level from the class average
C It models both the subject and the learner's evolving understanding
D It times each learner's responses and reorders a shared hint sequence to match

19. Rank the three LearnLM RCT conditions from highest to lowest success rate on harder follow-up topics.

A Human tutor, AI tutor, static hints
B AI tutor, human tutor, static hints
C Human tutor, static hints, AI tutor
D AI tutor, static hints, human tutor

20. By deal volume, which segment captured the largest share of 2025 EdTech investment?

A K-12 education
B Early childhood
C Post-secondary
D Workforce training

21. What was the adaptive learning platform market valued at in 2025, and what is it projected to reach by 2032?

A $1.72 billion → $5.47 billion
B $2.6 billion → $5.47 billion
C $1.72 billion → $10.7 billion
D $2.6 billion → $10.7 billion

22. Global EdTech investment in 2025 hit $2.6 billion. Roughly how much was that up over 2024?

A About 22%
B About 38%
C About 11%
D About 4%

23. Which pairing of 2025's two headline deals with their values is correct?

A Workday–Sana $2.5B; Coursera–Udemy $1.1B
B Workday–Sana $1.72B; Coursera–Udemy $2.6B
C Workday–Sana $2.6B; Coursera–Udemy $1.72B
D Workday–Sana $1.1B; Coursera–Udemy $2.5B

24. The Coursera–Udemy acquisition created a combined platform of what scale?

A 290 million learners and 28,000 enterprise customers
B 290 million learners and 18,000 enterprise customers
C 180 million learners and 28,000 enterprise customers
D 180 million learners and 18,000 enterprise customers

25. What was global EdTech investment in 2025?

A $2.6 billion
B $1.1 billion
C $1.72 billion
D $5.47 billion

26. By roughly how much did global EdTech investment grow in 2025 versus 2024?

A 25%
B 50%
C 30%
D 11%

27. Which category does Google NotebookLM belong to?

A LMS Infrastructure
B Teacher Tools
C Research Assistants
D AI Tutors

28. Synthesis is categorized under AI Tutors. Which category does Synthesis Teams fall under?

A Enterprise / Workforce
B Micro / Game Learning
C Assessment & Analytics
D Research Assistants

29. MagicSchool AI sits in the same category as which other named platform?

A Eedi
B Diffit
C Sana
D Kahoot

30. A parent wants an app that adapts vocabulary from their child's performance history and replaces rote grammar drills with conversation practice. Which platform fits?

A Duolingo — Language Learning
B Gradescope — Assessment & Analytics
C Sana — Enterprise / Workforce
D Blooket — Micro / Game Learning

31. Which platform-to-category pairing is correct?

A Gradescope — Teacher Tools
B Kahoot — Assessment & Analytics
C Perplexity — Research Assistants
D Duolingo — Micro / Game Learning

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/learning-theory/the-modern-edtech-landscape

STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

LESSON 8 OF 10

LMS, Standards & Gamification

LMS history & leaders · Interoperability standards · Gamification & motivation

WHAT YOU'LL BE ABLE TO DO

- Sequence the milestone years of LMS evolution — Pressey's machine, PLATO, SCORM, and Moodle.
- Recognize the major LMS platforms (PLATO, Moodle, Canvas, Blackboard) and Canvas's rise over Blackboard.
- Distinguish SCORM from xAPI and explain the role of the Learning Record Store, including xAPI's Actor-Verb-Object statements.
- Define gamification and match its key thinkers to their works, including the mechanic that reframes failure as information.
- Explain Self-Determination Theory's three needs and autotelic, intrinsic motivation.

LMS history & leaders

The **Learning Management System** didn't appear with the web — its roots are mechanical, and its evolution tracks every major shift in educational technology across a century.

A century of teaching machines

The LMS lineage begins with Sidney **Pressey**'s mechanical teaching machine in **1924**: a typewriter-sized device that presented multiple-choice questions and advanced only when the learner answered correctly, embedding the idea of immediate corrective feedback decades before it had a name. The next landmark arrived in **1960** when Donald **Bitzer** launched **PLATO** (Programmed Logic for Automated Teaching Operations) at the University of Illinois — a mainframe-based system that supported simultaneous users, touchscreen interaction, and early forms of online community, anticipating every major feature of modern e-learning by thirty years.

The public web brought the first generation of web-based course systems in the 1990s, but interoperability was chaos until **SCORM** (Sharable Content Object Reference Model) debuted as version 1.0 in **2000**, with the widely-adopted SCORM 1.2 arriving in **2001** — together giving vendors a common language for packaging and tracking learning content across platforms. A year later, in **2002**, Martin Dougiamas released **Moodle** as open-source software, shifting power toward institutions that couldn't or wouldn't pay enterprise licensing fees. Moodle's constructivist design philosophy and zero cost made it the dominant LMS in international higher education.

The 2010s brought cloud and SaaS consolidation. **Canvas** (Instructure), noted for its clean, instruction-friendly interface, steadily took market share from the long-entrenched **Blackboard**, whose reputation for clunky UX and aggressive pricing created openings for nimbler competitors. The subsequent **xAPI** (Tin Can) era extended tracking beyond the LMS boundary — logging learning activity in simulations,

mobile apps, and the physical world. AI-integrated systems in the 2020s use that data for adaptive pathways and predictive analytics.

The through-line: every era's LMS reflects the dominant delivery technology — mechanical, mainframe, web, cloud, AI — and each transition reshuffled the vendor landscape.

Interoperability standards

Learning platforms need shared rules for exchanging content and records. **SCORM** and **xAPI** define most of that exchange, and xAPI adds a separate store for the records it produces.

SCORM and xAPI

SCORM (Sharable Content Object Reference Model), introduced as version 1.0 in 2000 and widely adopted as version 1.2 in 2001, gave vendors a common language for packaging and tracking learning content across LMS platforms. Its keeper is the **Advanced Distributed Learning (ADL) Initiative** of the U.S. Department of Defense. When ADL asked for ideas for the next generation of SCORM, the research effort **Project Tin Can**, delivered by Rustici Software, produced what was first called the Tin Can API and is now the **Experience API (xAPI)**; version 1.0.0 was released on April 26, 2013. In 2023 the IEEE approved xAPI as a standard (IEEE 9274.1.1-2023) for tracking data about the experiences a person has, online and offline: in a course, in a simulation or mobile app, or on the job.

Statements and the Learning Record Store

xAPI records each experience as a **statement**. Every statement must contain an **actor**, a **verb** and an **object**: the "I", "did" and "this" in "I did this", as in "a learner completed a fire-drill simulation." The application that tracks the experience, called a **Learning Record Provider**, sends statements to a **Learning Record Store (LRS)**: a server responsible for receiving, storing and providing access to learning records. Other authorized systems then read those records from the LRS for reporting and analytics. An LRS can stand alone or sit inside an LMS, and one LRS can share statements with another. The contrast with SCORM is scope: SCORM packages and tracks content across LMS platforms, while xAPI statements can come from any learning context and collect in an LRS.

Gamification & motivation

Gamification is younger as a buzzword than as a practice — and understanding the motivation theory underneath it matters more than collecting points and badges.

Older than the buzzword

Nick Pelling coined the term *gamification* in 2002, but the intellectual groundwork was laid earlier. **Thomas Malone**'s 1980 research asked what made early computer games intrinsically engaging and identified challenge, fantasy, and curiosity as the core drivers — arguably the first academic attempt to reverse-engineer game motivation for instructional use. **Jesse Schell**'s 2010 DICE conference talk predicted game elements would penetrate everyday life far beyond entertainment. **Jane McGonigal**'s *Reality Is Broken* (2011) made the cultural case that games were better at motivating people than real-

world institutions, and that **mastery framing** — treating failure as information rather than judgment — is what keeps players returning after defeat. **Karl Kapp** codified the instructional design angle in *The Gamification of Learning and Instruction* (2012). The rules layer comes from **Salen & Zimmerman**'s *Rules of Play* (2003), the canonical game-design text that defined games as systems in which players engage in artificial conflict defined by rules.

Self-Determination Theory and autotelic activity

The most durable motivational account behind gamification is **Self-Determination Theory (SDT)**, developed by Edward **Deci** and Richard **Ryan** in 1985. SDT names three basic psychological needs that sustain intrinsic motivation: **autonomy** (feeling in control of one's actions), **competence** (feeling effective), and **relatedness** (feeling connected to others). Well-designed game mechanics address all three — choice of path satisfies autonomy, progressive difficulty satisfies competence, cooperative or competitive play satisfies relatedness.

An **autotelic activity** is one that is intrinsically rewarding — done for its own sake, not for an external payoff. Csikszentmihalyi's concept of **flow** describes the peak state that emerges from autotelic engagement: full absorption when challenge matches skill. The cautionary corollary is the **overjustification effect**: introducing external rewards (points, prizes) for an already-intrinsically-motivating task can undermine that intrinsic motivation. External rewards do not reliably increase intrinsic motivation — this is one of the most replicated findings in motivational psychology and a known risk in shallow gamification implementations.

Key terms

SCORM

The 2001 interoperability standard that gave vendors a common language for packaging and tracking learning content across platforms.

xAPI / Tin Can API

A learning-data interoperability standard that captures experience statements across all learning contexts, not just the LMS.

LRS (Learning Record Store)

The server that receives, stores and gives access to xAPI statements; it can stand alone or sit inside an LMS.

Gamification

The application of game design elements — points, badges, leaderboards, levels, narrative, challenges — to non-game contexts to increase engagement and motivation. Term coined by Nick Pelling in 2002.

Self-Determination Theory (SDT)

Deci & Ryan's theory (1985) naming three basic psychological needs for intrinsic motivation: autonomy, competence, and relatedness. A framework for engagement and gamification design.

Autotelic activity

An activity that is intrinsically rewarding — done for its own sake, not for an external payoff. Central to Csikszentmihalyi's concept of flow, the peak state of full absorption when challenge matches skill.

Key concepts

PLATO

- Launched in 1960 at the University of Illinois, a mainframe system that anticipated modern e-learning by roughly thirty years.
- Created by Donald Bitzer, it supported simultaneous users, touchscreen interaction, and early online community.
- Its name is an acronym: Programmed Logic for Automated Teaching Operations.

Moodle

- Released in 2002 as open-source software, it shifted power toward institutions unwilling to pay enterprise licensing fees.
- Created by Martin Dougiamas, its constructivist design philosophy and zero cost drove wide adoption.
- It became the dominant learning management system in international higher education.

Canvas

- A cloud- and SaaS-era learning platform noted for its clean, instruction-friendly interface.
- Made by Instructure, it steadily gained market share during the 2010s consolidation.
- It won share from a long-entrenched incumbent whose clunky UX and aggressive pricing left openings.

Blackboard

- For years the long-entrenched, dominant learning management system before cloud-era rivals emerged.
- Its reputation for clunky UX and aggressive pricing created openings for nimbler competitors.
- During the 2010s it steadily lost market share to Instructure's cleaner, instruction-friendly platform.

Key facts

> **A century of teaching machines**
>
> The **LMS** lineage runs back further than the web. It starts with Sidney Pressey's mechanical **teaching machine** (1924), continues through **PLATO** computer-based training (1960, Dr. Donald Bitzer), web-based systems in the 1990s, **Moodle**'s open-source release (2002), the cloud/SaaS era (2010s), the xAPI/analytics era, and AI-integrated systems in the 2020s.

Canvas overtakes Blackboard

Canvas has earned a reputation as instruction-friendly and has been steadily taking market share from Blackboard, even as Moodle remains the leading open-source LMS and Brightspace holds its own.

PLATO's 1960 debut

Donald Bitzer launched PLATO at the University of Illinois in 1960 — a mainframe system with simultaneous users and touchscreens, anticipating modern e-learning by thirty years.

LMS history, in sequence

The LMS timeline runs Pressey's machine (1924), then PLATO (1960), then SCORM (2001), then Moodle (2002) — SCORM arrives decades after PLATO, not before it.

Canvas's maker: Instructure

Canvas is built by Instructure — not to be confused with Blackboard Inc., which makes the rival product, or Moodle, which came from Martin Dougiamas.

Older than the buzzword

Nick Pelling coined *gamification* in 2002, but its educational roots are older: **Thomas Malone's** 1980 study on intrinsically motivating computer games asked what actually makes games engaging. **Jesse Schell**'s 2010 DICE talk predicted game elements would invade everyday life; **Jane McGonigal**'s *Reality Is Broken* (2011) argued we should harness gamer motivation for real-world problems.

Failure as feedback

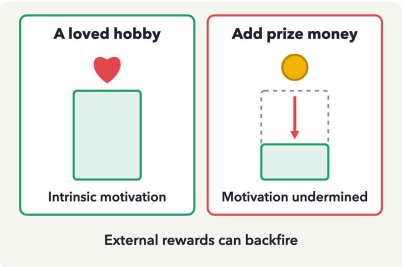
Mastery framing is the core game mechanic that reframes failure as information rather than judgment — treating a wrong answer as feedback, not a verdict on the learner.

What gamification really means

Gamification means applying game design elements — points, badges, leaderboards, levels, narrative — to non-game contexts to boost engagement, not building actual games.

SDT's three core needs

Self-Determination Theory names autonomy, competence, and relatedness as its three basic psychological needs — not points and badges, which are surface mechanics, not needs.



FlashFeed original diagram · CC-BY-4.0

The overjustification effect

Adding prize money to a hobby someone already loves can backfire — the overjustification effect describes how external rewards for an already-intrinsically-motivating task can undermine that intrinsic motivation.

By the numbers

Year Sidney Pressey built his mechanical teaching machine

1924 year

Year PLATO computer-based training launched (Donald Bitzer)

1960 year

Year the SCORM interoperability standard was introduced

2001 year

Year Moodle was released as an open-source LMS

2002 year

Matched pairs

Each item on the left goes with the one on the right.

SCORM → Packaging and tracking content across platforms

xAPI → Tracking beyond the LMS, in simulations and apps

LRS → Backend store for xAPI statements

Jesse Schell → 2010 DICE talk: game elements will invade everyday life

Jane McGonigal → Reality Is Broken (2011)

Karl Kapp → The Gamification of Learning and Instruction (2012)

Salen & Zimmerman → Rules of Play (2003)

Step by step

Trace the evolution of the learning management system, earliest to latest

1. Pressey's mechanical teaching machine (1924)
2. PLATO computer-based training (1960, Donald Bitzer)
3. Web-based LMS (1990s)
4. Moodle open-source LMS (2002)
5. Cloud / SaaS LMS era (2010s)
6. xAPI / analytics era (mid-2010s)
7. AI-integrated systems (2020s)

The throughline is the same instinct across a century: automate the delivery, tracking, and adaptation of instruction.

Self-test

Answer each question from memory, then check your work against the answer key.

1. In what year did Sidney Pressey build his mechanical teaching machine?

A 1954
B 1924
C 1912
D 1938

2. Donald Bitzer launched PLATO at the University of Illinois in which year?

A 1970
B 1950
C 1960
D 1980

3. In what year did Martin Dougiamas release Moodle as open-source software?

A 1998
B 2006
C 2011
D 2002

4. Which sequence puts the LMS milestones in correct chronological order?

A Pressey's machine → PLATO → SCORM → Moodle
B PLATO → Pressey's machine → SCORM → Moodle
C PLATO → Pressey's machine → Moodle → SCORM
D Pressey's machine → PLATO → Moodle → SCORM

5. Roughly how many years separate Pressey's teaching machine from the launch of PLATO?

A 22 years
B 61 years
C 48 years
D 36 years

6. Which LMS is noted for being instruction-friendly and gaining market share from Blackboard?

A Schoology
B Moodle
C Canvas
D Brightspace

7. Which LMS was released as open-source software and became dominant in international higher education?

A Canvas
B Moodle
C Blackboard
D PLATO

8. Which platform's reputation for clunky UX and aggressive pricing created openings for nimbler competitors?

A Blackboard
B PLATO
C Canvas
D Moodle

9. Which company makes Canvas?

A McGraw Hill
B Blackboard
C PowerSchool
D Instructure

10. Which delivery-technology era does PLATO belong to?

A The public-web era
B The mechanical era
C The mainframe era
D The cloud/SaaS era

11. What did the xAPI (Tin Can) era add that SCORM did not track?

A Immediate corrective feedback on every multiple-choice answer
B Learning activity in simulations, apps, and the physical world
C A common language for packaging content across different LMS platforms
D Simultaneous users and touchscreen interaction on a mainframe

12. What does SCORM stand for?

A Sharable Content Object Reference Model
B Sharable Content Object Runtime Manifest
C Sharable Content Organization Reference Manifest
D Sharable Content Organization Runtime Model

13. What did SCORM give the LMS field once version 1.2 was widely adopted in 2001?

A A common language for packaging and tracking content across LMSs
B Simultaneous users and touchscreen interaction on a mainframe
C Immediate corrective feedback on every multiple-choice answer
D Open-source course software free of enterprise licensing fees

14. Which era extended LMS tracking beyond the LMS boundary itself?

A The Pressey teaching-machine era
B The xAPI (Tin Can) era
C The PLATO mainframe era
D The SCORM era

15. A firefighter completes a live drill with no LMS involved and the activity is logged. Which standard makes this possible?

A Moodle
B SCORM
C Canvas (Instructure)
D xAPI (Tin Can)

16. Which of these did SCORM track?

A Learning activity tracked in the physical world
B Learning activity logged in simulations and mobile apps, beyond the LMS
C Content packaged and tracked consistently across different LMSs
D A three-need theory behind intrinsic motivation

17. Which scenario best fits what the xAPI (Tin Can) era added?

A. A course package copied from one LMS to another
B. A workshop simulation completed away from any LMS
C. A quiz score recorded inside a single course module
D. A completion flag set when a course module finishes

18. A flight simulator sends xAPI statements about each training run. Which component receives and stores them?

A. A Learning Record Store
B. A SCORM content package
C. A PLATO terminal
D. The Learning Record Provider

19. Every xAPI statement must contain which three parts?

A. Actor, result and context
B. Package, manifest and score
C. Provider, store and LMS
D. Actor, verb and object

20. Which core game mechanic reframes failure as information rather than judgment?

A. Narrative framing
B. Scaffolded difficulty
C. Mastery framing
D. Social connection

21. Who coined the term "gamification," and in what year?

A. Thomas Malone, 1980
B. Karl Kapp, 2012
C. Nick Pelling, 2002
D. Jane McGonigal, 2011

22. Gamification is best defined as which of the following?

A. Designing systems in which players engage in artificial conflict defined by rules
B. Identifying which features make computer games intrinsically engaging
C. Building full-fledged video games to deliver instruction in classrooms
D. Applying game design elements to non-game contexts to boost engagement

23. Match the thinker to the work: who wrote Reality Is Broken (2011)?

A. Jane McGonigal
B. Nick Pelling
C. Jesse Schell
D. Karl Kapp

24. Which pairing of thinker and contribution is INCORRECT?

A. Jane McGonigal — Reality Is Broken (2011)
B. Thomas Malone — Rules of Play (2003)
C. Jesse Schell — DICE conference talk (2010)
D. Deci & Ryan — Self-Determination Theory (1985)

25. Who developed Self-Determination Theory, and in what year?

A. Malone, 1980
B. Deci & Ryan, 1985
C. Salen & Zimmerman, 2003
D. Pelling, 2002

26. Which trio names SDT's three basic psychological needs?

A Points, badges, leaderboards
B Challenge, fantasy, curiosity
C Attention, relevance, satisfaction
D Autonomy, competence, relatedness

27. Letting a learner choose their own path through a course primarily satisfies which SDT need?

A Autonomy
B Competence
C Relatedness
D Curiosity

28. What is an autotelic activity?

A One that is externally rewarded, pursued for a points or prize payoff
B One that is automatically adjusted, scaled to the learner's skill
C One that is intrinsically rewarding, done for its own sake
D One that is cooperatively pursued, done alongside other learners

29. Adding prize money to a hobby someone already loves can reduce their desire to do it. What is this called?

A The overjustification effect
B The mastery-framing mechanic
C The reinforcement schedule
D The challenge-skill balance

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/learning-theory/lms-standards-and-gamification

STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

LESSON 9 OF 10

Who's Who & What's What of Learning

The theorists · The frameworks · Right or Wrong: spot the better practice

WHAT YOU'LL BE ABLE TO DO

- Recognize the behaviorist and constructivist theorists (Skinner, Pavlov, Piaget, Vygotsky, Dewey) from their ideas.
- Recognize the memory researchers and modern figures (Ebbinghaus, Bloom, Csikszentmihalyi, Siemens, Khan), including Bloom's 1984 tutoring finding.
- Recognize the memory frameworks — Forgetting Curve, Spaced Repetition, Testing Effect, ZPD — and the most durable study strategy.
- Recognize the cognitive and instructional-design frameworks (Bloom's Taxonomy, Flow, Cognitive Load, Dual Coding, Connectivism, ADDIE).

Every idea in this pack has a name attached — a researcher who first ran the experiment, or a framework that crystallized the insight. This lesson is pure recognition practice. Given a few clues, can you name the **theorist** behind an idea, or the **theory** behind a description? Knowing *who* and *what* turns a pile of disconnected facts into a map you can navigate.

The theorists

Learning science was built by a recognizable cast. The **behaviorists** came first: **Ivan Pavlov**, the Russian physiologist whose salivating dogs revealed classical conditioning, and **B.F. Skinner**, who studied how reinforcement shapes voluntary behavior (operant conditioning) and developed programmed-instruction "teaching machines."

The **cognitivists and constructivists** turned attention inward, to the mind that behaviorism ignored. **Jean Piaget** mapped four stages of children's cognitive development and described how we assimilate and accommodate new information. **Lev Vygotsky**, who died at just 37, argued learning is social and defined the gap between solo and supported performance. **John Dewey**, the great American pragmatist, championed learning by doing.

Then the **measurers and modelers**. **Hermann Ebbinghaus**, memorizing nonsense syllables in the 1880s, produced the first curve of forgetting. **Benjamin Bloom** gave us both a six-level hierarchy of cognitive objectives and the famous 1984 finding that one-to-one tutoring is worth two standard deviations. **Mihaly Csikszentmihalyi** named the state of total absorption where challenge meets skill. **Allan Paivio** showed the mind codes words and images separately. **George Siemens** updated learning theory for networks and devices. And **Sal Khan**, a former hedge-fund analyst, turned online tutoring into a global nonprofit and a 2024 manifesto for AI in education. Recognize each one by the idea they're welded to.

The frameworks

The ideas themselves have names worth knowing on sight. **The Forgetting Curve** is the steep decay of unreviewed memory — and the reason **Spaced Repetition**, which schedules reviews at expanding intervals, works so well. **The Testing Effect** (retrieval practice) is the finding that pulling information *out* of memory beats putting it back *in* by re-reading.

From constructivism comes the **Zone of Proximal Development** — the productive band between independent and supported performance. From Bloom comes **Bloom's Taxonomy**, the Remember-to-Create ladder of cognitive skill. From the cognitive tradition come **Flow** (effortless immersion when challenge matches skill), **Cognitive Load Theory** (managing working memory's hard limits), and **Dual Coding Theory** (words and images as two channels). **Connectivism** reframes knowledge as something distributed across networks for the digital age. And from instructional design comes **The ADDIE Model** — Analyze, Design, Develop, Implement, Evaluate — the dominant framework for building a course. Learn to spot each from a sentence or two of description, and you'll have the whole field's vocabulary at your fingertips.

Key concepts

B.F. Skinner

- An early-20th-century American psychologist and the most influential figure in behaviorism.
- He studied how rewards and punishments shape voluntary behavior, coining the term 'operant conditioning.'
- He developed programmed-instruction 'teaching machines' and the chamber used to study reinforcement schedules.

Ivan Pavlov

- A Russian physiologist whose work on the digestive system earned a Nobel Prize.
- He found that a neutral stimulus, repeatedly paired with food, could itself trigger a reflex.
- His experiments conditioning dogs to salivate at a bell became the classic demonstration of classical conditioning.

Jean Piaget

- A Swiss psychologist who studied how children's thinking develops, anchoring the cognitivist view of learning.
- He argued learners actively build knowledge by assimilating new input and accommodating their mental schemas.
- He proposed four stages of cognitive development, from sensorimotor to formal operational.

Lev Vygotsky

- A Soviet psychologist who died young in 1934 but reshaped how we think about social learning.
- He argued that learning is fundamentally social, mediated by culture and language.
- He defined the gap between what a learner can do alone versus with help from a 'more knowledgeable other.'

John Dewey

- An American philosopher and education reformer of the early 20th century, central to pragmatism.
- He insisted education should connect to real experience and problem-solving, not abstract drills.
- His advocacy of 'learning by doing' anchors experiential and problem-based learning.

Benjamin Bloom

- An American educational psychologist at the University of Chicago in the mid-20th century.
- He led the committee that classified cognitive skills into a six-level hierarchy of educational objectives.
- His 1984 paper showed one-to-one mastery tutoring lifts students about two standard deviations.

Hermann Ebbinghaus

- A 19th-century German psychologist who pioneered the experimental study of memory.
- He memorized long lists of nonsense syllables and tracked how fast he forgot them.
- His curve of memory decay — and the finding that review slows it — underpins spaced repetition.

Mihaly Csikszentmihalyi

- A Hungarian-American psychologist and a founder of positive psychology.
- He studied the 'optimal experience' of complete, energized absorption in a task.
- He named that state — where challenge precisely matches skill — and wrote its defining 1990 book.

George Siemens

- A 21st-century learning theorist writing for the internet era.
- With Stephen Downes, he argued that older theories ignore learning that lives in networks and devices.
- He proposed that knowing where to find current information now matters more than what you've memorized.

Sal Khan

- He left a hedge-fund career after tutoring his young cousin in math over the internet.
- He founded a nonprofit that posts free instructional videos and exercises for the whole world.
- In 2024 he wrote a book arguing AI will revolutionize education, and built a GPT-4 tutor to prove it.

The Forgetting Curve

- A graph from 19th-century memory research describing how quickly we lose new information.
- It shows steep early loss — roughly half within an hour, most within a day — without review.
- Each successful review flattens it, which is the whole rationale for spaced repetition.

Zone of Proximal Development

- A core idea from social constructivism about where learning is most productive.
- It is the space between what a learner can do independently and what they can do with guidance.
- Instruction aimed here — supported but not frustrating — is the target that scaffolding supports.

Bloom's Taxonomy

- A 1956 classification scheme, revised in 2001, used to write learning objectives and assessments.
- It ranks cognitive skills from lower-order recall up to higher-order thinking.
- Its six levels run from Remember and Understand at the bottom to Create at the top.

Flow

- An 'optimal experience' studied within positive psychology.
- It is the state of complete, effortless immersion that arises when challenge matches skill.
- Too-easy tasks cause boredom and too-hard ones anxiety; the balance produces it.

Cognitive Load Theory

- A 1988 instructional theory built on the strict limits of working memory.
- Its classic 1998 version split load into a topic's inherent difficulty, wasteful poor-design load and schema-building effort.
- The 1998 advice: cut the wasteful kind first, then promote the schema-building kind.

Dual Coding Theory

- A 1971 theory of memory proposing two distinct but interconnected systems.
- One system handles language; the other handles pictures and mental imagery.
- Engaging both at once — text plus a relevant image — activates more pathways than either alone.

Connectivism

- A learning theory proposed around 2004–05 explicitly 'for the digital age.'
- It holds that knowledge lives in networks of people, databases, and devices, not just one mind.
- Its proponents hold that knowing where to find current information matters more than what you currently know.

The ADDIE Model

- An instructional-design framework traced to a mid-1970s Florida State University model for the U.S. armed forces.
- It structures course creation into five phases, originally a waterfall and now iterative.
- Those phases are Analyze, Design, Develop, Implement, and Evaluate.

Spaced Repetition

- An evidence-based study method that decisively beats cramming for long-term retention.
- It distributes reviews over expanding intervals — a day, then a few days, then weeks.
- Software like Anki and SuperMemo schedules each review near the moment of forgetting.

The Testing Effect

- A robust cognitive-psychology finding about how studying actually works.
- Actively retrieving information from memory strengthens it far more than re-reading does.
- It is why frequent low-stakes quizzes beat passive review — also called retrieval practice.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Which theorist was the Russian physiologist whose salivating dogs revealed classical conditioning?

A B.F. Skinner
B Lev Vygotsky
C Ivan Pavlov
D John Dewey

2. Who studied how reinforcement shapes voluntary behavior (operant conditioning) and developed programmed-instruction "teaching machines"?

A Ivan Pavlov
B George Siemens
C Jean Piaget
D B.F. Skinner

3. Which theorist mapped four stages of children's cognitive development and described how we assimilate and accommodate new information?

A Benjamin Bloom
B Jean Piaget
C Lev Vygotsky
D John Dewey

4. What was Lev Vygotsky's contribution to learning theory?

A Defining the gap between solo and supported performance
B Mapping the stages of children's cognitive development
C Showing that the mind codes words and images separately
D Insisting that genuine learning requires learning by doing

5. A teacher rebuilds a unit around hands-on projects, saying students "learn best by doing." Which theorist's principle is she applying?

A B.F. Skinner
B Jean Piaget
C John Dewey
D Ivan Pavlov

6. Benjamin Bloom's famous 1984 finding claimed that one-to-one tutoring lifts the average student's performance by how much, versus conventional classroom instruction?

A Half a standard deviation
B Two standard deviations
C Three standard deviations
D One standard deviation

7. Who memorized nonsense syllables in the 1880s and produced the first curve of forgetting?

A Hermann Ebbinghaus
B Mihaly Csikszentmihalyi
C Allan Paivio
D Benjamin Bloom

8. A game designer tunes difficulty to rise with the player's growing skill, chasing a state of total absorption. Which researcher named that state?

A Hermann Ebbinghaus
B George Siemens
C Benjamin Bloom
D Mihaly Csikszentmihalyi

9. What did George Siemens contribute to learning theory?

A A view of knowledge as distributed across networks and devices
B A finding that one-to-one tutoring is worth two standard deviations
C A model in which words and images are coded as two channels
D A curve of forgetting charted from nonsense syllables

10. Which former hedge-fund analyst turned online tutoring into a global nonprofit and wrote a 2024 manifesto for AI in education?

A John Dewey
B Benjamin Bloom
C Sal Khan
D George Siemens

11. According to the Testing Effect (retrieval practice), which study strategy builds the most durable long-term memory?

A Re-reading the material several times
B Highlighting the key passages
C Listening to the lecture again
D Quizzing yourself from memory

12. Which framework names the steep decay of unreviewed memory?

A Cognitive Load Theory
B The Forgetting Curve
C Spaced Repetition
D The Testing Effect

13. Which framework works by scheduling reviews at expanding intervals?

A Dual Coding Theory
B Spaced Repetition
C The Forgetting Curve
D The Testing Effect

14. A student can solve a problem with a tutor's hints but not on her own. Which framework names that productive band?

A Zone of Proximal Development
B Conditions of Learning
C Self-Determination Theory
D Cognitive Load Theory

15. What is the finding known as the Testing Effect?

A Challenge matched to skill beats challenge set too high or low
B Pairing words with images beats presenting either one alone
C Reviews spaced at expanding intervals beat one crammed session
D Pulling information out of memory beats re-reading it

16. The ADDIE model, the dominant framework for building a course, stands for which sequence of five stages?

A Assess, Design, Deploy, Instruct, Evaluate
B Analyze, Draft, Deliver, Integrate, Examine
C Analyze, Design, Develop, Implement, Evaluate
D Assemble, Design, Demonstrate, Improve, Extend

17. Which framework is the six-level ladder of cognitive skill running from Remember up to Create?

A Bloom's Taxonomy
B Merrill's Principles
C The Kirkpatrick Model
D The Affective Domain

18. A lesson piles twelve new terms onto one dense slide and learners stall out. Which framework best explains the failure?

A The Testing Effect
B The Forgetting Curve
C Dual Coding Theory
D Cognitive Load Theory

19. Which framework-to-description pairing is correct?

A Connectivism — learning held inside the individual mind
B Flow — effortless immersion when challenge matches skill
C Cognitive Load Theory — steep decay of memory left unreviewed
D Dual Coding Theory — managing working memory's hard limits

20. Which statement accurately describes Connectivism?

A It locates learning in the gap between solo and supported performance
B It holds that knowledge built through guided questioning outlasts knowledge merely received
C It reframes knowledge as distributed across networks for the digital age
D It holds that different kinds of learning outcome each demand their own instruction

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/learning-theory/who-s-who-and-what-s-what-of-learning

STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

LESSON 10 OF 10

Essential Vocabulary & Quick Recall

AI & adaptive-systems terms · Generative AI & system infrastructure terms · Pedagogy & instruction terms · Learning-science terms · Assessment, data & standards terms · Quick recall (mixed)

WHAT YOU'LL BE ABLE TO DO

- Define the adaptive-systems and knowledge-tracing terms (ALS, ITS, Cognitive Tutor, Knowledge State, BKT, DKT, algorithm-based sequencing).
- Define the generative-AI and infrastructure terms (GenAI, Agentic AI, zero-shot learning, prompt engineering, HITL, affective computing, ontology).
- Define the pedagogy and instruction terms (metacognition, differentiated vs personalized learning, microlearning, multimodal, PBL, scaffolded curriculum).
- Define the core learning-science terms (working memory, chunking, transfer, PCK, EdTech) and SDT's three needs.
- Define the assessment, data, and standards terms (formative vs summative assessment, learner analytics, Kirkpatrick, xAPI, MOOC, syllabus).

AI & adaptive-systems terms

The core vocabulary for software that observes a learner, models what they know, and adjusts what comes next.

An **Adaptive Learning System (ALS)** is software that dynamically adjusts content difficulty, sequence, and modality based on ongoing learner performance data. At the human-teaching end of the spectrum sits the **Intelligent Tutoring System (ITS)** — software providing personalized instruction and feedback without a human teacher, using models of the domain, the learner, and pedagogy. The **Cognitive Tutor**, developed at Carnegie Mellon, is the canonical ITS: it models student cognition and gives personalized hints and feedback within a specific domain, originally mathematics.

Underpinning all of these is the idea of a **Knowledge State** — a model representing what a specific learner currently knows and doesn't know, updated continuously by the system. Two competing approaches estimate that state. **Bayesian Knowledge Tracing (BKT)** is a probabilistic model that estimates the probability a learner has mastered a skill, updating after each response. **Deep Knowledge Tracing (DKT)** replaces the hand-crafted probability tables with a recurrent neural network (LSTM) that models learner knowledge as a hidden state evolving with each interaction (Piech et al., 2015).

Once the knowledge state is estimated, **Algorithm-Based Sequencing** uses ML models — often BKT or DKT — to predict that state and determine the optimal next item to present. The loop is: observe → update state → select next item → repeat.

Generative AI & system infrastructure terms

The vocabulary for understanding how modern foundation models slot into edtech pipelines — from raw AI capabilities down to curriculum representation.

Generative AI (GenAI) refers to AI systems that produce novel text, images, or audio; in education it enables dynamic content creation, conversational tutoring, and personalized feedback at scale. A step further is **Agentic AI** — autonomous AI that can plan, take actions, use tools, and pursue multi-step goals with minimal human intervention, capable of orchestrating curriculum planning, content generation, assessment, and feedback in a single loop.

Practical use of these systems requires **Prompt Engineering**: designing the inputs given to LLMs so they produce the desired instructional outputs — a core skill for edtech builders working with foundation models. A related capability is **Zero-Shot Learning (AI)**, an LLM's ability to perform a task it was not explicitly trained on, generalizing from broad pre-training — useful for generating curriculum on rare or niche subjects.

Responsible deployment calls for **Human-in-the-Loop (HITL)** design, where humans review, approve, or override AI outputs before delivery — the standard check against errors in edtech. A more experimental layer is **Affective Computing**: AI that detects and responds to learner emotions — frustration, boredom, curiosity — to adapt instruction accordingly.

At the structural layer, a **Curriculum Graph / Knowledge Graph** is a representation of learning objectives and their dependencies, used by adaptive systems to find prerequisite relationships and optimal learning paths. Formalizing that structure further is an **Ontology (Learning)** — a representation of knowledge and the relationships between concepts in a domain, used to organize curriculum graphs and content recommendations.

Pedagogy & instruction terms

The vocabulary for describing how instruction is shaped, sequenced, and matched to individual learners.

The broadest term here is **Personalized Learning** — an instructional approach that tailors pace, content, sequence, and modality to the individual learner's needs, goals, and learning style. Its classroom precursor is **Differentiated Instruction**, where a teacher tailors content, process, or product to individual needs within a group setting. Both concepts feed the algorithmic vision of adaptive systems.

Supporting learners as they grow is the job of a **Scaffolded Curriculum** — a structured sequence that provides appropriate support at each level and fades assistance as competence grows, directly implementing Vygotsky's zone of proximal development. **Competency-Based Education (CBE)** takes a related stance: progression depends on demonstrating mastery of specific competencies, not time spent in instruction.

Delivery format matters too. **Microlearning** delivers content in short, focused bursts of two to ten minutes, each built around a single learning objective — well suited to mobile usage and limited attention spans. **Multimodal Learning** goes broader, engaging multiple sensory channels — visual,

auditory, kinesthetic — together to deepen encoding, grounded in dual coding and cognitive load theories.

Problem-Based Learning (PBL) shifts the design entirely: students learn by investigating and solving an authentic, complex, open-ended problem, rooted in Dewey's experiential philosophy. Binding all of these together is **Metacognition** — thinking about one's own thinking, awareness of one's learning process, knowledge gaps, and strategies. AI tutors like Khanmigo foster it by prompting students to explain their reasoning rather than just supplying answers.

Learning-science terms

Six concepts from cognitive psychology and motivation research that explain why learning succeeds or stalls.

Two terms concern memory and processing. **Working Memory** is the cognitive system that temporarily holds and manipulates information during active processing — roughly 7±2 items at a time. Cognitive load theory is built on its limits: overload it and learning degrades. **Chunking** is the direct response — breaking complex information into smaller, more manageable units to reduce that load and improve encoding.

The ultimate measure of learning is **Transfer of Learning**: applying knowledge or skills from one context to new, different ones. It is the goal that shallow memorization typically fails to reach; deep, connected understanding is what transfers.

On the teaching side, Lee Shulman's 1986 concept of **Pedagogical Content Knowledge (PCK)** distinguishes knowing a subject from knowing how to teach it. A chemistry expert and a chemistry teacher have different knowledge; PCK names what the teacher has that the expert may lack.

Motivation is addressed by **Self-Determination Theory (SDT)** (Deci & Ryan, 1985), which names three basic psychological needs for intrinsic motivation: autonomy, competence, and relatedness. It is the theoretical foundation most often cited in gamification and engagement design.

Finally, **EdTech** is the broad term for any technology used to facilitate or enhance learning — the field in which all the above concepts are applied.

Assessment, data & standards terms

The vocabulary for measuring learning outcomes, tracking learner data, and situating edtech within the broader education landscape.

Assessment splits into two distinct modes. **Formative Assessment** happens during the learning process — low-stakes quizzes, check-ins, retrieval prompts — providing feedback and allowing instruction to adjust. **Summative Assessment** evaluates learning after instruction: exams, final projects, grades. The distinction matters because the two serve different purposes and carry different stakes.

Evaluating whether training worked at the organizational level calls for the **Kirkpatrick Model**, a four-level framework: Reaction (did learners like it?), Learning (did they acquire knowledge?), Behavior (did they apply it?), and Results (did it affect outcomes?). It remains the standard evaluation structure in corporate and institutional training.

Data infrastructure has its own vocabulary. **Learner Analytics** covers the measurement, collection, analysis, and reporting of data about learners and their contexts, with the aim of optimizing learning. **xAPI / Tin Can API** is the interoperability standard that captures experience statements across all learning contexts — not just inside an LMS — enabling analytics that follow the learner wherever they learn.

Three category terms round out the field. A **MOOC (Massive Open Online Course)** is a large-scale online course open to unlimited participation; Coursera, edX, and Udemy established the model. **STEM / STEAM** names the disciplinary groupings — Science, Technology, Engineering, (Arts), Mathematics — most commonly addressed by edtech platforms. A **Syllabus / Curriculum Map** is the structured outline of learning objectives, content, sequence, and timeline for a course — the planning artifact that sits behind every adaptive system.

Key terms

Adaptive Learning System (ALS)
Software that dynamically adjusts content difficulty, sequence, and modality based on ongoing learner performance data.

Intelligent Tutoring System (ITS)
Software that provides personalized instruction and feedback without a human teacher in the loop, using models of the domain, the learner, and pedagogy.

Cognitive Tutor
An AI tutoring system developed at Carnegie Mellon that models student cognition and gives personalized hints and feedback within a specific domain, originally mathematics.

Knowledge State
A model representing what a specific learner currently knows and doesn't know within a domain, updated continuously by the system.

Bayesian Knowledge Tracing (BKT)
A probabilistic model used in intelligent tutoring systems to estimate the probability that a learner has mastered a skill, updating that estimate after each response.

Deep Knowledge Tracing (DKT)
A recurrent neural network (LSTM) approach to knowledge tracing that models learner knowledge as a hidden state evolving with each interaction (Piech et al., 2015).

Algorithm-Based Sequencing
Using ML models (often BKT or DKT) to predict learner knowledge states and determine the optimal next item to present.

Generative AI (GenAI)
AI systems that produce novel text, images, or audio. In education, GenAI enables dynamic content creation, conversational tutoring, and personalized feedback at scale.

Agentic AI
Autonomous AI that can plan, take actions, use tools, and pursue goals across multiple steps with minimal human intervention. In education it can orchestrate curriculum planning, content generation, assessment, and feedback in one loop.

Zero-Shot Learning (AI)
An LLM's ability to perform a task it was not explicitly trained on, generalizing from broad pre-training — relevant to generating curriculum for rare or niche subjects.

Prompt Engineering
Designing the inputs given to LLMs so they produce the desired instructional outputs — a practical skill for edtech builders working with foundation models.

Human-in-the-Loop (HITL)
AI system design where humans review, approve, or override AI outputs before delivery — used in responsible edtech to catch errors and ensure quality.

Affective Computing
AI systems that detect and respond to learner emotions — frustration, boredom, curiosity — to adapt instruction accordingly.

Curriculum Graph / Knowledge Graph
A structured representation of learning objectives and their dependencies, used by adaptive systems to find prerequisite relationships and optimal learning paths.

Ontology (Learning)
A formal representation of knowledge and the relationships between concepts in a domain, used to structure curriculum graphs and content recommendations.

Metacognition
Thinking about one's own thinking — awareness of one's learning process, knowledge gaps, and strategies. Tutors like Khanmigo foster it by asking students to explain their reasoning.

Differentiated Instruction
Tailoring content, process, or product to individual learner needs within a classroom setting — the human precursor to algorithmic personalization.

Personalized Learning
An instructional approach that tailors pace, content, sequence, and modality to the individual learner's needs, goals, and learning style.

Microlearning
Delivering content in short, focused bursts of 2–10 minutes, each built for a single learning objective. It exploits attention spans and mobile usage patterns.

Multimodal Learning
Engaging multiple sensory channels — visual, auditory, kinesthetic — together to deepen encoding. Grounded in dual coding and cognitive load theories.

Problem-Based Learning (PBL)
An approach where students learn by investigating and solving an authentic, complex, open-ended problem — rooted in Dewey's experiential philosophy.

Scaffolded Curriculum
A structured learning sequence that provides appropriate support at each level and fades assistance as competence grows — directly implementing Vygotsky's ZPD.

Competency-Based Education (CBE)
An educational model where progression depends on demonstrating mastery of specific competencies, not on time spent in instruction.

Pedagogical Content Knowledge (PCK)
Shulman's 1986 concept: the specific knowledge teachers need about how to teach a particular subject, distinct from knowing the subject matter itself.

Transfer of Learning
Applying knowledge or skills learned in one context to new, different contexts. It is the ultimate goal of deep learning; shallow memorization often fails to transfer.

Working Memory
The cognitive system that temporarily holds and manipulates information during active processing (about 7±2 items). Cognitive load theory focuses on its limits.

Chunking
Breaking complex information into smaller, more manageable units to reduce cognitive load and improve encoding.

Self-Determination Theory (SDT)
Deci & Ryan's theory (1985) naming three basic psychological needs for intrinsic motivation: autonomy, competence, and relatedness. A framework for engagement and gamification design.

EdTech
Education technology — any technology used to facilitate or enhance learning.

Formative Assessment
Assessment during the learning process to provide feedback and adjust instruction. Low-stakes quizzes that trigger retrieval practice are an example.

Summative Assessment
Evaluation of learning after instruction — exams, final projects — to grade outcomes. Contrasted with formative assessment.

Learner Analytics
The measurement, collection, analysis, and reporting of data about learners and their contexts in order to optimize learning.

Kirkpatrick Model

A four-level framework for evaluating training effectiveness: Reaction, then Learning, then Behavior, then Results.

xAPI / Tin Can API

A learning-data interoperability standard that captures experience statements across all learning contexts, not just the LMS.

MOOC (Massive Open Online Course)

A large-scale online course open to unlimited participation. Coursera, edX, and Udemy pioneered the model.

STEM / STEAM

Science, Technology, Engineering, (Arts), and Mathematics — disciplinary categories commonly addressed by edtech platforms.

Syllabus / Curriculum Map

A structured outline of learning objectives, content, sequence, and timeline for a course.

Key concepts

Cognitive Tutor

- The canonical, textbook example of an AI system that instructs a student one-on-one without any human teacher.
- Developed at Carnegie Mellon, it models how a student thinks and delivers personalized hints and feedback within a specific domain, originally mathematics.

Bayesian Knowledge Tracing

- One of two competing methods for estimating what a specific learner currently knows, updating after every response.
- It is a probabilistic model that computes the probability a learner has mastered a skill, relying on hand-crafted probability tables.

Deep Knowledge Tracing

- The newer of two competing methods for estimating a learner's evolving mastery after each interaction.
- It replaces hand-crafted probability tables with a recurrent neural network (an LSTM) that models a learner's mastery as an evolving hidden state (Piech et al., 2015).

Knowledge State

- A continuously updated model, at the heart of adaptive software, of what a specific learner does and doesn't understand.
- It is precisely the thing two competing methods — one probabilistic, one a neural network — race to estimate.

Matched pairs

Each item on the left goes with the one on the right.

Passive learning → Observing, watching, reading — weak for retention

Anki / SuperMemo → SRS apps that schedule reviews at the optimal interval

B.F. Skinner → Operant conditioning

Lev Vygotsky → Zone of Proximal Development

Comprehension (1956) → Understand (2001)

Apply → use, execute, implement, solve

Siemens & Downes (2004–05) → Connectivism

Engagement (UDL) → The 'why' — multiple means of motivation and interest

Analyze (ADDIE) → Identify goals, audience, prior knowledge, and constraints

SAM (2012) → Rapid, agile prototyping; explicitly iterative

The Diamond Age (Neal Stephenson)
→ An AI tutor for a poor girl becomes her greatest educational resource

conmigo → Spanish for "with me" — the root of Khanmigo's name

Research Assistants → Document synthesis, multi-source knowledge (NotebookLM, Perplexity)

Self-test

Answer each question from memory, then check your work against the answer key.

1. The Cognitive Tutor, the canonical Intelligent Tutoring System, was developed at which university and originally for which subject?

A Stanford, originally computer science
B MIT, originally introductory physics
C Harvard, originally reading comprehension
D Carnegie Mellon, originally mathematics

2. An Adaptive Learning System dynamically adjusts which three aspects of instruction, based on ongoing learner performance data?

A Representation, expression, and engagement
B Content difficulty, sequence, and modality
C Instructional content, process, and product
D Autonomy, competence, and relatedness

3. How does Deep Knowledge Tracing (Piech et al., 2015) differ from Bayesian Knowledge Tracing?

A It replaces the learner model with explicit models of the domain and the pedagogy (the other two ITS models)

B It replaces per-response updating with a single mastery estimate (a posterior) computed at the end of each unit

C It replaces hand-crafted probability tables with a recurrent neural network (LSTM) hidden state

D It replaces the neural hidden state with hand-crafted probability tables (one per skill)

4. A system maintains a model of what one specific learner currently knows and doesn't know, updating it continuously. What is that model called?

A Knowledge State

B Learner Analytics

C Learning Ontology

D Knowledge Graph

5. Algorithm-Based Sequencing runs a repeating loop. Which step is NOT part of that loop?

A Update the estimated knowledge state

B Observe the learner's response

C Select the optimal next item to present

D Award a completion certificate once the unit timer expires

6. What most distinguishes Agentic AI from ordinary Generative AI in an edtech pipeline?

A It can produce novel text, images, or audio from a single prompt, generating content and feedback at scale

B It can detect a learner's frustration, boredom, or curiosity and adapt the next instruction to match

C It can autonomously plan, use tools, and pursue multi-step goals with minimal human intervention

D It can route every output through a human reviewer, who approves or overrides it before delivery

7. Zero-Shot Learning (AI) describes an LLM's ability to do what?

A Master a task after a few labelled examples appear in the prompt, generalizing from those demonstrations

B Perform a task it was not explicitly trained on, generalizing from broad pre-training

C Train on data that carries no human-supplied labels, discovering structure in the raw corpus

D Retain every prior learner interaction across sessions, drawing on that history at inference

8. Prompt Engineering, a core skill for edtech builders working with foundation models, is best described as which activity?

A Designing the inputs given to LLMs so they produce the desired instructional outputs

B Writing the integration code so a model's outputs are served inside the school's LMS

C Ranking pairs of a model's outputs so a separate reward model learns instructional preferences

D Fine-tuning a model's weights on curriculum data so it produces domain-specific outputs

9. An edtech team requires a teacher to review and approve every AI-generated quiz before students see it. Which design principle is this?

A Adaptive Learning System (ALS)
B Competency-Based Education (CBE)
C Human-in-the-Loop (HITL)
D Problem-Based Learning (PBL)

10. How does an Ontology (Learning) relate to a Curriculum Graph?

A It logs each learner's interactions with the graph, scoring its prerequisite edges from that evidence
B It represents domain concepts and their relationships, organizing curriculum graphs and recommendations
C It is the per-learner layer of the graph, tracking what one student has mastered up to now
D It is the interoperability standard for the graph, carrying its objectives between LMS platforms

11. Microlearning delivers content in bursts of what length, and each burst is built around how many learning objectives?

A 30–60 seconds, built around a single learning objective
B 45–60 minutes, built around one unit's learning objectives
C 20–30 minutes, built around several learning objectives
D 2–10 minutes, built around a single learning objective

12. AI tutors like Khanmigo prompt students to explain their reasoning rather than just supplying answers. Which capacity is this designed to foster?

A Metacognition
B Transfer of learning
C Intrinsic motivation
D Working memory

13. Which statement describes Differentiated Instruction rather than Personalized Learning?

A An adaptive system tailors pace, sequence, and modality to each learner's goals and learning style
B A tutor tailors content, process, and product to a single learner in private tutoring
C A teacher tailors each learner's rate of progression to demonstrated mastery rather than time spent
D A teacher tailors content, process, or product to individual needs within a group setting

14. A Scaffolded Curriculum gives support at each level and fades assistance as competence grows, directly implementing whose idea?

A Csikszentmihalyi's theory of flow
B Bloom's taxonomy of cognitive objectives
C Vygotsky's zone of proximal development
D Piaget's stages of cognitive development

15. Which statement about these pedagogy and instruction terms is NOT accurate?

A. Multimodal Learning delivers one modality at a time so working memory is never overloaded

B. Microlearning builds every short, focused burst around one learning objective only

C. Competency-Based Education counts demonstrated mastery, never time spent, toward progression

D. Problem-Based Learning has students learn by investigating an authentic, open-ended problem

16. Self-Determination Theory names which three basic psychological needs that drive intrinsic motivation?

A. Challenge, fantasy, and curiosity

B. Autonomy, competence, and relatedness

C. Context, culture, and collaboration

D. Attention, retention, and reproduction

17. Working memory temporarily holds and manipulates information during active processing. In Miller's classic estimate, roughly how many items can it handle at once?

A. About 7±2

B. About 4±1

C. About 10±2

D. About 12±2

18. A designer splits a 12-digit code into three groups of four so learners can hold it more easily. Which technique is this?

A. Scaffolding

B. Chunking

C. Multimodal learning

D. Transfer of learning

19. Which statement about these learning-science terms is NOT accurate?

A. Self-Determination Theory was put forward by Deci & Ryan in 1985

B. EdTech is any technology used to facilitate or enhance learning

C. Working memory temporarily holds and manipulates information during active processing

D. Transfer of Learning means repeating material until it can be recalled verbatim

20. Lee Shulman's 1986 concept of Pedagogical Content Knowledge names which kind of knowledge?

A. Command of a grade's curriculum standards, distinct from mastery of the subject itself

B. Deep expertise in a subject itself, distinct from any skill at teaching that subject

C. Knowing how to teach a specific subject, distinct from knowing the subject itself

D. General skill at managing a classroom, distinct from expertise in any one subject

21. In the Kirkpatrick Model of training evaluation, which of the four levels asks whether learners actually applied what they learned back on the job?

A. Behavior

B. Learning

C. Results

D. Reaction

22. Which of these is an example of Formative Assessment?

A. A final project graded once the course ends that fixes each student's overall mark
B. A low-stakes retrieval quiz during a unit that lets instruction adjust
C. A high-stakes midterm exam partway through a unit that counts toward the final grade
D. A certification test at the close of training that attests to a candidate's competence

23. The xAPI / Tin Can API standard exists to do what?

A. Generate quiz items from a source document, so assessments can be produced at scale
B. Represent learning objectives and their prerequisites, so optimal paths can be found
C. Capture experience statements across all learning contexts, so analytics follow the learner
D. Estimate the probability a learner has mastered a skill, so the next item can be chosen

24. Learner Analytics is defined as which of the following?

A. Capturing, storing, and exchanging experience statements across systems, to keep learning records portable
B. Outlining objectives, content, sequence, and timeline for a course, to plan what is taught when
C. Rating reaction, learning, behavior, and results after training, to judge whether it worked
D. Measuring, collecting, analyzing, and reporting data about learners and their contexts, to optimize learning

25. Which statement about these assessment, data, and standards terms is NOT accurate?

A. Coursera, edX, and Udemy established the MOOC model
B. STEAM adds Assessment to the STEM disciplines
C. A syllabus / curriculum map outlines objectives, content, sequence, and timeline
D. A MOOC is a large-scale online course open to unlimited participation

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/learning-theory/essential-vocabulary-and-quick-recall

STUDY Education Theory & Learning Technology in the FlashFeed app flashfeedlearningapp.com/packs/learning-theory

Answer key

Lesson 1: How Humans Learn

1. C Hebbian learning

Hebbian learning is the principle summarized as 'neurons that fire together, wire together.' Pavlovian conditioning pairs stimuli, Skinnerian shaping rewards successive approximations, and Piagetian assimilation absorbs new information into an existing schema — none describes synaptic co-activation.

2. D The synapse thickens and signals travel faster

Repeated co-activation makes connections structurally stronger — the synapse thickens and signals travel faster. Learning strengthens existing connections rather than growing replacement neurons.

3. B The neurons encoding it never fire during retrieval or use, so the connection doesn't strengthen

Passive learning keeps activation low, so the target neurons don't fire in the context of retrieval and the connection never wires. Exposure doesn't erase prior synapses — it simply fails to strengthen new ones.

4. A Practice and repetition are merely motivational advice

Practice, repetition, and varied application are not motivational advice — they are the literal mechanism of biological change. The other three statements are all accurate.

5. A Weak connection-building, because activation stays low without retrieval

Re-watching is passive: activation stays low and the neurons never fire in a retrieval context, so wiring is weak. Repetition only builds connections when the target neurons actually fire during recall or use.

6. D Teaching and debating

Interactive learning — teaching, debating, contributing — forces the deepest retrieval and negotiates your schema against other mental models.

7. C Active learning

Active learning is defined as recalling, practicing, and testing — it reinforces neural pathways. Interactive learning goes further, adding teaching and debating.

8. B Re-reading a chapter you already highlighted

Passive learning is observing, watching, and reading — re-reading fits squarely. Flashcards are active retrieval; teaching and debating are interactive.

9. C Passive → active → interactive

Passive learning is weakest for retention, active learning reinforces neural pathways, and interactive learning demands the deepest retrieval — producing the most robust encoding.

10. D Schema negotiation — integrating, defending, and adapting the fact

Teaching and debating force schema negotiation: you must not only recall a fact but integrate it, defend it, and adapt it. That layered demand is what produces the most robust encoding.

11. B The first review is most valuable when it happens soon after learning

Decay is fastest right after learning, so an early first review flattens the curve the most. Ebbinghaus showed the timing of review matters as much as total duration — the whole basis for spaced repetition's expanding intervals.

12. A 50%

Ebbinghaus found about 50% of new information is gone within 30 minutes without review. Roughly 75% is the 24-hour figure, not the 30-minute one.

13. B About 75%

Ebbinghaus's curve shows roughly 75% lost within 24 hours. About 50% is the 30-minute figure — the decay continues well past the first half hour.

14. A Hermann Ebbinghaus, using nonsense syllables

Ebbinghaus ran self-experiments in the 1880s memorizing nonsense syllables — chosen precisely because they carried no prior meaning. Roediger and Karpicke are associated with the testing effect instead.

15. D It is steepest right after learning and slows thereafter

Ebbinghaus's curve is exponential, not linear: forgetting is fastest in the minutes and hours right after learning and slows from there. That early steepness is why a first review pays off most when it comes soon.

16. C Expanding intervals

Spaced repetition distributes sessions over expanding intervals, so each successful review buys a longer gap before the next. Fixed intervals ignore how the curve flattens with each review.

17. C Retrieval at the memory's weakest point forces effortful encoding and resets the decay clock

You are forcing retrieval at the moment the memory is weakest, which triggers a more effortful encoding process and resets the decay clock. Cramming isn't harmful in itself — it simply wastes the timing advantage.

18. D Anki and SuperMemo

Anki and SuperMemo are the SRS pair — both algorithmically schedule each card at its optimal interval.

19. A How confidently you recalled it last time

SRS scheduling is typically based on how confidently you recalled the card last time: easier cards get longer gaps, harder cards come back sooner. Card length and topic grouping don't drive the interval.

20. B Longer gap for the easy card, sooner review for the hard one

Easier cards get longer gaps; harder cards are reviewed sooner. Identical gaps would waste time on material you already know while letting shaky material decay.

21. A Administer low-stakes quizzes frequently

MIT Open Learning summarizes the implication simply: give students frequent low-stakes quizzes, which trigger retrieval and solidify learning.

22. B Actively recalling information rather than re-exposing yourself to it

Retrieval practice means actively pulling information out of memory instead of re-exposing yourself to it — the mechanism behind the testing effect. Re-reading only confirms the information is accessible from the page.

23. C Retrieval practicers retained significantly more after one week

Karpicke & Roediger (2008) found self-testing students retained significantly more after a week than those who restudied the same material the same number of times — equal exposure, unequal retention.

24. D Roediger & Butler (2011)

Roediger & Butler (2011) extended the finding beyond vocabulary to a range of material types. Karpicke & Roediger (2008) was the one-week restudy comparison; Ebbinghaus studied forgetting, not testing.

25. B When retrieval is difficult but successful

This is the retrieval effort hypothesis: the effort of reconstructing an answer, when retrieval is difficult but successful, strengthens the memory trace most. Easy retrieval yields smaller gains, and a failed attempt lacks the successful reconstruction the effect depends on.

26. A Frequently — the testing itself drives learning

MIT Open Learning's practical implication: frequent low-stakes quizzing works because being tested is itself the learning event, not just an assessment.

27. D Being tested is itself the learning event

MIT's practical implication: frequent low-stakes quizzing works because the act of being tested is itself the learning event, not merely an assessment of prior learning.

Lesson 2: Learning Theories: Behaviorism to Constructivism

1. B B.F. Skinner — operant conditioning

Skinner is credited with operant conditioning — behavior shaped by its consequences — and with the insight that reinforcement schedules matter. Pavlov demonstrated classical conditioning with dogs; Watson extended conditioning to humans, treating all behavior as conditioned reflexes.

2. C Classical conditioning

This is classical conditioning: a neutral stimulus paired with a natural one until it alone triggers the response. Operant conditioning (Skinner) depends on the learner's own actions and their consequences; generalization and discrimination concern transfer to other stimuli.

3. D Behaviorism

Watson, with Skinner and Pavlov, is counted among behaviorism's early-20th-century founders; he extended conditioning to humans, treating all behavior as conditioned reflexes.

4. A As unmeasurable and therefore scientifically irrelevant

Skinner, Pavlov, and Watson argued that beliefs, feelings, and attention are unmeasurable and therefore scientifically irrelevant, so they treated the mind as a black box and studied only observable stimulus-response conditioning.

5. D John Watson's

Watson extended conditioning to humans, treating all behavior as conditioned reflexes. Pavlov's demonstrations stayed with dogs, Skinner's operant conditioning turns on consequences rather than reflexes, and Bandura, a cognitivist, studied the internal processes behaviorism set aside.

6. B Reinforcing successive approximations toward a target behavior

Shaping reinforces successive approximations toward a goal, so instructors can teach complex skills by rewarding small steps. The wrong options describe discrimination, stimulus generalization, and classical conditioning respectively.

7. A Behavior is shaped by its consequences — reinforcement and punishment

Skinner's operant conditioning holds that consequences — reinforcement increases a behavior, punishment decreases it — shape it. Pairing two stimuli is Pavlov's classical conditioning; schema revision is Piaget's accommodation.

8. C Shaping

Shaping rewards successive approximations toward a target behavior, teaching complex skills in small reinforced steps. Fading withdraws support as competence grows, pairing links a neutral stimulus to a natural one, and chunking groups items into larger units for encoding.

9. D When a reward arrives matters as much as whether it arrives

Skinner showed that timing matters: different reinforcement schedules produce different response rates and extinction curves, so one schedule does not sustain a behavior as well as another and when a reward arrives counts as much as whether it does.

10. B Operant conditioning hinges on the learner's own actions

Unlike Pavlov's passive stimulus pairing, in which a cue comes to trigger a reflex, operant conditioning is driven by the learner's own actions and their consequences.

11. C It contradicts an existing schema, and the drive to resolve that disequilibrium forces effortful accommodation

A clash between an old schema and new experience creates disequilibrium; equilibration, the drive to resolve it, produces effortful accommodation and a stronger memory.

12. A Assimilation

Assimilation integrates new information into an existing schema without altering it. Accommodation would be required only if the new case contradicted the schema and forced it to be revised.

13. A Accommodation

Accommodation revises the schema itself when new information contradicts it — a more effortful process that produces genuine conceptual change. Assimilation leaves the schema intact; disequilibrium is the tension the contradiction creates, and equilibration the drive to resolve it.

14. D The drive to balance assimilation and accommodation and resolve schema tension

Equilibration is the drive to resolve the tension between old schemas and new information by balancing assimilation and accommodation. The tension itself is disequilibrium, the stored pattern is the schema, and the effortful revision is accommodation.

15. B New information conflicts with a schema → disequilibrium → equilibration drives accommodation

Conflict between an existing schema and new experience creates disequilibrium; equilibration is the drive to resolve it, often via accommodation. Information that fits is simply assimilated with the schema intact, and accommodation is the resolution of conflict rather than its trigger.

16. C A cognitive framework or category used to organize and interpret information

A schema is a cognitive framework — a stored pattern of understanding — used to organize and interpret information. Grouping items into meaningful units is chunking; temporary support is scaffolding.

17. B Roughly 7 ± 2 chunks

Miller's 1956 paper established that working memory holds roughly 7 ± 2 chunks at once — a hard capacity limit that has shaped instructional design ever since.

18. A It reduces the number of working-memory slots occupied by grouping items into one meaningful unit

Chunking groups raw items into meaningful units, so fewer of working memory's ~7±2 slots are occupied and encoding improves. Chunking works within the capacity limit rather than raising it.

19. C A schema

A schema is the cognitive framework used to organize and interpret new information. A chunk groups raw items into one memory unit, a scaffold is temporary instructional support, and a stimulus is the input that triggers a response, not the stored pattern that interprets it.

20. D It permanently raises the number of chunks working memory can hold

Chunking exploits the ~7±2 limit by packing more meaning into each slot; it does not raise the limit itself. The other three statements correctly describe chunking.

21. D A more knowledgeable other

The 'more knowledgeable other' (MKO) — a teacher, parent, or more capable peer — provides the scaffolding that lets the learner operate within their zone of proximal development.

22. A Inside the gap between independent ability and guided ability

A task inside the ZPD is hard enough to need support but not so hard it frustrates: too easy and no growth occurs, too hard and progress blocks. The zone is measured against the learner's own independent and guided ability, not against what a peer or teacher can do.

23. C Scaffolds must be temporary and progressively withdrawn through fading

Scaffolding is temporary by design: support fades as competence grows. Scaffolds never removed create dependency, a 'more knowledgeable other' can be a peer or structured tool, not only a teacher, and pitching the task at what the learner already does alone produces no growth.

24. B John Dewey

Dewey's pragmatic constructivism insisted on 'learn by doing'. Vygotsky is matched with the ZPD and social constructivism, Piaget with cognitive constructivism, and Bandura with the cognitivist study of the mind's internal processes.

25. C It holds that higher mental functions arise between people before becoming internal

Vygotsky argued higher mental functions arise first between people, then become internal — learning is inherently social. The individual's encounter with the physical world is Piaget's emphasis, and learning by doing through authentic problems is Dewey's.

Lesson 3: Bloom's Taxonomy & Mastery Learning

1. D Benjamin Bloom and colleagues, 1956

Bloom and colleagues at the University of Chicago published the original cognitive taxonomy in 1956. Anderson and Krathwohl published the 2001 revision, not the original, and 2001 is the revision's date rather than the taxonomy's.

2. C Synthesis to Create

Synthesis was renamed Create and moved to the summit. Each wrong pairing slips one rung too high: Knowledge became Remember, Comprehension became Understand, and Analysis became Analyze.

3. B It kept the taxonomy at its original six levels

The revision renamed the levels and reordered the top two but kept all six. Five is the level count of the affective domain, not the cognitive taxonomy, and nothing was added or cut.

4. A Evaluation

In 1956 the order ended Synthesis then Evaluation, so Evaluation was the summit. The 2001 revision swapped them, dropping Evaluate one rung below Create.

5. C Level names became verbs, making objectives directly actionable

The verb shift forces a clearer choice of evidence than the noun form. The top-two swap put Create, not Evaluate, at the summit; the levels still rank, and the affective domain stayed a separate 1964 handbook.

6. A Receiving, Responding, Valuing, Organizing, Characterizing

The affective domain (1964) runs Receiving to Characterizing, charting how attitudes and values deepen.

7. B Receiving

Receiving is the entry level: merely attending to a stimulus. Responding is the next rung, where the learner actively reacts rather than just notices.

8. D Characterizing

Characterizing is the top level, where a value system is integrated into identity. Valuing and Organizing are lower rungs on the same ladder, short of that full internalization.

9. B Valuing

The affective five are Receiving, Responding, Valuing, Organizing, Characterizing. Reflecting, Believing and Committing sound affective but name no level in the 1964 handbook.

10. A 1964

The affective handbook came in 1964. 1956 was the original cognitive taxonomy, 1984 the 2 Sigma paper, and 2001 the Anderson and Krathwohl revision.

11. D Create

The revision moved Create to the summit, ahead of Evaluate, to emphasize original production as the peak cognitive skill.

12. C use, execute, implement, solve

Apply is about putting knowledge to use: use, execute, implement, solve. 'define, list, recall, identify' are Remember verbs — lower-order retrieval, not use.

13. A Create

Design and produce are Create verbs — original production, the summit of the revised ladder. Apply verbs (use, execute, implement, solve) work an existing method rather than making something new.

14. D Remember

These are retrieval verbs, so they sit at Remember, the lowest rung. Understand would require explaining or summarizing rather than simply recalling.

15. B Evaluate

The revision put Create at the summit with Evaluate one rung below. Create is the summit itself, not the level beneath it, and Analyze sits two rungs down, above Apply.

16. C Create

The 2001 revision swapped the top two levels, moving Create above Evaluate to the summit of the hierarchy.

17. D Create

Synthesis (1956) became Create (2001) and took the top spot, ranking above Evaluate in the revised hierarchy.

18. B One-to-one tutoring is economically unscalable

The gain is huge but tutoring everyone 1:1 is unaffordable — Bloom challenged researchers to find a scalable group method that matches it. This is now the core pitch for AI tutoring.

19. A As an instructional gap to correct, not a student deficit

Mastery learning reframes failure as a feedback-corrective signal: the instruction missed, so fix the instruction and re-test.

20. C 98%

A two standard deviation gain puts the average tutored student above about 98% of the control class. 84% would correspond to a one-sigma gain, the level mastery learning alone reached.

21. D Conventional teaching, classroom mastery learning, and one-to-one tutoring

Bloom's 1984 comparison had three arms: conventional classroom teaching, mastery learning in a classroom, and one-to-one tutoring with mastery techniques.

22. C John Carroll

John Carroll developed mastery learning and Bloom expanded it. Anderson and Krathwohl are associated with the 2001 taxonomy revision, not mastery learning.

23. B One-to-one tutorial instruction

One-to-one tutorial instruction led at 2 sigma. Reinforcement was second at 1.2 sigma — large, but only about half the tutoring effect.

24. A 1.2 sigma

Reinforcement came second at 1.2 sigma. The 2 sigma figure belongs to one-to-one tutorial instruction, which topped the list.

25. B Mastery learning with feedback-corrective cycles, and student time on task

Feedback-corrective mastery learning and time on task each hit 1 sigma. One-to-one tutorial instruction sits at 2 sigma, reinforcement at 1.2 and cooperative learning at 0.8, so every pair containing one of those misses the mark.

26. A 0.6 sigma

Classroom morale sat at the bottom of the ranking at 0.6 sigma. 0.8 sigma belongs to cooperative learning and graded homework, the next rung up.

27. C Reinforcement, cooperative learning, classroom morale

Reinforcement 1.2, cooperative learning 0.8, classroom morale 0.6 — a correct descending order. Every other option puts a smaller effect ahead of a larger one.

28. D One-to-one tutorial instruction

One-to-one tutorial instruction topped Bloom's ranking of alterable variables at 2 sigma, the largest effect size measured.

29. B 2 sigma

Bloom's alterable-variables ranking put one-to-one tutorial instruction at 2 sigma — the top of the list.

30. C Classroom morale

Classroom morale contributed the smallest effect, 0.6 sigma, placing it at the bottom of Bloom's ranking of alterable variables.

31. A 0.6 sigma

Classroom morale reached only 0.6 sigma — the smallest effect size in Bloom's ranking of alterable instructional variables.

Lesson 4: The Cognitive Science of Learning

1. C Anxiety

Challenge above skill produces anxiety; challenge below skill produces boredom. Flow lives in the balance between the two.

2. A 1975

3. D Autotelic

Autotelic means rewarding in itself, with no external payoff — the mark of flow. Exotelic describes activity pursued for an outside reward, the opposite case; vicarious describes learning by watching someone else act; habitual describes a routine done from repetition, not a reward structure.

4. B Boredom

When challenge is far below skill, engagement collapses into boredom — the mirror-image failure mode to anxiety, which occurs when challenge exceeds skill.

5. D Boredom

Flow theory holds that a task far easier than the learner's skill produces boredom, while one far harder produces anxiety.

6. B Allan Paivio, 1971

Allan Paivio proposed Dual Coding Theory in 1971. Sweller (1988) gave us Cognitive Load Theory and Gagné (1965) the Conditions of Learning — different theories entirely.

7. C Verbal and visual

Paivio's model pairs a verbal system (language, text, narrative) with a visual system (imagery, spatial layout). Episodic/semantic, working/long-term and implicit/explicit are all real memory distinctions, but none is the pair Dual Coding Theory is built on.

8. A Interconnected, with each able to encode information on its own

Paivio describes the verbal and visual systems as interconnected: each can encode information independently, and learning improves when both are engaged at once. They remain two systems rather than one merged trace, and neither recodes for or directs the other.

9. A It encodes the material through both memory channels at once

The diagram engages the visual system while the spoken explanation engages the verbal one, so the same material is encoded twice, at the same time. The channels stay distinct: the material is neither split between them, merged into one trace, nor passed through them one after the other.

10. B A wall of unbroken text

Text alone engages just the verbal system. The other three each combine imagery with language, engaging both channels — the whole point of dual coding.

11. A Germane load

In 1998, germane load was the resources spent building schemas, to promote once extraneous load (from poor design) was cut; intrinsic load comes from the material. Sweller later (2010) recast germane load as resources spent on intrinsic load.

12. C John Sweller, 1988

Sweller advanced Cognitive Load Theory in 1988, building on the working-memory limit George Miller had quantified in 1956. Paivio's 1971 work is Dual Coding Theory, and Gagné's 1965 Conditions of Learning is an instructional-design framework.

13. C 7

Miller's 1956 paper put working memory at about 7 ± 2 chunks. Cowan (2001) later argued the true limit is nearer 4, so the figure is debated, but 4 is the later estimate, not Miller's. 10 and 14 overshoot Miller's range.

14. D Extraneous load

Extraneous load is unnecessary complexity from poor instructional design, and should be cut. Germane load (1998 sense) is schema-building effort, intrinsic load comes from the material, and perceptual load is an attention-research term, not a CLT load type.

15. B The inherent complexity of the material

Intrinsic load comes from the inherent complexity of the material, relative to what the learner already knows; better design cannot remove it. Design quality governs extraneous load, schema-building effort is 1998-sense germane load, and working memory's limit is why load matters.

16. A Chunking

Chunking exploits working memory's limit: grouping raw items into meaningful units (1-4-9-2 becomes 1492) reduces the slots they occupy. Spaced repetition spreads reviews over expanding intervals, scaffolding is temporary support, and the Method of Loci places items along a mental route.

17. D Chunks

Working memory holds a limited number of chunks of information at once, the meaningful units chunking creates. A schema is a stored framework for interpreting information, verbal and visual are dual coding's two channels, and nodes are the points in connectivism's network.

18. B Toward know-where — accessing and evaluating information

Connectivism argues the capacity to know where to find, evaluate, and contextualize information outweighs memorized facts — especially when an LLM can answer anything instantly.

19. A Learning that occurs outside the human mind, in networks and systems

Siemens and Downes argued behaviorism, cognitivism, and constructivism all locate learning inside the individual, missing learning that happens in networks, organizations, and digital systems.

20. C Cognitive strategies

Gagné's five outcome categories are verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes — each requiring a different type of instruction.

21. B Gain attention

The sequence opens by gaining attention (reception), then informs learners of objectives, and ends by enhancing retention and transfer.

22. A Siemens & Downes, 2004

George Siemens and Stephen Downes developed connectivism in 2004–05, starting from Siemens's 2004 paper. Anderson and Krathwohl's 2001 revision of Bloom's taxonomy, Gagné's 1965 Conditions of Learning and Sweller's 1988 load theory all predate the network framing.

23. D Knowing where to find and evaluate information

Connectivism's core claim is that knowing where to find information — the 'know-where' — outweighs knowing the facts themselves, especially now that AI can answer instantly.

24. C Learning that happens outside the mind, across networks

Connectivism argued behaviorism, cognitivism, and constructivism only accounted for learning inside an individual mind, missing learning distributed across networks and systems.

25. C Motor skills

Gagné's five learning-outcome categories are verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes.

26. B Gain attention

Gagné's sequence opens by gaining attention, since information that goes unattended is never encoded in the first place.

27. A Engagement

UDL's three principles map to what (Representation), how (Action & Expression), and why (Engagement) — the why being motivation and interest.

28. D Spatial-episodic memory

By placing information along a familiar route, the method of loci leverages the brain's strong spatial-episodic memory — which is why memory champions use it to memorize thousands of digits.

29. D Reinforcement

UDL's three principles are Representation (the what), Action & Expression (the how), and Engagement (the why). Reinforcement belongs to behaviorism, not UDL.

30. A Link a foreign word's sound to an image that bridges to its translation

The Keyword Method is a language mnemonic — e.g. picturing a four (quatre) on a fork for fourchette. Placing items along a route is the Method of Loci, a different technique.

31. B Ancient Greece and Rome

The Method of Loci comes from ancient Greece and Rome, where orators used it to hold long speeches in sequence. It long predates the Renaissance revival of the technique.

32. C A vivid image that bridges to the translation

The Keyword Method links a foreign word's sound to a memorable image that then bridges to its translation — a different mechanism than the Method of Loci's spatial route.

33. C Picturing a four on a fork to remember "fourchette"

This Keyword Method example links the sound of "fourchette" (fork) to a picture of a four (quatre) on a fork, bridging sound to translation via imagery.

Lesson 5: Instructional Design Frameworks

1. D Florida State University's Center for Educational Technology, 1975

ADDIE was developed in 1975 at Florida State University's Center for Educational Technology. 1978 is the Dick & Carey Model's date, not ADDIE's.

2. A The U.S. Army

The U.S. Army commissioned ADDIE to bring engineering-style rigor to training production. The other services were not the commissioning body.

3. C Analyze

Analyze is the front-end phase that establishes goals, audience, prior knowledge, and constraints. Design comes next and instead defines objectives, assessment, and sequencing.

4. B Design — define objectives, assessment strategy, sequencing, and modalities

Design follows Analyze, and it is where objectives, assessment strategy, sequencing, and modalities are set. Producing the actual content is Develop, the phase after Design.

5. C Develop

Develop is the build phase — producing the content, activities, and assessments. Implement would be delivering that finished material to learners.

6. A It threads through all five phases, surfacing problems early rather than only at the end

ADDIE's Evaluate is not a final gate — it runs continuously through Analyze, Design, Develop, and Implement, catching design flaws early instead of waiting until after delivery.

7. D Design flaws surface early rather than after delivery

Continuous evaluation catches problems while they are still cheap to fix, instead of waiting until learners have already received the course. It does not merge or reorder the other four phases, and it does not lighten the documentation ADDIE is valued for.

8. B Evaluate

Evaluate is ADDIE's continuous quality check — it threads through the other phases instead of running once. Implement, by contrast, is the discrete delivery step.

9. A Evaluate should thread through every phase, not act as a final gate

Deferring all feedback to after launch treats Evaluate as a final gate, which is exactly what ADDIE says it is not. The other options are not ADDIE principles at all: Analyze runs once up front, Develop waits for Design's objectives, and Implement is the discrete delivery step.

10. B It is continuous, feeding findings back into the earlier phases

A final gate runs once at the end; ADDIE's Evaluate runs throughout and returns findings to earlier phases of the same project. It is not a one-off front-end step, and it is not limited to compliance work.

11. D SAM (2012)

SAM, Michael Allen's Successive Approximation Model, is the iterative counterpoint to ADDIE, built on rapid prototyping and short revision cycles.

12. C Task-centered 'first principles' of effective design

Merrill's Principles are task-centered 'first principles' — problem-centered, activation, demonstration, application, integration. The nine-component systems view is Dick & Carey.

13. B Dick & Carey Model

The Dick & Carey Model (1978) takes a systems view of instruction as nine interacting components, and is more prescriptive than ADDIE.

14. C Understanding by Design

Understanding by Design (1998) is built on exactly this outcome-first, work-backward sequence. The Successive Approximation Model (SAM) would instead push them toward early prototyping.

15. A SAM (2012) — a linear, phase-by-phase process built for thorough documentation

SAM is rapid, agile, explicitly iterative prototyping; the linear, documentation-heavy description belongs to ADDIE, the model SAM was built as a counterpoint to.

16. D Understanding by Design (Wiggins & McTighe)

Understanding by Design (1998) is the framework that defines backward design — starting from desired learning outcomes and working back.

17. A Cathy Moore

Action Mapping is Cathy Moore's performance-focused method. Michael Allen created SAM, Grant Wiggins co-created Understanding by Design with Jay McTighe, and Robert Gagné's contribution is the Nine Events of Instruction.

18. C Strip out 'nice to know' content and design around what learners must do on the job

Action Mapping is performance-focused: cut the 'nice to know' and design around real on-the-job actions. Starting from outcomes and working back is backward design (UbD); task-centered first principles are Merrill's; successive-approximation prototype loops are SAM's.

19. D Backward design

This outcomes → assessments → instruction order is backward design, from Wiggins and McTighe's Understanding by Design. Performance-focused design (Action Mapping) would instead start from required on-the-job performance; task-centered design is Merrill's and rapid prototyping is SAM's.

20. B Backward design starts from desired learning outcomes; Action Mapping starts from on-the-job performance

Backward design (Wiggins & McTighe, UbD 1998) works back from desired learning outcomes; Action Mapping (Cathy Moore, 2008) starts from required on-the-job performance.

21. D Strategic questions that make learners surface and examine their own reasoning

The Socratic method is teaching through probing questions so learners reach the insight themselves. Journals, worked examples and group projects are other ways to engage reasoning, but none is the Socratic method's means.

22. C Sal Khan

Sal Khan built Khanmigo. Chrisman Frank founded Synthesis, a rival AI tutor; Stephen Downes co-developed connectivism; John Warner is the critic who reviewed Brave New Words.

23. B Guide them through it with probing questions

Khanmigo guides students through problems with probing questions rather than surfacing the answer — that is the Socratic design choice. Walking them through a worked solution, swapping in an easier task or re-explaining the concept all hand over what Khanmigo withholds.

24. A Knowledge constructed through guided questioning encodes more durably than knowledge merely received

The design rests on the finding that knowledge a learner constructs through guided questioning encodes more durably than knowledge simply handed over. Modality preference is not the supported claim here.

25. C Delivering the conclusion directly so the learner can memorize it

Handing over the conclusion is the opposite of the Socratic method, which presses the learner with questions, forces them to examine their own reasoning and leaves them to reach the insight themselves.

Lesson 6: Brave New Words: AI & Education

1. C Where they are, what they know, how they learn, and what engages them

The personalization problem is defined as understanding where a specific learner is, what they know, how they learn, and what engages them. The other options list demographic or diagnostic data, not the four dimensions Khan names.

2. A That level of individual attention required expensive private tutors

Khan's framing is economic: understanding each learner individually was historically only possible with expensive private tutoring, which wealthy families could buy and under-resourced students could not.

3. B Two standard deviations

Bloom's 2 Sigma Problem (1984) found a two-standard-deviation advantage for tutored students — the gap Khan argues AI can finally close at scale. Mastery learning alone reached about one sigma in Bloom's comparison, and nothing in his ranking of alterable variables came near three.

4. D AI tutoring should replace the teacher's professional judgment

Khan explicitly says the technology does not replace the teacher's judgment; it fills the hours between classes. The other three are claims the book makes directly.

5. B The gap between what tutored and classroom learners achieve

This is Bloom's 2 Sigma gap — the tutoring advantage no systemic intervention has closed at scale. Khan frames free, ubiquitous tutoring as the first credible answer to it; the other gaps are real complaints about schooling, but none is the one Bloom measured.

6. C The Diamond Age

Khan opens with three touchstones: The Diamond Age, where an AI tutor transforms a poor girl's life; Ender's Game, for challenge-driven simulation learning; and Asimov's "The Fun They Had", where a future child finds a classroom of peers exotic. Snow Crash, also by Stephenson, is not among them.

7. A An AI tutor becomes a poor girl's greatest educational resource

The Diamond Age features an AI tutor that transforms a poor girl's life — the equity vision at the heart of Khan's argument. The simulated-battle and marvelling-at-a-classroom visions belong to Ender's Game and 'The Fun They Had'; a shared virtual classroom appears in none of the three.

8. D Ender's Game

Ender's Game supplies the challenge-driven simulation model. The Diamond Age supplies the AI-tutor-as-equalizer image, and 'The Fun They Had' the exotic-classroom image; Snow Crash is not a touchstone at all.

9. C A future child finds a classroom of other children exotic

Asimov's story imagines a future child for whom a room full of peers is an exotic concept. The rescue-from-poverty and battle-simulation ideas come from The Diamond Age and Ender's Game; the virtual-world school belongs to none of Khan's three touchstones.

10. A Each imagines personalized, adaptive instruction available to any child

Khan opens with three works of speculative fiction that each imagine personalized, adaptive instruction regardless of wealth. Two of the three put a machine rather than a human mentor at the centre, and each follows a single child rather than a class or a community.

11. D Snow Crash

Snow Crash does not appear as an inspiration, while The Diamond Age, Ender's Game, and "The Fun They Had" are Khan's three cited works.

12. B "With me"

The pun is on conmigo, Spanish for 'with me' — encoding a tutor that accompanies rather than lectures. The other glosses are plausible Spanish-sounding readings but not what conmigo means.

13. D GPT-4, in partnership with OpenAI

Khanmigo is built on GPT-4 in collaboration with OpenAI, serving as Khan Academy's proof of concept for the book's thesis.

14. C The Socratic method — guiding toward answers through questions

Khanmigo guides students toward answers via Socratic dialogue and never simply delivers them. Direct instruction is closest to what the design deliberately avoids; the flipped classroom is a Khan Academy association, not the tutor's method.

15. A It would undermine the productive struggle that makes learning stick

The design choice is pedagogical: a system that supplies answers on demand undermines the productive struggle that makes learning stick — knowledge a learner constructs through guided questioning encodes more durably than knowledge merely received.

16. B Ask a question that moves the student toward the next step

Khanmigo is built to refuse direct answers and respond with guiding questions, because handing over the answer would undermine the productive struggle that makes learning stick.

17. B substitutes technology optimism for rigorous pedagogical evidence

Warner charges that Khan assumes transformation will happen because the tools are impressive, not because controlled research shows learning gains. The other options describe positions the book actually takes the opposite of.

18. C College admissions, the workplace, and civic participation

Khan names college admissions, the workplace, and civic participation — treating AI tutoring as lifelong infrastructure rather than a school feature.

19. D It is a lifelong utility, like electricity or the internet — not a school feature

The infrastructure framing is about scope: AI tutoring is a lifelong utility the way electricity and the internet are not just for students.

20. A Transparency, human oversight, and ongoing evaluation

Khan's responsible-deployment argument rests on transparency, human oversight, and ongoing evaluation — adopting imperfect tools carefully rather than waiting for hallucination, bias and privacy risks to disappear.

21. D Controlled research showing students using the AI tutor learn more

Warner's objection is that Khan expects transformation because the tools are impressive, not because controlled research shows learning gains.

Lesson 7: The Modern EdTech Landscape

1. B Lesson planning, rubric generation, and admin reduction

Teacher Tools keep the human educator central by handling lesson planning, rubrics, and administrative load. Adaptive one-to-one tutoring is the AI Tutors category, progress tracking is Assessment & Analytics, and source-grounded document synthesis is Research Assistants.

2. A Enterprise / Workforce

Enterprise / Workforce platforms focus on upskilling and corporate training where measurable job-readiness matters to the buyer. Assessment & Analytics is Gradescope, Eedi, and MagicQuizzes.

3. C Khanmigo, Synthesis, and LearnLM

The AI Tutors category covers Khanmigo, Synthesis, and LearnLM: adaptive, conversational 1:1 instruction, the closest digital analog to a personal teacher.

4. D Progress tracking that surfaces where a class is collectively lost

Assessment & Analytics tools handle progress tracking and formative assessment, surfacing where a class is collectively lost. Adaptive vocabulary sequencing is Language Learning, source-grounded synthesis is Research Assistants, and game-based challenges are Micro / Game.

5. C Micro / Game Learning — a consolidation and motivation layer

Kahoot, Blooket, and Synthesis Teams are Micro / Game Learning: game-based, challenge-driven engagement used primarily as a consolidation or motivation layer, not as primary instruction.

6. B The Socratic method of questioning

Khanmigo uses the Socratic method, guiding students with questions rather than supplying the answer.

7. A Built for the SpaceX employee school

Synthesis was built for the SpaceX employee school and founded by Chrisman Frank.

8. D 700,000

Khanmigo served 700,000 K-12 students by 2024–25. The 2+ million figure belongs to MagicSchool AI — but that counts educators, not students.

9. D Sequencing and personalizing lessons from performance history

BirdBrain is the proprietary adaptive engine that sequences and personalizes lessons from each learner's performance history. Roleplay scenarios, 'Explain My Answer', and the Lily open-conversation chat mode are GPT-4-powered Max-tier features layered on top of it.

10. C Software that adjusts content, sequence, and difficulty in real time from performance history

An adaptive learning system adjusts content, sequence, and difficulty in real time based on each learner's performance history — Duolingo's BirdBrain is the example. Source-grounded responses describe NotebookLM instead.

11. B BirdBrain

BirdBrain is Duolingo's proprietary adaptive model; Max is the GPT-4 tier built on top of it, and Lily is a chat mode within Max.

12. A Adjusts content, sequence, and difficulty in real time

BirdBrain is an adaptive system that adjusts content, sequence, and difficulty in real time based on learner performance history.

13. C SpaceX

Synthesis was built for the SpaceX employee school, which is said to explain its design focus on problem-solving over test prep.

14. D Chrisman Frank

Synthesis was founded by Chrisman Frank, built originally for the SpaceX employee school.

15. A Students paired with less-experienced tutors

Gains reached up to 9 points for students with less-experienced tutors — the AI raised the floor of tutor quality.

16. B 66%

LearnLM students hit 66%, ahead of the human-tutor group's 61% and static hints' 56%. The 76% option rounds the 76.4% share of LearnLM responses human tutors approved with little or no edits — a quality signal, not the outcome.

17. A LearnLM responses human tutors approved with little or no edits

Human tutors reviewing LearnLM's responses approved 76.4% with little or no edits — a quality signal, not an outcome or preference measure. The outcome measure was the 66% success rate.

18. C It models both the subject and the learner's evolving understanding

An intelligent tutoring system models both the subject and the learner's evolving understanding to deliver individualized feedback — that dual model is what a static-hints tool lacks.

19. B AI tutor, human tutor, static hints

The AI tutor (LearnLM) led at 66%, the human-tutor group followed at 61%, and static hints trailed at 56% — a 10-point spread between best and worst.

20. D Workforce training

2025 EdTech deal volume split workforce training 38%, K-12 36%, post-secondary 22%, and early childhood 4%. Workforce narrowly led — mirrored by the year's two biggest deals, Workday–Sana and Coursera–Udemy.

21. A $1.72 billion → $5.47 billion

The adaptive learning platform market was $1.72B in 2025, projected to $5.47B by 2032 — roughly 3x over seven years. The $2.6B figure is total 2025 global EdTech investment, a different measure.

22. C About 11%

2025 global EdTech investment reached $2.6B, up roughly 11% over 2024, with capital concentrating in AI-enabled and workforce-aligned products. The 38%, 22%, and 4% figures are 2025 deal-volume shares (workforce, post-secondary, early childhood), not growth rates.

23. D Workday–Sana $1.1B; Coursera–Udemy $2.5B

Workday acquired Sana for $1.1B, and Coursera's all-stock acquisition of Udemy was $2.5B (Dec 2025). The $1.72B and $2.6B figures are the 2025 adaptive-learning market size and total EdTech investment, not deal values.

24. B 290 million learners and 18,000 enterprise customers

The $2.5B all-stock Coursera–Udemy deal combined into 290 million learners and 18,000 enterprise customers. The other pairings each swap in an incorrect figure for one or both numbers.

25. A $2.6 billion

Global EdTech investment hit $2.6 billion in 2025 — distinct from the $1.72B/$5.47B adaptive-learning market-size figures.

26. D 11%

Global EdTech investment rose roughly 11% over 2024 — a different statistic from the 30-50% learning-time and 15-25% outcome figures.

27. C Research Assistants

NotebookLM ingests documents to build a research-grounded knowledge base — a research assistant, alongside Perplexity.

28. B Micro / Game Learning

Synthesis itself is the K-6 adaptive math tutor and sits under AI Tutors with Khanmigo and LearnLM; Synthesis Teams appears under Micro / Game Learning alongside Kahoot and Blooket, as a game-based consolidation and motivation layer rather than primary instruction.

29. B Diffit

MagicSchool and Diffit are both Teacher Tools — lesson planning, rubric generation, admin reduction. Kahoot is Micro / Game Learning, Eedi is Assessment & Analytics, and Sana is Enterprise / Workforce.

30. A Duolingo — Language Learning

Duolingo is the flagship of Language Learning (with Lingokids), where adaptive vocabulary sequencing and conversation practice replace rote drills. The other three platforms are correctly paired but serve different functions.

31. C Perplexity — Research Assistants

Perplexity is filed with NotebookLM under Research Assistants — document synthesis and multi-source retrieval. Duolingo and Lingokids anchor Language Learning, not game learning or AI tutoring, and Gradescope sits in Assessment & Analytics rather than Teacher Tools.

Lesson 8: LMS, Standards & Gamification

1. B 1924

Pressey's typewriter-sized machine appeared in 1924, presenting multiple-choice questions and advancing only on a correct answer. The other years bracket it but are not the milestone.

2. C 1960

PLATO (Programmed Logic for Automated Teaching Operations) launched in 1960 — a mainframe system with simultaneous users and touchscreens, anticipating modern e-learning by thirty years.

3. D 2002

Moodle arrived in 2002, a year after SCORM, shifting power toward institutions unwilling to pay enterprise licensing fees. 1998 predates the open-source release; 2006 and 2011 fall too late, into the web and cloud LMS eras.

4. A Pressey's machine → PLATO → SCORM → Moodle

The order is 1924 (Pressey), 1960 (PLATO), 2001 (SCORM), 2002 (Moodle). Pressey's mechanical machine came 36 years before Bitzer's mainframe, and SCORM arrived the year before Moodle, not the year after.

5. D 36 years

1960 minus 1924 is 36 years, mechanical era to mainframe era. The other gaps each swap a wrong year in for one milestone — 22 years counts from 1938, 48 from 1912 (or to 1972), 61 to 1985.

6. C Canvas

Canvas is instruction-friendly and has been taking market share from Blackboard. Moodle is the open-source global leader; Brightspace is another current leader.

7. B Moodle

Moodle's constructivist design and zero cost made it the global open-source leader. Canvas and Blackboard are commercial; PLATO was a 1960 mainframe system.

8. A Blackboard

Blackboard was the long-entrenched incumbent whose clunky UX and pricing let Canvas take share. Moodle competed on cost, and Canvas is the one praised for a clean interface.

9. D Instructure

Canvas is built by Instructure. Blackboard Inc. sells the rival product Canvas took share from, while PowerSchool and McGraw Hill are other education-technology vendors with no hand in Canvas.

10. C The mainframe era

PLATO was Bitzer's 1960 mainframe-based system at the University of Illinois, with simultaneous users and touchscreens. Pressey's 1924 machine belongs to the mechanical era; Moodle arrived with the web, and Canvas and Blackboard fought it out in the cloud/SaaS era.

11. B Learning activity in simulations, apps, and the physical world

The xAPI (Tin Can) era extended tracking beyond the LMS into simulations, mobile apps and the physical world. A common packaging language is SCORM, immediate corrective feedback is Pressey's 1924 teaching machine, and simultaneous touchscreen users is PLATO.

12. A Sharable Content Object Reference Model

SCORM is the Sharable Content Object Reference Model, introduced in 2001 to give vendors a common language for packaging and tracking content across LMSs. The other expansions keep the initials but swap in look-alike words; none is the standard's name.

13. A A common language for packaging and tracking content across LMSs

SCORM (v1.0 in 2000, widely adopted as v1.2 in 2001) gave vendors a common language for packaging and tracking content across LMSs. Immediate corrective feedback is Pressey's teaching machine, free open-source course software is Moodle, and touchscreen users sharing a mainframe is PLATO.

14. B The xAPI (Tin Can) era

The xAPI (Tin Can) era extended tracking beyond the LMS boundary into simulations, mobile apps, and the physical world. The SCORM era packaged and tracked content across LMS platforms, and the PLATO mainframe and Pressey teaching-machine eras came decades earlier.

15. D xAPI (Tin Can)

xAPI (Tin Can) extended tracking beyond the LMS boundary, logging learning activity in simulations, mobile apps, and the physical world. SCORM gave vendors a common language for packaging and tracking content across platforms; Moodle and Canvas are LMS platforms.

16. C Content packaged and tracked consistently across different LMSs

SCORM (2001) gave vendors a common language for packaging and tracking content across different LMSs. Activity logged in simulations, mobile apps, or the physical world belongs to the later xAPI (Tin Can) era; the three-need theory is Self-Determination Theory.

17. B A workshop simulation completed away from any LMS

xAPI (Tin Can) extended tracking beyond the LMS boundary to simulations, mobile apps, and the physical world — exactly this kind of off-platform activity. A quiz score, a completion flag, and a package copied between LMSs all stay inside SCORM's LMS-bound tracking.

18. A A Learning Record Store

A Learning Record Store (LRS) is the server that receives, stores and gives access to xAPI statements. The simulator itself is the Learning Record Provider that sends them, a SCORM package is content, and PLATO was a 1960 teaching system.

19. D Actor, verb and object

The xAPI spec requires every statement to use an actor, a verb and an object: the 'I did this' of 'a learner completed a fire-drill simulation.' Result and context are optional extras, and the provider and store are the systems that send and hold statements.

20. C Mastery framing

Mastery framing treats failure as feedback, not a verdict. Narrative framing supplies the fantasy Malone identified; scaffolded difficulty implements the ZPD; social connection drives leaderboards and co-op.

21. C Nick Pelling, 2002

Nick Pelling coined gamification in 2002. Malone's 1980 research predates the term; McGonigal and Kapp wrote later books but did not name the concept.

22. D Applying game design elements to non-game contexts to boost engagement

Gamification applies game elements — points, badges, leaderboards, levels, narrative — to non-game contexts. What makes games engaging was Malone's 1980 question, building actual games is a different practice, and rule-defined conflict is Salen & Zimmerman's definition of games.

23. A Jane McGonigal

McGonigal's Reality Is Broken argued games motivate better than real-world institutions. Kapp wrote The Gamification of Learning and Instruction (2012); Schell gave the 2010 DICE talk.

24. B Thomas Malone — Rules of Play (2003)

Rules of Play (2003) is Salen & Zimmerman's. Malone's 1980 research identified challenge, fantasy, and curiosity as what makes games engaging. McGonigal, Schell, and Deci & Ryan are each paired correctly.

25. B Deci & Ryan, 1985

Edward Deci and Richard Ryan developed SDT in 1985. Malone researched game motivation, Pelling coined gamification, and Salen & Zimmerman wrote the game-design rules text.

26. D Autonomy, competence, relatedness

SDT names autonomy, competence, and relatedness. Challenge, fantasy, and curiosity are Malone's game-motivation drivers; points and badges are surface mechanics, not needs.

27. A Autonomy

Autonomy is feeling in control of one's actions, which choice of path directly serves. Competence comes from progressive difficulty; relatedness from cooperative or competitive play. Curiosity is one of Malone's game-motivation drivers, not an SDT need.

28. C One that is intrinsically rewarding, done for its own sake

Autotelic means intrinsically rewarding — done for itself, not an external payoff, and the engagement from which flow emerges. Chasing points or prizes is the extrinsic opposite.

29. A The overjustification effect

The overjustification effect: external rewards for an already-intrinsically-motivating task can undermine intrinsic motivation. The challenge-skill balance is flow's precondition, reinforcement schedules are Skinner's reward timing, and mastery framing treats failure as data.

Lesson 9: Who's Who & What's What of Learning

1. C Ivan Pavlov

Pavlov was the Russian physiologist whose salivating dogs revealed classical conditioning. Skinner is the other behaviorist, but his work was on operant conditioning — reinforcement shaping voluntary behavior.

2. D B.F. Skinner

Skinner studied operant conditioning — reinforcement shaping voluntary behavior — and developed programmed-instruction teaching machines. Pavlov's conditioning was classical (reflexive), not operant.

3. B Jean Piaget

Piaget mapped the four stages of children's cognitive development and described assimilation and accommodation. Vygotsky is the other constructivist, but his contribution was the social view of learning.

4. A Defining the gap between solo and supported performance

Vygotsky, who argued that learning is social, defined the gap between solo and supported performance — the Zone of Proximal Development. The stages of cognitive development are Piaget's, the separate coding of words and images is Paivio's, and "learn by doing" is Dewey's.

5. C John Dewey

"Learning by doing" is the slogan most associated with Dewey, the great American pragmatist. Piaget also studied active meaning-making, but learning by doing is Dewey's.

6. B Two standard deviations

Bloom's 1984 result — the '2 sigma problem' — found one-to-one tutoring raised average students two standard deviations above classroom peers. It's the benchmark adaptive and AI tutoring try to reach at scale.

7. A Hermann Ebbinghaus

Ebbinghaus used nonsense syllables in the 1880s to chart the first forgetting curve. Paivio is also a memory researcher, but his contribution was dual coding — words and images as separate codes.

8. D Mihaly Csikszentmihalyi

Csikszentmihalyi named Flow — total absorption where challenge meets skill, exactly what the designer is tuning for. Siemens is a modern figure too, but he updated learning theory for networks and devices.

9. A A view of knowledge as distributed across networks and devices

Siemens updated learning theory for a world of networks and devices — connectivism. The two-standard-deviation tutoring finding is Bloom's, the nonsense-syllable forgetting curve is Ebbinghaus's, and words and images as two channels is Paivio's dual coding.

10. C Sal Khan

Sal Khan, a former hedge-fund analyst, built a global tutoring nonprofit and published a 2024 manifesto for AI in education. Siemens also works on digital-age learning, but from networks theory, not tutoring at scale.

11. D Quizzing yourself from memory

The Testing Effect shows that pulling information *out* of memory — self-quizzing — beats putting it back *in* by re-reading or highlighting. Retrieval is the more effortful, and more durable, practice.

12. B The Forgetting Curve

The Forgetting Curve is the steep decay of unreviewed memory, first charted by Ebbinghaus. Spaced Repetition is the countermeasure — the scheduling of reviews — not the decay itself.

13. B Spaced Repetition

Spaced Repetition schedules reviews at expanding intervals, which is why it defeats the Forgetting Curve. The Testing Effect is about how you review (retrieval), not when.

14. A Zone of Proximal Development

The Zone of Proximal Development is the band between what a learner can do alone and with support, which is this gap. Cognitive Load Theory is about working memory, Self-Determination Theory about motivation, Conditions of Learning about outcome types; only the ZPD involves another person.

15. D Pulling information out of memory beats re-reading it

The Testing Effect — retrieval practice — is the finding that pulling information out of memory, as in self-quizzing, beats re-reading. Expanding intervals are Spaced Repetition, words plus images is Dual Coding, and challenge matched to skill is Flow.

16. C Analyze, Design, Develop, Implement, Evaluate

ADDIE = Analyze, Design, Develop, Implement, Evaluate — the dominant instructional-design framework, taking a course from needs analysis through build-out to a final evaluation.

17. A Bloom's Taxonomy

Bloom's Taxonomy is the six-level hierarchy of cognitive objectives, Remember to Create. The affective domain is Bloom's team's five-level companion (Receiving to Characterizing), and the Kirkpatrick Model's four levels evaluate training rather than rank learner thinking.

18. D Cognitive Load Theory

Cognitive Load Theory is about managing working memory's hard limits — overloading them stalls learning. Dual Coding's two channels (words and images) are a remedy, not the explanation; the Forgetting Curve and Testing Effect concern memory after a lesson, not a stall mid-lesson.

19. B Flow — effortless immersion when challenge matches skill

Flow is effortless immersion when challenge matches skill. The others are mismatched: managing working memory's limits is Cognitive Load Theory, steep decay of unreviewed memory is the Forgetting Curve, and Connectivism puts learning in networks, not inside the mind.

20. C It reframes knowledge as distributed across networks for the digital age

Connectivism reframes knowledge as distributed across networks, updating learning theory for the digital age. Siemens and Downes argued that older theories missed learning outside the individual mind, and that knowing where to find information now outweighs knowing it by heart.

Lesson 10: Essential Vocabulary & Quick Recall

1. D Carnegie Mellon, originally mathematics

The Cognitive Tutor was built at Carnegie Mellon. It models student cognition and delivers personalized hints and feedback within one domain — originally mathematics — making it the textbook example of an ITS.

2. B Content difficulty, sequence, and modality

An ALS is defined by adjusting content difficulty, sequence, and modality from ongoing performance data. Content, process and product are differentiated instruction's levers; representation, expression and engagement are UDL; autonomy, competence and relatedness are SDT.

3. C It replaces hand-crafted probability tables with a recurrent neural network (LSTM) hidden state

DKT models learner knowledge as an LSTM hidden state evolving with each interaction, replacing BKT's hand-crafted probability tables. Both model the learner and update after every response, so the domain-and-pedagogy and end-of-unit options fail; replacing the network with tables is backwards.

4. A Knowledge State

The Knowledge State is the per-learner model of what is and isn't known, updated continuously. A knowledge graph maps objectives and dependencies, a learning ontology formalizes a domain's concepts, and learner analytics measures and reports data — none is one learner's standing.

5. D Award a completion certificate once the unit timer expires

The loop is observe, update state, select next item, repeat. Timer-based certificates are the opposite of algorithmic sequencing, which selects items from the predicted knowledge state.

6. C It can autonomously plan, use tools, and pursue multi-step goals with minimal human intervention

Generative AI produces content; Agentic AI goes further, autonomously planning, using tools, and pursuing multi-step goals — able to orchestrate curriculum planning, content generation, assessment, and feedback in a single loop.

7. B Perform a task it was not explicitly trained on, generalizing from broad pre-training

Zero-shot means performing an untrained task by generalizing from pre-training — useful for curriculum on rare subjects. In-prompt examples make it few-shot, learning from unlabelled data is unsupervised training, and remembering past sessions is a memory feature, not zero-shot.

8. A Designing the inputs given to LLMs so they produce the desired instructional outputs

Prompt engineering is designing the inputs to LLMs so they produce the desired instructional outputs. Fine-tuning changes the model's weights — a different intervention entirely.

9. C Human-in-the-Loop (HITL)

HITL design has humans review, approve, or override AI outputs before delivery — the standard check against errors in edtech. An ITS is defined by teaching without a human teacher, UDL is a framework for building flexible curricula, and GenAI is the technology whose quizzes the teacher is checking.

10. B It represents domain concepts and their relationships, organizing curriculum graphs and recommendations

An ontology formalizes knowledge and concept relationships in a domain, and is used to organize curriculum graphs and content recommendations. The per-learner record of mastery is the Knowledge State, and the interoperability standard for learner data is xAPI, not an ontology.

11. D 2–10 minutes, built around a single learning objective

Microlearning delivers content in short, focused bursts of two to ten minutes, each built around a single learning objective — a format well suited to mobile usage and limited attention spans.

12. A Metacognition

Metacognition is thinking about one's own thinking — awareness of one's learning process, gaps, and strategies. Prompting learners to explain their reasoning targets exactly that awareness.

13. D A teacher tailors content, process, or product to individual needs within a group setting

Differentiated Instruction is the classroom precursor: teacher-led tailoring within a group. Tailoring pace, content, sequence, and modality to the individual is Personalized Learning, the broader term.

14. C Vygotsky's zone of proximal development

Scaffolding that fades as competence grows is a direct implementation of Vygotsky's zone of proximal development — the gap between solo and supported performance.

15. A Multimodal Learning delivers one modality at a time so working memory is never overloaded

Multimodal Learning engages several sensory channels — visual, auditory, kinesthetic — together to deepen encoding; it does not isolate them one at a time. The other three statements are accurate.

16. B Autonomy, competence, and relatedness

Deci & Ryan's Self-Determination Theory (1985) names autonomy, competence, and relatedness as the three needs behind intrinsic motivation — the framework cited most often in gamification and engagement design.

17. A About 7±2

Miller's classic estimate is roughly 7±2 items, and cognitive load theory is built on working memory's limit: overload it and learning degrades. Cowan (2001) later argued the limit is nearer 4.

18. B Chunking

Chunking breaks complex information into smaller, manageable units to reduce cognitive load and improve encoding — the direct response to working memory's limits.

19. D Transfer of Learning means repeating material until it can be recalled verbatim

Transfer of Learning is applying knowledge or skills from one context to new, different ones — the goal shallow memorization fails to reach. Verbatim repetition is the opposite of transfer. The other three are accurate.

20. C Knowing how to teach a specific subject, distinct from knowing the subject itself

PCK distinguishes knowing a subject from knowing how to teach it: a chemistry expert and a chemistry teacher have different knowledge, and PCK names what the teacher has that the expert may lack.

21. A Behavior

Kirkpatrick's four levels run Reaction (did they like it?), Learning (did they gain knowledge?), Behavior (did they apply it on the job?), and Results (did it affect outcomes?). Behavior is the application level.

22. B A low-stakes retrieval quiz during a unit that lets instruction adjust

Formative assessment happens during learning — low-stakes quizzes, check-ins, retrieval prompts — giving feedback so instruction can adjust.

23. C Capture experience statements across all learning contexts, so analytics follow the learner

xAPI is the interoperability standard that captures experience statements wherever learning happens, not just inside an LMS. Mastery probability estimation is BKT's job; dependencies are a curriculum graph's.

24. D Measuring, collecting, analyzing, and reporting data about learners and their contexts, to optimize learning

Learner Analytics covers measuring, collecting, analyzing, and reporting data about learners and their contexts to optimize learning. The exchange standard is xAPI; the four-level framework is Kirkpatrick.

25. B STEAM adds Assessment to the STEM disciplines

STEAM adds Arts — Science, Technology, Engineering, Arts, Mathematics — not Assessment. The other three statements match the definitions exactly.

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