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Active Learning: Engaging Students in Deep Thinking

Claire Major

Active learning has a long history in higher education, with Bonwell and Eison's (1991) influential report helping its rise to prominence in the early 1990s. Today, active learning remains a popular concept in college teaching. But what exactly do we mean when we use the term?

There are many views of what learning is and how it happens. One inclusive description of learning is that it is a process that leads to change (Barkley & Major, 2018). What that change is can vary. The change can involve acquiring content knowledge, developing a new skill, seeing the world in a new light, or other.

Whatever the change is, making it happen requires cognitive work on the part of the students. And as instructors, we can choose instructional strategies intentionally to support the process. Indeed, promoting and supporting learning is part and parcel of the job; as Angelo and Cross aptly suggested, "teaching without learning is just talking" (p. 3).

When we think of "active learning," we often think of instructional activities, such as think-pair-share or jigsaw. Over time, the term has become associated with instructional activities rather than the cognitive processes that those activities are intended to support. The challenge with this perspective is that an emphasis on activities can obscure and even undermine the fundamental goal of instruction: helping students learn through sustained and meaningful mental effort and engagement.

Active learning, however, is fundamentally about the quality and depth of students' thinking. Most instructional activities we ask them to complete can require active learning. Our task, then, is to make intentional choices about teaching activities that promote and support deeper levels of thinking relevant to the intended learning.

Redefining active learning: From activities to mental effort

My colleague Elizabeth Barkley and I have described active learning as the level of mental effort students put into their learning (Barkley & Major, 2018). What we mean by this is that cognitive engagement is itself more important than the outward apparent effort. Critically, we note that not all mental effort is equally productive. Thus, the challenge for

the instructor is not simply to choose activities that increase the amount of effort (which can be done via busywork) but instead to choose activities that encourage students to direct their efforts toward cognitive processes that support intended learning.

We also argue that learning activities do not predetermine the levels of thinking involved. This view challenges the common assumption that students are necessarily cognitively passive when listening to a lecture. Indeed, students can engage in substantial mental effort while listening, including investing attention, analyzing arguments, noting agreement or disagreement, and monitoring understanding and developing questions. Whatever activity we assign can engage students in basic-level cognitive processes or more complex ones.

See the following table for examples of levels of cognitive effort for several different instructional activities.

Table 1. Examples of cognitive processes across common learning activities

Activity	**Basic Cognitive Processes**	**More Complex Cognitive Processes**
Listening	Identifying facts	Evaluating arguments and monitoring understanding
Problem solving	Applying a familiar procedure	Recognizing structures and evaluating approaches
Reading	Locating information	Constructing meaning and evaluating ideas
Discussion	Reporting information	Evaluating perspectives and developing arguments
Writing	Describing concepts	Synthesizing, critiquing, and creating

Choosing instructional strategies to support active learning

The challenge is for instructors to assign activities that can produce the kind of learning they intend and then create conditions that promote and support active learning within those activities. Thus, active learning techniques (instructional activities) can support active learning (mental effort and engagement).

Table 2. Sample techniques to promote active learning

Activity	Sample Technique	Technique Description	How It Leads to Active Learning
Listening	Analytic Teams	Each team member assumes a different role with specific responsibilities to perform while listening to a lecture or watching a video.	Students listen, analyze information from a preassigned perspective, and evaluate ideas.
Problem solving	Case Studies	Students review a real-life problem scenario in depth.	Students apply concepts, analyze complex situations, and evaluate alternative solutions to real-world problems.
Reading	Active Reading Documents	Students complete a carefully prepared question set to use while reading.	Students actively interpret, question, and evaluate what they read while monitoring their own understanding.
Discussion	Jigsaw	Students work in expert groups to learn one part of a larger topic, then return to their home groups to teach what they have learned.	Students learn, organize, and explain information and deepen their understanding by teaching their peers.
Writing	Paper Seminar	Students participate in a structure process for meaningful discussion centered on student writing.	Students critically evaluate their own and others' writing, articulate their reasoning, and refine their thinking through discussion and feedback.

Simply using one of these activities does not guarantee deep thinking. Instead, success depends on how instructors structure the activity, set expectations, ask questions, and so forth, all of which influence the student experience and the mental effort learners willingly expend.

Evidence supporting active learning

A substantial body of research supports the efficacy of active learning in improving learning outcomes. In their now classic meta-analysis of 225 studies, Freeman et al. (2014), for example, found that undergraduate STEM students who learned in courses supported by active learning had higher performance on exams and lower failure rates than those who learned through lecture alone. These findings reinforce the importance of intentionally designing for cognitive effort.

Conclusion

Learning requires mental effort. Active learning means that students are engaging at a high level of mental effort. Viewing active learning as the depth and quality of mental effort and engagement rather than a specific instructional technique offers a new perspective for thinking about our work as instructors. The central question for instructors, then, is not simply whether students complete a learning activity but whether the activity helps them think deeply about what it is that they need to learn.

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Supporting Neurodivergent Students and Colleagues

Liz Norell

A few years ago, I had a student (let's call him George) whom I suspected was neurodivergent. He had many of the classically male neurodivergent traits: a propensity to explode with speech before I could finish answering a question and a tendency to get up during class and walk to the back of the room with no apparent or pressing reason, to name just two.

After teaching students like George for two decades, these ways of being no longer registered as problematic to me, so I just treated them like normal, everyday classroom behaviors. By semester's end, George had become a confident and integral part of the classroom community. On the last day of class, I told him that I appreciated his enthusiasm for our topic and his many valuable contributions to class. I think I used the word *intelligent* at some point.

George stilled. His body, normally in perpetual motion, barely moved as he looked at me in shock. "You . . . you think I'm *smart*?" he asked, the incredulity impossible to miss. Almost immediately, he was nearly in tears, telling me no teacher had ever said that to him before. I suspect the reason was the neurodivergence, the signals that suggested he was too undisciplined to learn—false signals, I hasten to add.

Defining key terms

We sometimes talk about different kinds of diversity that we value, be that the positive qualities of a biodiverse Earth, the benefits of a diverse array of gut microbes, or the strength that comes when we engage with diverse perspectives before forming an opinion. Neurodiversity is similarly beneficial. It refers to the naturally occurring diversity of neurological function that happens when two or more individuals are together.

Let's define some key terms:

- *Neurodivergent*: a person with a brain that processes information in a way different from most individuals, including a learning disability, attention deficit or anxiety disorder, obsessive-compulsive disorder, Tourette's syndrome, bipolar disorder, and more
- *Neurotypical*: a person with a brain that processes information in a way typical of most individuals
- *Neurodiversity*: a quality describing a group of people with diverse ways of processing information, including those considered typical

Because any learning space (or any group gathering, for that matter) includes people with diverse ways of knowing, processing information, and learning, all these spaces will be neurodiverse. Meeting the needs of the neurodivergent, though, requires some awareness and intentionality.

The word *accessibility* refers to the degree to which all people, including those with disabilities and those with limited English proficiency, can fully use or participate in services, facilities, or learning activities. As defined in the Americans with Disabilities Act,



disability is a physical or mental impairment that substantially limits one or more major life activities. In making the determination of disability, the ADA explicitly includes individuals who have a record of impairment, even if that impairment does not exist currently. The ADA also protects those who are assumed to be disabled, even if they are not.

Normalizing neurodivergence

The rates of neurodivergence among college students have been on the rise for many years. Among the reasons why:

- **Reduced stigma**. Data suggest that many individuals who are disabled or neurodivergent, or both, no longer feel as much shame or stigma as once existed.
- **Revised diagnostic criteria**. The American Psychiatric Association revised its *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)* in 2013 in ways that lowered barriers to diagnosis (e.g., Wills, 2014). In previous iterations, for example, the *DSM* specifically insisted that autism and ADHD could not co-occur in a single individual. The latest revision incorporates the latest research and wisdom about the ways many different neurodivergent conditions manifest in individuals, easing the path to diagnosis for many.
- **Greater understanding of gender-related differences**. Similarly, earlier understandings of the most common neurodivergent diagnoses (autism and ADHD) largely pathologized the more commonly male manifestations of the conditions. With greater research on gender-related differences, the *DSM-5* provides better tools to understand and diagnose neurodivergence among all people, regardless of gender identity.

In a bigger-picture sense, it's important for us to remember that we cannot always perceive disability. In fact, most disabilities are nonapparent. Because not all disabilities are readily apparent, this can create the perception of what's called the "disability con," or the notion that people who don't seem to be disabled from an outside perspective must be faking it to gain special treatment (Dorfman, 2019). There is little evidence that such deception occurs. Instead, the fear of being judged harshly prevents many individuals who need accommodations from asking for them.

It's likewise critical to remember that everyone will be disabled at some point in their life. At any given time, the CDC estimates that more than one in four adults in the United States have a disability. Some—perhaps many—are unaware that they do.

Three big differences

When we think about neurodivergence, there are three big categories of difference worth keeping in mind.

- **Executive functioning (EF)**. Think of EF as the command-and-control center of your brain. Your EF helps you organize your thoughts, prioritize tasks, remember details, plan ahead, stay focused, and set goals. Neurodivergence can compromise EF, leading to missed deadlines, forgotten tasks, or poor time management.
- **Sensory processing**. Neurodivergent brains process incoming information differently. As a result, any category of sensory information can be more challenging to parse than it is for neurotypicals: Smells, lights, sounds, touches, and tastes can be exquisitely sensitive for neurodivergent brains. If your student or colleague is experiencing the sensory environment as overwhelming, they will not be able to learn, focus, or complete work as well as they could in an environment with less sensory overwhelm.
- **Managing information**. Neurodivergent brains often struggle with memory (both short- and long-term), abstract thinking, or remembering key details. The reason could be EF challenges, or it might just be that they process information differently. Either way, expect that not all students will be able to manage information the same way you do.

Creating inclusive, neurodivergent-friendly practices

Although neurodivergence shows up differently for each person, there are clear ways to support your neurodivergent students and colleagues:

- **Make adjustments to environments**. Ask others for input on the sensory environment in which they are working. Are the lights too bright or too dim? How's the room temperature? Is the ambient noise conducive to learning or focus? And so on. Look for opportunities to adjust what you can to meet the needs of the students or colleagues in that space.
- **Collaborate on deadlines and pacing**. You may need students to move through course material at a particular pace, but that doesn't mean you must make all assignments due Sunday at 11:59 p.m. Ask your students (or your colleagues) when they do their best thinking and work, and see whether you can arrive at deadlines (and late policies) that work for the greatest number of them.
- **Openly welcome students of all abilities and neurotypes**. Creating a welcoming environment can be as simple as a statement that says: "I want to make sure you succeed in our course. If there's something I could adjust to make your success more

achievable, just ask." Don't assume every neurodivergent student has a diagnosis or formal accommodations; the testing process to obtain a diagnosis is lengthy and costly, and the process of requesting formal accommodations is often time-consuming. Look for ways to design your course so students need as few accommodations as possible, and every student will benefit.

- **Welcome self-accommodations**. Allow students to make themselves as comfortable as possible in the classroom, such as by moving their chair or desk to have more physical separation from classmates or sitting on the floor. Explicitly welcome things like doodling, knitting or crocheting, coloring, using fidget toys, or occasionally moving around the room. These behaviors don't indicate students are distracted; the fidgeting or doodling you see may be the very thing that allows neurodivergent students to stay cognitively engaged.
- **Communicate clearly and regularly**. Share your expectations and directions multiple times and explicitly. Don't assume your students can pick up on subtle cues or social norms. Limit your use of sarcasm or inside jokes—and if you use them, be over-the-top in signaling what you're doing. Define any subjective or unclear terminology in concrete terms (e.g., *professional*, *collaboration*, *effectiveness*). Provide written complements to any verbal directions and provide other ways to access important material outside class.
- **Ensure that social interactions are intentional and clear**. Normalize stimming behaviors in and out of class—by which I mean make them explicitly allowable, even encouraged. Clearly define the purpose of and expected roles in any interpersonal interactions (such as think-pair-share or group activities in class). Whenever possible, offer an option to work alone. Provide students with alternative ways (other than verbal) to communicate or interact with one another and with you.

Inclusive teaching helps everyone

I didn't know I was (multiply) neurodivergent until later in life—a common occurrence for women, by the way. Had my college instructors incorporated some of these practices, I would have learned much more as an undergraduate. And had my supervisors in previous jobs understood how to create neuroinclusive work environments, I would have spent far less time trying to navigate unclear expectations and norms.

Efforts you make to improve your neuroinclusion will help all your students and colleagues, including those who need it most—and those who don't yet know they need it.

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The Perfect PAIR: An Active Learning Framework for Teaching Challenges

Ching-Yu Huang and Kelly F. Ford

In a recent AAC&U survey (Finley, 2025), employers highlighted the skills the current workforce needs the most and assessed the preparedness of recent graduates. The findings revealed a stark 23-percentage-point gap between the importance employers placed on key skills and their perceptions of graduate preparedness. At the top of this list were critical thinking, collaboration and teamwork, oral communication, and the ability to apply knowledge in real-world settings.

When students struggle, our first instinct is often to ask whether they lacked content knowledge. But more often, the bottleneck isn't the content. It's a lack of development of these essential skills: how to think critically, analyze, communicate, and solve problems. Like any disciplinary content, these skills don't develop automatically; they require intentional practice, feedback, reflection, and refinement.

Many of us might reasonably point out: "But I already assign group work, class discussions, and complex problem sets." So why aren't these activities translating into true mastery in critical thinking, communication and collaboration, or problem-solving? And how do we find time for more learning when we're already struggling to cover a packed syllabus?

It may not be surprising that active learning offers answers. Doolittle et al. (2023) summarize active learning as "a student-centered approach to the construction of knowledge focused on activities and strategies that foster higher-order thinking," which includes "analyzing, synthesizing and evaluating" information (Ng et al., 2020). While we as teachers often design our courses and lesson plans with this goal in mind, how does that translate into daily teaching strategies and activities?

To bridge this gap, we developed the PAIR framework, a structured framework designed to help educators intentionally shape teaching strategies and activities that support students in cultivating these skills and developing greater independence as learners beyond simply constructing knowledge.

P is for processing

How often do we assume that because the content makes sense to us, simply lecturing will automatically click for our students? In reality, without intentional time to pause and chew on new ideas, our students, as novices, can't digest what the material actually means. If we never give them the time and space to realize they were confused, they could miss the critical moment where real understanding begins.

A crucial underpinning of active learning approaches is that students must engage cognitively with the material. During class, built-in pauses for processing are critical because they give students dedicated space to practice core higher-order thinking skills, such as evaluating assumptions (*critical thinking*), examining patterns (*analytical thinking*), and synthesizing new ideas (*creativity*). During this **processing** phase, students connect new concepts to their prior knowledge and lived experiences, mapping how the materials fit into their existing conceptual frameworks and the bigger picture of their lives and careers. Active learning strategies make this possible. Whether you use a one-sentence summary, pro-con grids, concept mapping, or sketch-noting, the strategy doesn't need to be fancy or overly complex. It's simply about building in that deliberate cognitive engagement, giving students a moment to digest the content, and letting it resonate so learning becomes personal, enduring, and meaningful.

A is for application

Covering content is not the same as teaching students how to use it. It's easy to fall into the trap of trying to cover everything—explaining every detail of a complex principle, assuming that walking through a few case studies is enough. But outside the classroom, problems don't arrive with preselected strategies and canned answer sheets. True application requires students to *independently* identify, select, and apply the appropriate principles to messy situations.

If we don't provide students with opportunities to practice application skills in our classrooms, they won't magically master them on their own or even on the job. The **application** bridges the gap between abstract theory and real-world execution. By engaging in active learning strategies like application cards, analytic memos, or case studies, students build critical higher-order thinking and problem-solving skills while you are right there to guide them. We prompt them to ask the questions: *When do I use this? How do I apply it?* and *To what extent does this apply to this specific scenario?* Students learn how to transfer abstract concepts into actual practices in new, authentic contexts.

I is for interaction

The **interaction** element of the PAIR framework emphasizes creating intentional time and space in the classroom for students to collaborate and exchange learning experiences. What's more, interaction works in tandem with both processing and application phases to support richer learning. Our students can benefit enormously from opportunities to interact with others. That interaction can take many forms: a nearby classmate who serves as a sounding board during a turn-and-talk activity in a large lecture hall, a trusted thought partner during small-group work, or a collaborator on a group project. Even in an online, asynchronous setting, students can benefit from talking through ideas with a friend or family member or using a discussion board to test and refine their thinking.

Learning alongside others gives students a lower-risk space to wrestle with challenging concepts, explore unfamiliar territory, and test out new ideas. This peer exchange is especially valuable in disciplines or contexts where there may be no single correct answer. Peer interaction can expose students to diverse perspectives, broaden individual viewpoints through authentic intellectual exchange, and provide built-in accountability and feedback that helps surface misconceptions. When paired with explicit guidance from us, these collaborative moments also offer a powerful venue for students to cultivate essential communication and leadership skills. Strategies like think-pair-share, fishbowls, gallery walks, and note exchanges create wonderful opportunities for students to summarize what they've learned to teach one another. Cognitively rich interactions force students to solidify and integrate novel concepts into their existing schemas as they articulate their thinking to a peer. Plus, let's be honest: Exploring and learning together is just a lot more fun.

R is for reflection

Reflection is more than a polite sign-off at the end of a lecture; it's the engine for continuous growth. It transforms isolated classroom activities into a lifelong learning cycle. When we guide students to synthesize their learning, review their progress, and solidify meaningful connections, they develop cognitive awareness needed for ongoing personal and professional development. It prompts them to consider how newly learned ideas have shifted their perspectives and how to gauge their own comprehension. In a rapidly changing world, the ability to self-assess, track one's own progress, and adjust strategies as needed is a skill that outlasts any single course.

Incorporating reflection isn't difficult, nor does it require vast amounts of time. The power of reflection lies in strategic timing and well-scaffolded prompts. While a generic question like *How do you think you did?* yields shallow, superficial answers, targeted prompts placed at a pivotal moment force students to make their learning visible, pinpoint confusion, and map out concrete steps to improve moving forward. Prompts like "Identify one concept from today's session that shifted or challenged your prior thinking. Elaborate how so"

guide students beyond superficial reactions and into deep, meaningful thinking and skill development. Simple, low-prep activities like entry or exit tickets, muddiest points, minute papers, and exam wrappers take only minutes yet build a habit of self-directed mastery. Better yet, because reflection is the nimblest component of the PAIR framework, these prompts can be easily introduced in class and completed on students' own time and pace, ensuring that learning doesn't stop when class ends.

Using PAIR in your teaching context

The PAIR framework serves as a quick diagnostic tool when we encounter teaching challenges in the classroom. It can help dismantle instructional roadblocks and open up opportunities for engaged, meaningful learning. To see this framework in action, let's use it to tackle a common teaching challenge.

(Meta moment: We're about to have you use **processing** and **application** right now through the following case study. Go grab a pen and dive in!)

The challenge

You instructed your class to have a small group discussion on a controversial topic, expecting a deep debate. Instead, you overhear one student state an opinion, and the rest just nod in polite agreement. There's no further elaboration, no challenge of ideas, and no collective inquiry. Students just missed an opportunity for peer learning.

Your task

1. Grab a piece of paper and write down the core root causes of this situation, considering both student perspectives and your classroom observations (this is where you'll use **processing**).

2. Select one or more components of the PAIR framework to design a solution that addresses the root cause (this is where you'll use **application**).

Let's take a moment to consider what might actually be happening beneath the surface. When asked to discuss complex or controversial topics on the spot, students often fall back on polite agreement simply because they haven't had time to make sense of the question, clarify their own stance, or organize their thoughts.

How using PAIR strategies could help

Consider providing structured opportunities for students to **process** information before contributing (e.g., dedicated **"think time"** or pre-lecture prompts). These brief pauses give students the cognitive space needed to digest new concepts, connect them to prior knowledge, and prepare meaningful contributions that foster deeper discussion.

Depending on the learning goal for this discussion, you could anchor the debate in a concrete, real-world scenario or case study, moving students beyond their superficial opinions into authentic contexts. **Application** tests students on whether they can select and apply what they have learned in a new, unfamiliar situation, forcing them to navigate complexity, weigh competing considerations, and make informed decisions in situations where multiple answers are possible.

Even when **interaction** is already built into a lesson, debating complex or controversial topics carries high social risk for students. Pairing discussions with scaffolded prompts provides structure that guides students to examine underlying assumptions, surface constructive disagreements, and explore alternative viewpoints. This intentional scaffolding lowers the social barrier to entry, fostering psychological safety and enabling truly meaningful student contributions. Establishing clear expectations, explicit group norms, and structured accountability encourages productive discussions that push beyond surface-level agreement and ensure equal participation.

Students often mistake pleasant, agreeable conversation for successful group work. If time allows, closing the activity with an exit ticket or muddiest point prompt forces students to assess their own group discussion—reflecting on how their assumptions were challenged, how their thinking shifted, and how peer interaction drove that change. This simple cognitive step turns a simple discussion into a lasting learning moment and solidifies the learning process (**reflection**).

What other strategies could you implement for processing, application, interaction, or reflection in your class?

Summary

The PAIR framework is never intended to be a rigid blueprint or a set of isolated, sequential steps. Instead, it serves as a flexible, diagnostic lens for instructional design and lesson plans. In practice, **processing**, **application**, **interaction**, and **reflection** are deeply interconnected and complementary.

This is precisely why we call it PAIR: These components naturally work together in tandem as complementary partners that reinforce one another. For example, interaction feeds processing—explaining an idea to a partner forces students to digest, articulate, and refine their thinking far deeper than passive listening alone could. Likewise, the moment students pause to **process** a new concept, they naturally **reflect** on what clicks and where confusion remains.

Active learning doesn't happen by chance; it happens by intentional design. Ultimately, PAIR helps shift our classroom dynamics away from passive content delivery toward

active knowledge construction and skill building. You don't need to overhaul your entire curriculum overnight, nor do you need complex, high-prep activities for every class session. By weaving brief moments of PAIR into your teaching routine, you create a space that fosters the higher-order thinking, skill development and adaptability that modern employers demand.

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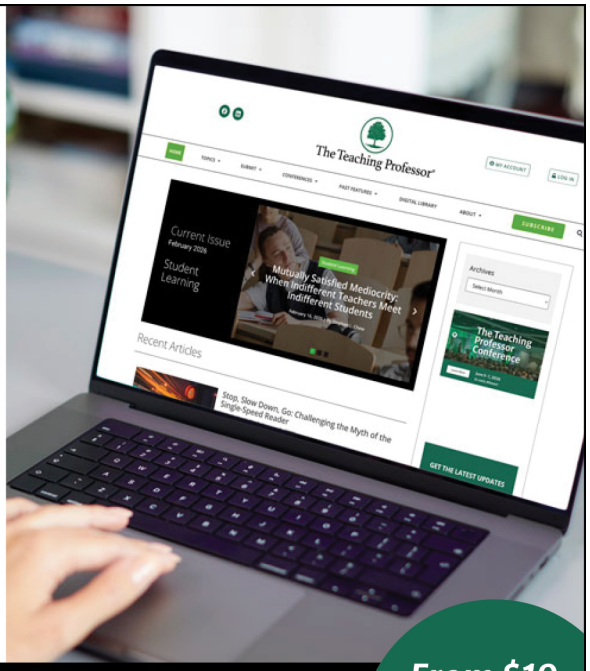
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Better Together: Collaborative Exam Reviews

Kyra Noerr

For years, I dreaded returning graded exams.

Too often when I returned exams in my undergraduate human anatomy course, many students immediately looked at their score, flipped the exam over, and, when they saw a grade they did not like, pushed it to the side. Others carefully examined every question, looking for answers they thought they could argue over and claw back a few points. Neither response was what I wanted from the experience.

I wanted students to learn from the exam: to recognize what they had understood and identify concepts that had remained unclear. In other words, I wanted them to see the exam as part of the learning process instead of the end of it.

Turning exam return into active learning

Cooperative exams, collaborative group testing, two-stage testing, and team test retakes are related approaches with slightly different structures and grading strategies (Cooke et al., 2019; Zipp, 2007). A common feature is that students complete or revisit exam questions with a small group of peers. In my course, the collaborative review does not change the student's original exam score. Its purpose is not to let students recover points but to create a structured opportunity for students to revisit their thinking after the assessment.

In the class session after the exam but before students have received their exam scores, I give groups of about four students one copy of the exam and one pen. They may use their notes, textbook, or other course resources. They have one task: Complete the same exam again, together.

There is one additional rule. Every five minutes, the pen must move to another student. That small requirement makes it more difficult for one confident student to take control of the exam while everyone else passively agrees. The student holding the pen records the group's responses, but the group must discuss the questions, compare answers, explain reasoning, and submit one set of agreed-upon responses.

The result is a very different kind of exam review. Instead of listening to me explain why an answer is correct, students explain it to each other. When everyone immediately agrees on an answer, they move on. When four students have three different answers, they stop. They return to their resources, defend their reasoning, question one another, and try to determine where their understanding varied. Those are often the most valuable moments of the class period.

During this process, students begin to recognize what they knew rather than focus only on the points they missed. After the collaborative review, I return their individually graded exams. At that point, students are rarely surprised by their grade and often approach the exam with a clearer understanding of what they knew and what they missed.

Why collaboration changes the review

Collaborative exam reviews bring several well-established learning strategies into a single activity. Students retrieve information they previously studied, encounter concepts again through repetition, identify and correct errors, verbalize their reasoning, and teach one another. In courses where long-term retention is critical, collaborative exams can improve retention and application (LaBossiere et al., 2016; Cortright et al., 2003).

The conversation itself is valuable for processing information and reinforcing learning for long-term retention. As students explain their chosen answers, they must articulate why they selected them and listen to classmates explain alternative reasoning.

In an anonymous student survey following a course using the collaborative exam review, students reflected on their experiences with the activity. One student described the experience this way:

> If we all had different answers, we all kind of knew that we all didn't really understand the material, so thinking about it longer and talking helped us solve and come to a conclusion on an answer. Sometimes we were able to think about it in different ways which made us kind of have light bulb moments.

Another student emphasized the value of learning from classmates:

> Questions that I got wrong, some of my group members got right and were able to explain to me why and how they got the question right. Going back over the exam with my peers benefited everyone because of the shared knowledge between me and my classmates.

These conversations extend beyond anatomy content. Students hear how their classmates approached a difficult question, interpreted exam question wording, or structured their study strategies. In doing so, they are exposed to learning and test-taking strategies they might not otherwise encounter.

Stepping back to make room for learning

One of the most important changes I made was recognizing that I do not need to lead the review. During collaborative exam reviews, less is often more.

Different groups will focus on different parts of the exam. Some groups move quickly through questions based on recall but spend considerable time debating questions that require application. That variation is useful. Students determine where they need to spend their time rather than following an instructor-led review that gives every question equal attention.

I am present but intentionally not at the center. I circulate, listen, and answer questions when students ask. Occasionally, a group reaches an impasse and asks me to settle a debate or clarify the wording of a question. Even then, I often begin by asking them to explain their competing reasoning before providing an answer.

There is another skill hidden in these interactions: asking for help. Some students are comfortable calling me over immediately. Others need to see their peers do it several times before they become comfortable asking themselves. The structure creates a low-stakes opportunity for students to practice recognizing when they need assistance and seeking it.

Collaborative review does not automatically produce collaboration. Some students are more willing to speak than others, and occasionally a group reaches consensus around an incorrect answer. The rotating pen helps distribute participation, but it does not eliminate these challenges. Although my role is less central during collaborative review, I engage less active groups by asking guiding questions, encouraging quieter students to contribute, and directing groups to relevant resources when misconceptions arise. Rather than providing the correct answer, I aim to help students work through their reasoning and share what they learn with their peers.

The review also gives me valuable information about the exam itself. As I listen to students debate questions, I hear the reasoning behind their incorrect answers. Sometimes I discover a persistent misconception that I need to address in the next class. Occasionally, I also discover that the problem wasn't a lack of student understanding at all but the way I wrote the question. Collaborative reviews become feedback for me as much as they are for my students.

Making the exam part of learning

The days when I had to return exams used to be among my least favorite class periods. I used to have to prepare myself to deal with student frustration, with arguments over points, and with students who seemed ready to move on from the material as soon as they saw their grade.

Now the class period after an exam is one of my favorites.

The approach I have developed makes learning visible. Students recognize mistakes and correct misunderstandings themselves. They explain concepts to one another, work through the wording of challenging questions, compare study strategies, and discover that a classmate may explain a concept in a way that makes it suddenly click.

Perhaps most importantly, students begin to see their classmates differently. The person sitting across the table is not simply another student who received a higher or lower score. That person is another resource who can share a different way of thinking; that person becomes another potential teacher.

Sometimes the most productive thing I can do after an exam is hand students one copy, one pen, and then get out of their way.

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With LOVE: Turning Technical Learning into Professional Communication Skills

Sirong Lin

If you teach a project-based or experiential course, you may have had this experience: Students can do sophisticated work in their discipline yet struggle to articulate that work in ways that are meaningful beyond the classroom.

I saw this pattern in my senior-level mobile app development course. Students selected real-world problems they cared about, designed solutions, built mobile applications, tested them with users, and refined their designs over the semester. Yet when they talked about that work, their descriptions often emphasized features, technologies, and completed tasks. These details are important, but they tell only part of the story. Being able to tell that fuller story is an important part of students' career readiness. That ability aligns with several competencies identified by the National Association of Colleges and Employers (NACE), particularly communication, career and self-development, and technology.

The issue was not a lack of presentation opportunities: Students discussed and presented their work throughout the project lifecycle. The problem was *professional articulation*. In professional settings, students need to make their technical competence visible to people who didn't see the work unfold. If they describe only features, tools, and tasks, their reasoning, judgment, and contributions may remain invisible in resumes, interviews, portfolios, and conversations with employers.

To address the gap, I embedded career-connected communication more deliberately into the existing project lifecycle. Students completed guided writing activities, translated project work into resume language, participated in several rounds of career services–facilitated peer mock interviews in which they rotated roles, and created public-facing portfolios. Looking across these activities, I began to see a repeatable pattern that I now describe as the LOVE framework.

LOVE: A lightweight framework for professional articulation

LOVE stands for *learn*, *observe*, *verbalize*, and *exhibit*. Students first learn by developing disciplinary knowledge and skills through authentic project work. They then observe by stepping back to look more closely at what they have done: what matters, what feedback they received, what choices they made, and how different audiences may understand the work. Next, they verbalize that understanding in professional language. Finally, they exhibit their work through artifacts such as resumes, interviews, presentations, and portfolios.

Because LOVE is embedded in project work students are already doing, most of the added scaffolding centers on observing and verbalizing, while exhibiting gives students an authentic context in which to use and refine that articulation. At a project checkpoint, for example, students might identify an important design decision and why it mattered (observe), turn that reflection into a project summary or resume bullet (verbalize), and use that language in a peer mock interview or portfolio entry (exhibit). Feedback from these experiences can then help students refine both how they understand the project and how they communicate it.

Three shifts in student communication

As students practiced this process, three recurring shifts became visible in their work.

The first shift was from *features* to user *value*. One student team built HawkAdvisor, a career-planning application. An early description focused mainly on what the app did: "Students could enter the kind of work they wanted to pursue, and the app would recommend courses." That description was accurate, but it remained close to functionality. A later version explained the problem from the user's perspective: "Students can struggle to connect course choices with future careers, and the application helps make that connection clearer." The technical product had not changed; what changed was how the students understood and communicated its value. This framing helps professional audiences understand the problem the project addresses, not just what the product does.

The second shift was from *implementation details* to *design reasoning*. Students often began by listing technologies, such as Flutter, Vue.js, Python, and Azure. These details can demonstrate technical knowledge, but they do not necessarily reveal the reasoning behind technical choices—an important part of professional practice. With structured prompts, students began to explain why a choice mattered—for example, how an automated data process reduced manual effort or how supporting both mobile and web interfaces improved consistency for users. A stronger explanation connects implementation to purpose and gives students a way to demonstrate judgment and problem-solving, not simply familiarity with tools.

The third shift was from *tasks performed* to *professional contributions*. In one early description, a student emphasized having built much of the system and then listed the components they had built. In the revised version, the student framed the same work as leading development of a career-planning application and building the major system components needed to support multiple academic majors. The student had not done more work between the two versions. What changed was the student's ability to recognize and articulate ownership, responsibility, and impact. That shift is especially important when students prepare resumes or answer interview questions about team projects.

What students reported

End-of-semester reflections and survey feedback suggested that students recognized the value of this practice. Among 20 respondents in a class of 26 students, 90 percent reported feeling more prepared to discuss projects professionally, 85 percent reported a better understanding of the kinds of questions employers may ask about technical projects, and 85 percent reported improved professional project communication. Because these results are self-reported, I view them as early evidence rather than a measure of long-term learning. The same pattern was visible in students' project descriptions and portfolio artifacts, which increasingly emphasized value, reasoning, and contribution.

Trying LOVE in other courses

Although LOVE emerged from a computer science course, it does not require a fully project-based course or a major course redesign. Instructors can begin with one existing project or experiential assignment—even if it is only one component of the course—and add a few prompts at natural points: *Why does this work matter, and to whom? What important decisions did you make, and why? What did you personally contribute?* Students can then turn those reflections into a project summary, resume bullet, interview response, presentation, or portfolio entry.

The goal is not to replace disciplinary learning with career preparation, but to help students articulate the learning already taking place. Students need not only to do disciplinary work but also to explain why that work matters, how they made decisions, and what they contributed. LOVE offers a simple way to make that practice intentional.

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Acknowledgment

This work was supported by the Career-Integrated Curriculum Mini-Grant at the University of Massachusetts Lowell (2025–2026).

Metacognition and Mindset: Keys to Igniting Success

Saundra Yancy McGuire

"I studied and studied for this test and I still failed. I don't know what happened!"

We've all heard this lament from students when they see the score on their first exam. Most are exasperated and are desperate for advice on how to improve. It's tempting to tell them that they just need to study more or study a different way, but most students don't know how to translate this advice into actions that will indeed significantly improve their performance on subsequent exams.

The reason that highly capable students often fail their first college test is because the higher-order thinking skills that are tested in college (applying, analyzing, evaluating, and creating) are quite different from the skills that are tested in high school (primarily memorizing and understanding). Therefore, many students entering college find themselves struggling to succeed in courses that require skills that they have never had to develop or use before.

I learned just how large the gap is between the demands of high school tests and college tests by asking students two questions:

1. What did your teachers in high school do the class session before the test?
2. What did the teachers do during the review session?

Their answers to the first question were not surprising. Most students said their teachers conducted a review session. I fully expected them to say that.

Their answer to the second question caught me totally off guard. I expected students to respond that "the teacher reviewed the concepts that were going to be covered on the test" or "we played a game of Kahoot! to test our mastery of the material" or something similar. Instead, the typical response was this: "They gave us the test questions, and we went over the answers." The first time I got this response, which was now over 10 years ago, I was shocked. If they had given me one of the answers I'd predicted, I was prepared to respond, "Yes! But we don't do that in college; you have to do your review on your own." But upon

learning that they had gone over the actual questions, I proposed a third question. I asked, "What grade would you have made on the test if you hadn't attended class all semester except the day before the test, and you paid very close attention that day?" A few students said A, and a few said C, but most said B.

This answer has been consistent from students across the country. It was then that I understood why most students don't do any work before the first college test. They think that they will get a review session like the ones they got in high school. That, to me, was clear evidence that we must help students understand and close the gap between high school and college skills. They must move on from the memorization and regurgitation skills needed for success in high school to the application, analysis, and higher skills needed for success in college. I knew that we had to teach students *how* to learn. I have found that the most effective way to do this is by teaching them about metacognition and helping them develop metacognitive learning strategies.

Metacognition, a term coined by John Flavell in 1976, can be simply defined as "thinking about your own thinking." The concept is much more nuanced than that, but I provide this simplified definition for students because it's easy for them to understand the concept and apply it to their courses. I explain that it's like have a big "metacognitive brain" looking at what your brain is doing and asking it questions like "Do you really understand this, or did you just memorize it last night because the test is today?" and "Do you understand the information well enough to explain it to someone else?" These questions help students analyze the extent to which they have mastered the content and whether they're really prepared for the test and not just feeling prepared because they've memorized definitions and equations.

Two reflection questions, done as a think-pair-share, help students identify the difference between their ineffective study behaviors and the metacognitive behaviors that would lead them to success.

1. What is the difference between studying and learning?
2. Would you work harder if you
    a. knew that you had to make an A on the next test? or
    b. had to teach the material in a review session to the class the class period before the exam?

These questions are paradigm shifting for students. The discussions they engage in when considering the questions are quite lively. Some answers I've heard to the first question:

A. Studying is just memorizing answers for a test or a quiz, but learning is when I understand the information and can apply it to answer questions or work problems I've never seen before.

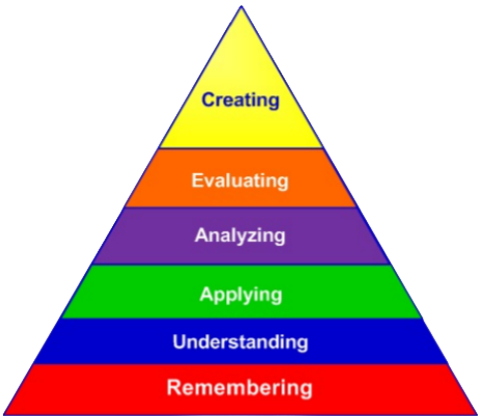
B. Studying is short term; learning is long term. I focus on studying to make an A on the test, but I focus on learning if I need to know that information for later.

The answer to question 2 is almost unanimous. Students would work harder if they had to teach the material. When asked why, they typically say one of three things:

1. I have to really understand the material if I'm going to teach it.
2. I don't want to look stupid in front of the class, so I try to anticipate questions I'll be asked and make sure I can answer those questions.
3. Since everyone's grade depends on how I teach, I want to make sure I can explain the material more than one way, using charts and diagrams for students who'd benefit from visuals.

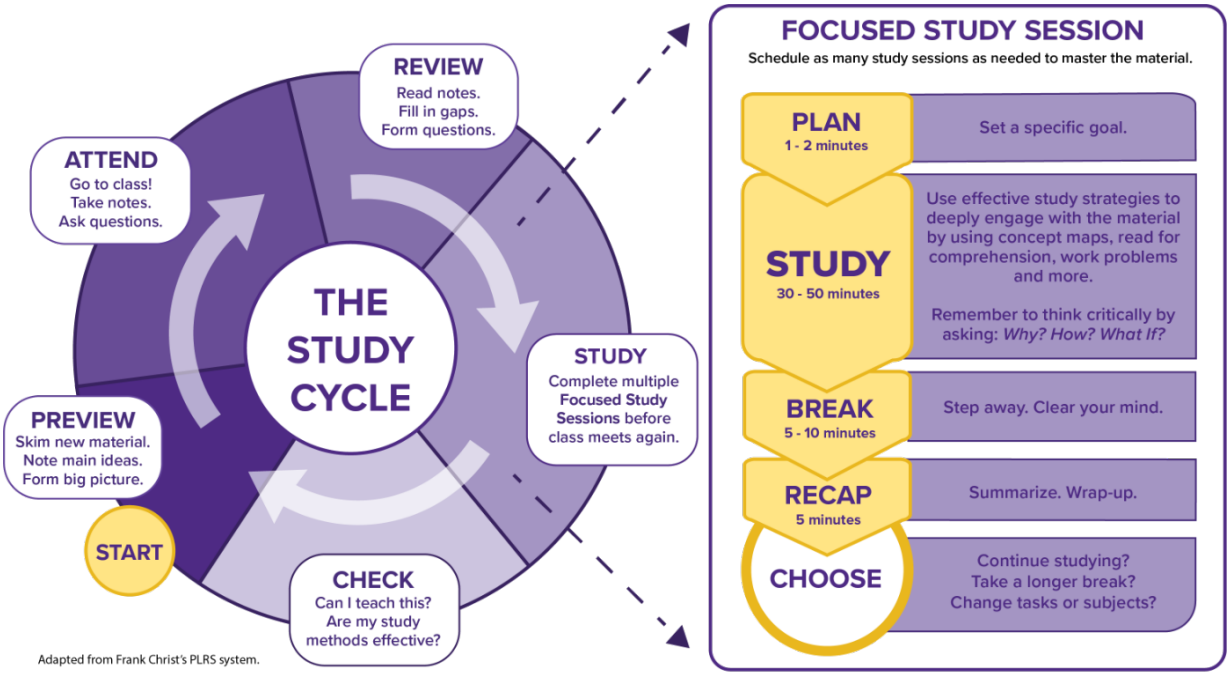
After getting their answers to the reflection questions. I then ask them to tell me whether they had been in study mode or learn mode prior to now and whether they'd been studying to make an A on the test or preparing to teach the material. The responses are consistently "study mode" for question 1 and "studying to make an A on the test" for question 2. My reply is always "Great! I love it when you're doing everything wrong!" The students always laugh when I say this. But I mean it: If students think they are already doing what they need to be doing, their behavior won't change. But when they realize they're not, we can help them change their actions.

I then introduce students to Bloom's taxonomy, commonly represented as a pyramid of six learning levels.



After they've learned about Bloom's, I ask what level they operated on in high school and what level is necessary in college. Students typically indicated they were at a level 1 or 2 in high school but need to be at a level 5 or 6 to perform well in college courses.

Now that they understand why their performance was not reaching their potential (they were in study mode, not learn mode; they were studying to make As on tests; and they were operating at lower levels of Bloom's), they're prepared to learn strategies that can rapidly and dramatically improve their performance. We must help students understand why they need new strategies before we teach them what the strategies are. Otherwise, they strongly resist giving up the strategies that worked so well before. Specific strategies I teach students include completing homework assignments without using examples, solution guides, or verbatim text from the book; practicing to teach the material to a real or imaginary audience, such as a stuffed animal, an empty chair, or pet; and actively reading by previewing the text, devising questions the reading is expected to answer, and reading paragraph by paragraph while paraphrasing the information in their own words. One strategy that students find especially appealing and easy to implement is using the LSU study cycle, shown below. The cycle provides a structured way to prepare for class, get the most out of class attendance, review after class, and test for concept mastery.



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In focus groups conducted by the LSU Office of Testing and Evaluation, students have often said that implementing the study cycle with focused study sessions has been game changing for them. They love the focused study session plan because most have never had a structured approach to their study time.

After students have learned why they need new strategies and what those strategies are, we need to convince them that using the strategies can make a rapid and dramatic impact on their ability to excel in courses they once thought they would not be able to master. We can accomplish this by introducing them to Carol Dweck's research on mindset. Dweck compares the two views of intelligence that are prevalent. One view, which she terms *fixed mindset*, holds that intelligence is relatively fixed at birth and will not change much over a person's lifetime. The other view, which she terms *growth mindset*, claims that a person can grow their intelligence over their lifetime. According to the growth mindset, if people whom others initially deem to be of low intelligence implement the strategies that the "smart" people use, they will make themselves smarter. There is scientific evidence to support this concept. Neuroscientists have shown that the brain can grow new neurons (neurogenesis) and make new neuronal connections (brain plasticity) throughout a person's lifetime.

Although the mindset of college students often depends on the specific activity in which they're engaged, many have a fixed mindset about areas such as mathematical ability, writing ability, and artistic ability. When we expose students to the idea that they can make themselves smarter by using learning strategies, they feel motivated to implement those strategies. The result is a better performing, more motivated, and enthusiastic group of students.

One additional key component of transforming memorizers into critical thinkers is providing the before and after scores of students who implemented the strategies. One such example is a first-year student in general chemistry at LSU who made a 42 on the first test and then made perfect 100s on every subsequent one!

When we provide students with information that makes them aware of the specific reasons they are not doing well, teach them to implement specific and targeted strategies to address those deficiencies, and show them research that confirms that they can make themselves smarter, their motivation soars and their behaviors change. Metacognition and a growth mindset become their superpowers.

Resources

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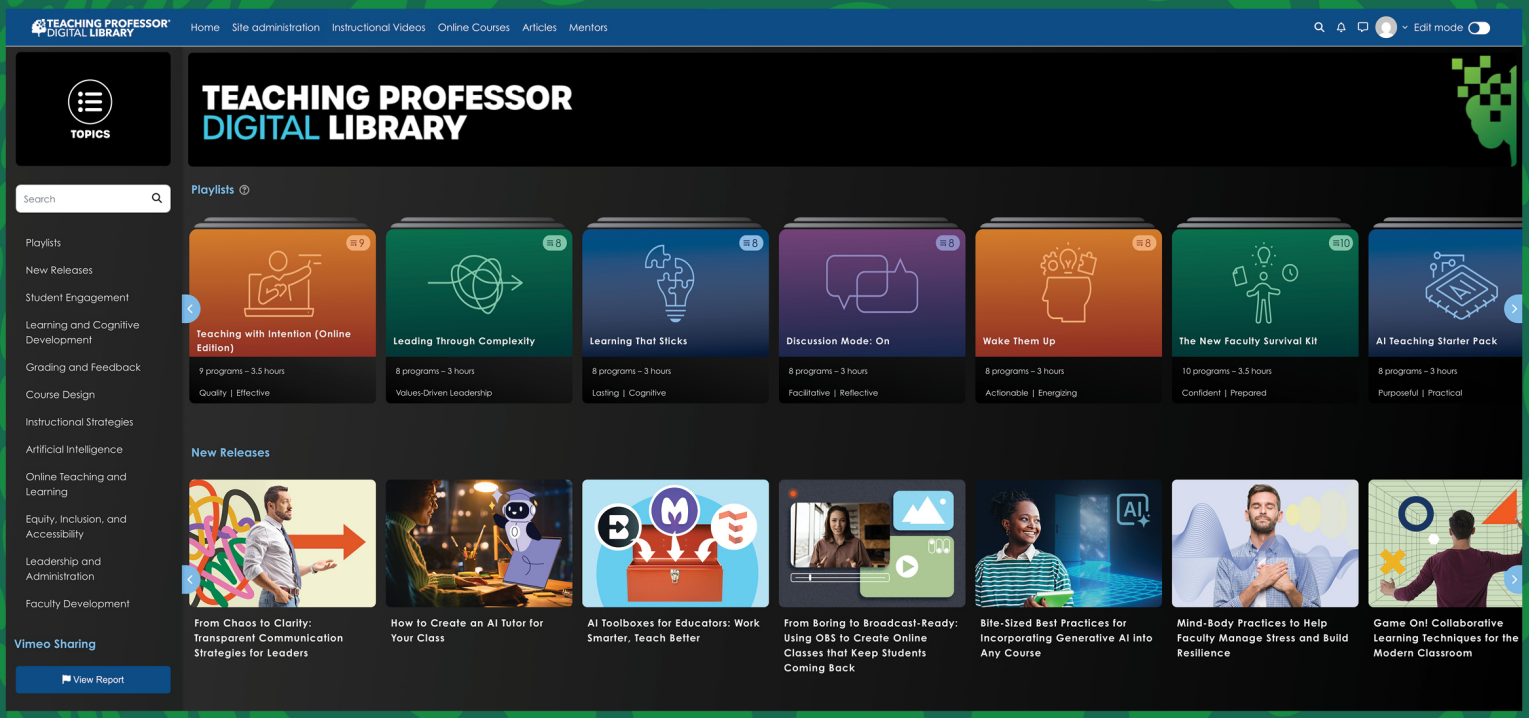
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