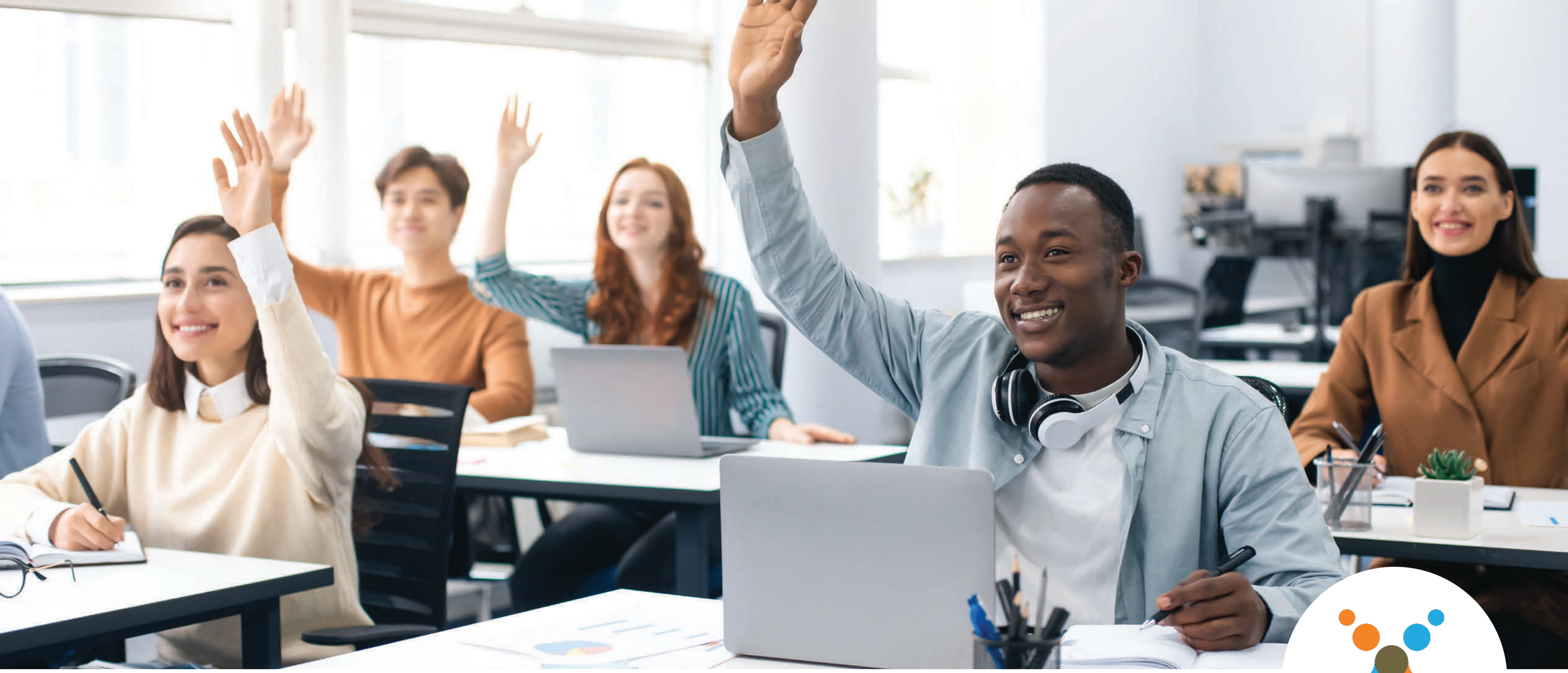


THE LEARNWELL PROJECTS

BUILDING STEM STUDENTS' ACADEMIC WORK COMPETENCE

As professors guide their classes through complex sequences, rules, and steps in the problem-solving process, students vicariously solve the problems with them. Their participation leaves them feeling confident that they can solve the types of problems they encountered on their own. When they attempt to solve similar problems outside of the classroom context and without their professors' assistance, however, they are surprised by how much they struggle. Their confidence erodes and is quickly replaced by feelings of incompetence.

This document explains why students are tricked into believing they can do things that they cannot do and provides a roadmap for how professors can help students build problem-solving competence and build true confidence.

The Problem: Why Students Are Being Tricked

Like many academic challenges, the problem is two-fold: educators' and students' labor must complement each other. But this is rarely the case. Here's how students and professors are tricked.

Professors enjoy working through problems in class, and students expect to spend most of the class time working through problems. These mutual interests are particularly true in math-based courses, such as those in the STEM fields. Leading the class through complex problems gives professors opportunities to demonstrate their knowledge and problem-solving skills. Meanwhile, participating (or even merely watching) professors navigate problems makes students feel as if they have worked through the problems themselves.

Working through problems in class can be deceptive to both students and educators because the mental labor that is being invested in the work is misunderstood. Students concentrate on what professors say and what they write on the boards or screens. This is the information they capture in their notes, and it is subsequently the information they use to solve future problems. This type of visible labor is useful, but it has its limits. Students are oblivious to the invisible labor that powers their professors' problem-solving abilities: *their ability to use their conceptual knowledge as lenses to navigate problems*.

As professors solve problems, they draw upon deep conceptual knowledge of core disciplinary concepts. They use this knowledge to guide their work before and throughout the problem-solving experience. Yet educators are unaware of the essential role that their conceptual knowledge plays during class. Professors are using two types of labor: explicit and implicit. The explicit labor is the verbal and written information they dispense to students. The implicit labor consists of the concepts they draw upon that inform which formulas, rules, or sequences to use while solving problems.

> **Students are oblivious to the invisible labor that powers their professors' problem-solving abilities.**

Students focus on capturing the explicit labor, so they leave class with lots of formula knowledge. They expect the problem-solving process to go smoothly later as they simply plug in formulas they've written in their notes. They don't realize that before they can work through the problems, they must also draw upon conceptual knowledge. Trying to solve problems with only the external information is like trying to drive a car without an engine. It's the unseen labor that makes the visible labor work.

The Solution: Define, Distinguish and Divide the Labor

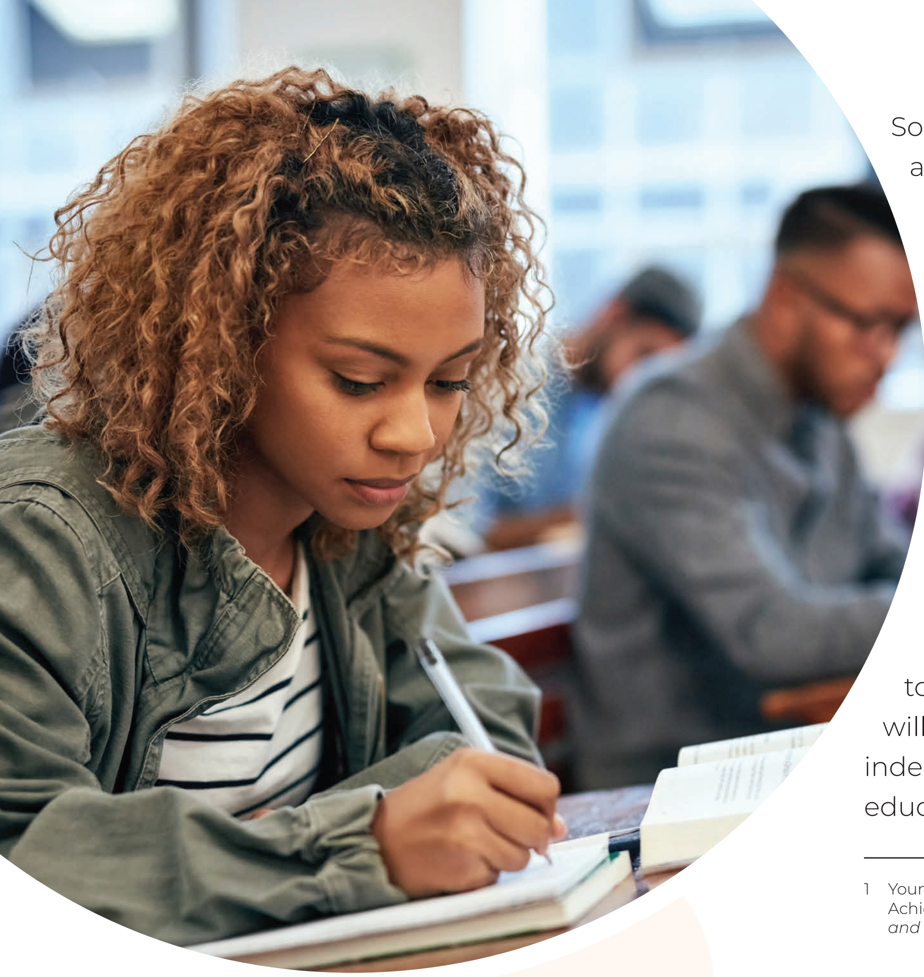
Research suggests that students who have the same cognitive abilities may have different metacognitive abilities underlying their thinking.[1] This means that students with stronger metacognitive skills may extract the unspoken conceptual knowledge from the class and automatically combine it with the explicit knowledge dispensed during class. This synthesis of conceptual knowledge and specific formulaic knowledge facilitates deeper learning and higher performance. Their peers may only get the explicit knowledge, however, and thus have powerless learning and lower performance. These differences may manifest in the following three ways:

1. **Improper metrics.** Since low-performing students tend to measure their learning by external metrics, such as how much time they spent on a task and the quantity of notes they accumulated, they may conflate outputs with outcomes. Conversely, higher-performing students tend to be guided by internal knowledge-based metrics, which lead to the production of outcomes.
2. **Poor retest scores.** Because students have not learned the core concepts that are embedded in assessments, their grades may not significantly improve when given opportunities to retake a test. In fact, they may decrease as students second-guess technical knowledge (e.g., knowledge of specific rules, functions, or formulas) and continue to ignore the conceptual elements.
3. **Poorer performance on comprehensive assessments.** Students may perform better on quizzes, which tend to focus on topic knowledge rather than conceptual knowledge. Higher performance on quizzes may deceive students into believing they are prepared for exams that are assessing different knowledge bases. Additionally, students may see significant decline in scores on comprehensive exams, as these tasks typically bypass topic knowledge while assessing for conceptual knowledge.

DIVISION OF ACADEMIC LABOR

	FACULTY	STUDENT
1	Introduce and explicate concept(s).	Identify the core concepts. Write down the concepts and what they mean. Distinguish concepts from each other.
2	Use the *3X10 Method* to work through example(s). Emphasize connections between unseen concepts, visible content (rules, formulas, functions, etc.), and the cognitive skills needed for the task.	Recall relevant content (rules, formula, functions, etc.).
3	Assist students as needed and note common barriers. Pay attention to the thinking requirements of respective tasks.	Work through the problems during class.
4	Discuss insights that are discovered with colleagues.	Check problems. Check for conceptual clarity and content accuracy.
5	Use insights to guide future instruction.	Summarize work in text form, being sure to synthesize concept and content.

NOTE: Students will likely need to use textbooks and other academic resources to build up their conceptual and content knowledge.



Solving this problem requires educators and students to properly divide the labor they invest in the work. The previous pages shows the steps professors and students can follow to ensure their labor complements each other.

Following these steps will push students to do different types of mental work that forces them to dig deeper into the material. Additionally, the feelings of incompetence that previously occurred after class will surface during class, providing opportunities for them to be addressed. Ultimately, this approach will enable students to do better work independently and shift the workload from educators to students.

1 Young, Andria and Jane D. Frye, "Metacognitive Awareness and Academic Achievement in College Students," *Journal of the Scholarship of Teaching and Learning* 8, no. 2 (2008): 1–10.

Testimonials

"Solving this dilemma helped decrease our math DFW rate by 34 percent in one semester."

(UNIVERSITY PROVOST)

"Working through problems in class is one of the foundation ways math professors teach. We never realized that this practice could negatively affect students. But after changing our approach, students are less stymied on assessments where the problems they must answer aren't like the ones they faced in class."

(COLLEGE MATH DEPARTMENT CHAIR,
FLORIDA POLYTECHNIC UNIVERSITY)

"Learning how to pick up the concepts rather than the formula and rules in my STEM courses has lifted my grades and has helped me truly learn the material."

(COLLEGE SOPHOMORE,
DENISON UNIVERSITY

Useful Links

Denison University Story
https://bit.ly/3urQPg6

Go-for-Green Method for Constructive Learning
https://bit.ly/358goKx

Differentiating Thinking Skills
https://bit.ly/36JQaOF

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