Beyond Hands-On

Some active-learning methods are more effective than others.

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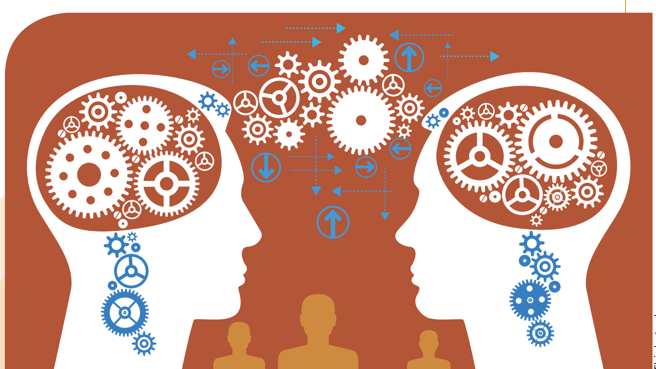
The relationship between instructional methods and student learning has been a central research topic in higher education for decades. Though many studies have shown that student-centered active learning methods are more effective than traditional lectures in helping students understand complex science and engineering topics, some studies have found no difference or even an opposite effect. These discrepancies can be explained by the variability in scope of active-learning methods; generally the term "active learning" is used for a wide variety of classroom activities. However, treating all classroom activities as engaging students in the same way ignores the specific cognitive processes associated with each type of activity. Without a comprehensive framework to classify active-learning methods, it is difficult to compare their value. Consequently, educators and administrators may underestimate the potential benefits of different active-learning methods.

To address the lack of such a framework, Michelene T.H. Chi (2009) proposed the Differentiated Overt Learning Activities (DOLA) framework, which divides active-learning methods into three modes — active, constructive, or interactive — depending on the students' overt engagement in them. Activities designed as active should involve learners in hands-on manipulation of learning materials. Constructive activities are expected to facilitate the generation of new ideas beyond those directly presented, while interactive activities typically should generate ideas that build on each other, but only when all students contribute substantial intellectual effort in collaborative settings.

Based on the hypothesized cognitive processes corresponding to each mode of activity, Chi reviewed and reinterpreted experimental studies in the learning sciences literature. She hypothesized that interactive activities are generally more effective than constructive activities, which in turn are better than active activities. All three modes are better than passive methods in promoting students' learning. Chi called this relationship the Interactive > Constructive > Active > Passive (ICAP) hypothesis.

In our study, we tested the ICAP hypothesis in an engineering context. We collected data from an actual classroom setting and from a controlled experiment to compare students' knowledge and conceptual understanding of materials science and engineering concepts after they completed learning activities using each mode of active learning.



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Results from the classroom provided support for the ICAP hypothesis when the DOLA framework was used to structure learning activities. The positive results held despite such confounding factors as differences in the level of student participation in the interactive activities and differences in time on task during the learning activities. By comparing all active-learning modes in a controlled environment, we reduced these confounds significantly. The results provided strong support for the part of the ICAP hypothesis that posits that interactive activities enhance learning better than constructive activities. Our results showed that when students engaged in joint dialogue and constructed knowledge collaboratively, they not only generated knowledge on their own but further benefited from their partners' feedback and contributions. Constructive activities enhance learning better than active activities because they allow students to generate new knowledge and revise misunderstandings. Finally, active activities are more effective than passive ones; actively emphasizing a part of the learning materials allows students to activate relevant knowledge and assimilate new information to fill knowledge gaps. Passive activities may store new information only infrequently.

A thorough understanding of core concepts in materials science and engineering provides a significant intellectual challenge for students. They must comprehend the relationships between the macroscale properties of materials and their nano-, micro-, or macroscale structures, and undertake complex cognitive processes such as decision making, spatial reasoning, knowledge construction, and integration. Our results show that DOLA can guide the design of learning materials and activities that promote development of these higher-order skills.

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