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, Michenele 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 present in the learning materials. 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 macroscopic 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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