# TAKING ADVANTAGE OF INTEGRATION OPPORTUNITIES IN SCHOOL CHEMISTRY COURSE

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Incorporating real-life context through connections to research early in the curriculum can create meaningful learning opportunities that encourage students to engage deeply with classroom content to construct chemistry knowledge. Course-based undergraduate research experiences have been successful at integrating real-life context, but are often only incorporated into upper-level courses. To provide an additional pathway to foster interaction with research, four activities from an introductory chemistry discussion class were created to incorporate authentic research connections. Care was taken to incorporate metacognitive questions designed to help students make connections between their preexisting knowledge and course content. Marzano's taxonomy was used to analyze the cognitive complexity of tasks, which increased in the revised activities, allowing for more opportunities for knowledge construction. Audio and written work of student groups as they worked through activities was collected. Qualitative analysis of student engagement revealed that control over the content of activities to incorporate opportunities for knowledge construction is not enough to facilitate students consciously engaging in meaningful learning. If instructors wish to promote students integrating chemistry knowledge into their existing framework, course instructors, including graduate teaching assistants, need to be trained on how to properly facilitate classroom experiences to increase the likelihood of success. Chemistry instruction should aim to enable students to integrate the knowledge they are learning into existing knowledge frameworks. Incorporating tenets of meaningful learning can be used as a guide for activity design to motivate students to build connections. However, multiple conditions must be met for a student to engage in meaningful learning: (1) students must have some prior knowledge about the topic into which new information may be integrated, (2) the material must contain important concepts related to existing knowledge, and (3) a student must consciously choose to incorporate the material into their existing knowledge. Only the content of the material can be controlled by the course instructor; the other two factors depend on the student's prior knowledge and conscious engagement with the course materials. Thus, if an instructor wants to incorporate meaningful learning opportunities into their course, it should be a goal to incorporate information that is relevant to the student population's lives. This will present opportunities for students to choose to engage with the material and incorporate new knowledge into existing knowledge frameworks.

Although instructors cannot control whether students will consciously choose to incorporate new material into their existing knowledge, they can promote knowledge integration through the questions asked. Marzano's taxonomy describes the cognitive engagement that tasks may promote from asking retrieval questions to pull information from their memory, comprehension questions that require applying knowledge to situations, analysis questions that use students' knowledge to create new insights, and knowledge utilization that require students to piece together their previous knowledge components to problem solve and accomplish a goal. Their work found that increasing the cognitive complexity of tasks that students complete increased the likelihood of students engaging in knowledge construction where they incorporate previous knowledge into their current knowledge structures. Thus, if instructors want to increase the likelihood that meaningful learning occurs through students' conscious integration of new material, higher cognitive complexity tasks, such as analysis or knowledge utilization, should be used. Special attention was taken to incorporate metacognitive questions designed to help students make connections between their preexisting knowledge and course content. This provided meaningful learning opportunities, where student groups engaged with the material, as they were able to find connections to their existing knowledge frameworks. By incorporating authentic research, cognitive question complexity was increased, allowing for more opportunities for meaningful learning through knowledge integration to occur as students analyzed and interpreted research data. Analysis of student work revealed that students were able to make connections with previous knowledge when prompted by the metacognition questions in the worksheets.