"Compel Them to Engage with the Content:" Upgrading an Undergraduate Geology Course Using ICAP

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Abstract: The purpose of this case study is to explore an experienced geology professor's use of the ICAP framework to increase the amount and level of active learning in his undergraduate geology class. Preliminary results indicate that the course has become more active and constructive compared with previous years through the professor's use of two strategies: scaffolding student notetaking and deliberate use of ICAP verbs to elicit higher ICAP level engagement from his students.

Keywords: Active learning, ICAP, undergraduate education, geoscience education

Introduction

As research correlates active learning with student achievement in undergraduate science, technology, engineering, and mathematics (STEM) courses (Freeman et al., 2014), there has been a call to infuse more active learning into these courses. Active learning through increased student engagement with course content seems to benefit students across demographics (Wiggins, Eddy, Grunspan, & Crowe, 2017), but a call to "do more active learning" with no recommendations on how to do it (Chi & Wylie, 2014) does not encourage faculty to adopt such practices (Graham, Frederick, Byars-Winston, Hunter & Handelsman, 2013). Faculty may also believe that a change from lecture-based to active learning requires complete course redesign. It is therefore important to provide professors with strategies to incorporate more active learning into their classes.

The ICAP Theory of Cognitive Engagement (Chi et al., 2018; Chi & Wylie, 2014) states that student learning outcomes increase with the level of student engagement with content, with interactive engagement > constructive engagement > active engagement > passive engagement. Active learning within the ICAP framework is subdivided into the first three categories–interactive, constructive, and active. Students in interactive mode work together to build off of each other's ideas and co-construct new knowledge (e.g. think-pair-share, debating). In constructive mode, students generate new knowledge by combining content in new ways of expression that are not verbatim from the class (e.g. synthesizing, predicting). In active mode, students manipulate the given content (e.g. direct copying, answering questions with wording from a text). Students in passive mode do not go beyond paying attention and receiving information, as is typical in lecture classes. By observing student behaviors, professors can use ICAP to assess the engagement level of their students.

"Upgrading" in ICAP terms refers to raising the level of a class/activity/course by one ICAP level–i. e., from mostly passive to mostly active or from mostly active to mostly constructive–which can improve student learning outcomes. Wiggins et al. (2017) found that an upgrade from constructive to interactive engagement led to significant learning gains for undergraduate biology students. Chi et al. (2018) provided a list of verbs that teachers used to prompt students to engage with the content at particular ICAP levels. Deliberate verb use can increase the likelihood of students reaching higher levels of engagement and therefore learning. This study reports on how an experienced geology professor (pseudonym Charles) used the ICAP framework to increase the amount of active learning in his undergraduate geology class by focusing on upgrading the ICAP level of in-class activities and guiding student notetaking.

Methods

Charles was selected for this case study because he is an institutional leader in effective teaching who is working to improve his own teaching practice. Charles expressed the goal of wanting to "compel them (his students) to engage with the content" more than they have in the previous years he has taught the course, a medium-sized (~50 students), upper-level, place-based undergraduate elective geology and sustainability course at a large R1 university located in the American Southwest.

Data for this analysis included discussions with Charles, instructional materials, and observations of instruction. Direct conversations with Charles about his motivation and strategies for the upgrade began the month before the course started and continued throughout the semester. Charles provided his original class materials and his ICAP-upgraded class materials and invited members of the research team to observe his

instruction throughout the semester. Type examples of paired before-and-after-upgrade activity prompts were purposefully chosen for analysis and comparison of ICAP levels, and student behavior during these activities was informally characterized according to ICAP level. Field notes of conversations with Charles provided insight into his thinking about ICAP and his strategies for the upgrade.

Results

In the months prior to teaching the ICAP-upgraded class, Charles started reviewing his previous years' class materials, mainly PowerPoints with embedded prompts requiring students to complete two short in-class activities, which they submitted on 5" x 8" index cards. Most activities required passive (e.g. reading a geologic map) and active (e. g. answering questions directly from the map content) ICAP-level engagement. These were the only required assignments each class meeting–students were not required to take notes. In order to keep students more actively engaged during class, Charles created guided notes. During each upgraded class, students did some combination of answering questions, taking notes, making sketches, and filling out tables for most of the 75 minutes of lecture. Some questions were discussed with partners for an interactive component. Using the verb list provided by Chi et al. (2018), Charles reworded many of the prompts that are embedded in his lectures to elicit higher levels of student engagement and interaction with the content during the activities.

Table 1 shows an example of an ICAP-upgraded activity used to help students understand an ancient geologic setting using the types of rocks that would be formed in that setting. Previously, the activity prompt was a series of pictures of different depositional environments with the associated sediment type that formed in that environment, and students had to do a simple recall of basic definitions of what rock types form from those sediments. The upgraded activity started with students identifying rock samples. Students then predicted the type of sediment that would form the rock and matched the sediment to the correct depositional environment. Students who worked together on this activity may have reached interactive levels of engagement.

Table 1: Specific example of an ICAP upgrade of a required class activity

Class structure	**Original**	**ICAP Upgrade**
Required task	*Match* modern sedimentary depositional environments and sediments to their rock type	*Identify* these four Paleozoic sedimentary rock specimens, and *interpret* their depositional environments
ICAP Verbs	Match	Identify, Predict, and Interpret
Activity Prompt	Match rock type to sedimentary depositional environment (Active)	1) Identify the rocks (Active) 2) Predict the types of sediments that would form the above identified rocks (Constructive) 3) Use this inferred knowledge to interpret what sedimentary depositional environment matches the identified rock (Active/Constructive)

Through scaffolding student notetaking and deliberate use of ICAP verbs to elicit higher-level engagement from his students, Charles upgraded the overall ICAP level of the course from primarily passive classes (lecture with no notetaking) with active activities to classes that are mostly active (guided notetaking and activities) with some constructive activities. This suggests that increasing the amount of active learning in a medium-sized STEM lecture class does not require a complete redesign of the course. Strategic upgrades can lead to increased engagement, potentially benefiting all students.

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