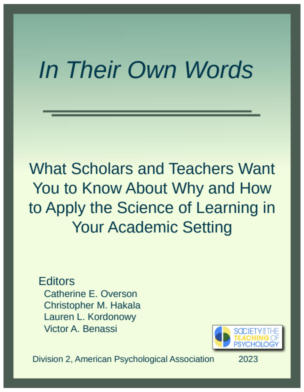

Applying the ICAP Framework to Improve Classroom Learning

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Introduction to ICAP

The recent drive to restructure classrooms to improve learning has been shaped by the term "active learning." While "active learning" has become a familiar term in education, it has been defined as referring to just about any learning strategy that is not a lecture (Freeman et al., 2014). Thus, educators remain without guidance in deciding which types of activities should be included in the classroom and for what purpose. To help teachers design and implement active learning strategies in the classroom, ICAP (*Interactive, Constructive, Active*, and *Passive*), a science of learning and evidence-based theory, provides heuristics that can help differentiate and distinguish between different types of active learning activities in terms of their effectiveness for improving learning (Chi & Wylie, 2014).

ICAP refers to two kinds of engagement: physical and cognitive. *Physical engagement* refers to the visible actions or activities students are doing while they interact with instruction—such as taking notes, listening to a lecture, and so forth (the term "instruction" is used broadly to include both the instructor's actions and the instructional materials). Although physical interactions with instruction involve overt behaviors, it is distinct from the traditional definition of *behavioral engagement,* which refers to students' overt actions that reflect their initiation, persistence, or completion of their interactions with instruction (Marks, 2000; Skinner & Belmont, 1993). For example, the frequency of "attending class" is an index of behavioral engagement, and it refers to the initiation of interactions with instruction, while "turning in homework assignments" refers to the frequency of completing interactions with instruction. Even in the context of online learning, many indices are measured, and they all refer to *behavioral engagement*, such as the frequency of accessing the homework assignments or a specific page of the instructional materials. We use the term *physical engagement* to refer to the *processes* of interacting with instruction, such as taking notes while reading or listening to a lecture, instead of the initiation and completion of interactions with instruction. Thus, ICAP is a theory about the processes of how students learn. *Cognitive engagement,* on the other hand, refers to students' underlying thinking processes while learning. Because cognitive processes are invisible, ICAP uses *physical engagement* as an index to reflect *cognitive engagement*.

The ICAP framework combines observable student *physical actions/interactions* with instruction, along with an analysis of student-produced outputs (such as notes or questions) to define four modes of student engagement: *Interactive, Constructive, Active,* and *Passive.* These four engagement modes correspond to four different levels of learning in the I>C>A>P descending order, with the *Interactive* mode leading to deeper and more learning and the *Passive* mode to shallower and less learning. The ICAP framework provides heuristics to help teachers differentiate active learning activities and classify each activity into the associated ICAP learning mode.

ICAP is applicable for many content domains, but it is particularly relevant for learning difficult to understand concepts, such as those in STEM (science, technology, engineering, and math) domains because ICAP enhances deeper learning. ICAP can be beneficial for students' learning from pre-K to college level and beyond, and in many contexts, such as face-to-face or online courses. Whereas existing overarching frameworks typically used in designing lesson plans or course work start by classifying instructional objectives or assessment items from the perspective of the instructors (Bloom & Krathwohl, 1956; Dick & Carey, 2005; Krathwohl, 2002), the ICAP theory designs lesson plans from the perspective of the students, based on what students are asked to do when interacting with instruction. ICAP and its supporting evidence is discussed in detail in Chi (2009), Chi et al. (2018), Chi and Wylie (2014), Fonesca and Chi (2011), and Menekse et al. (2013).

The taxonomy of the four ICAP modes are briefly described below. Each of these modes is operationally defined by heuristics consisting of two overt indices: the physical actions of what students *do* and the *visible outputs* (if any) of what students produce, while interacting with instruction. In addition, we allude to the potential underlying thinking processes of each mode. The heuristic indices and the plausible cognitive processes are shown in Table 1.

Passive

We define the *Passive* mode of engagement as learners interacting with instruction physically by *orienting towards* or *paying attention* to instruction with *no visible outputs* produced. For example, paying attention and listening to a teacher's lecture without taking notes is considered engaging in the *Passive* mode. Thus, the two overt indices of engaging in the *Passive* mode are *paying attention* and producing *no visible outputs*.

Note that ICAP's definition of each mode does not allude to the thinking processes, as thinking processes are invisible to instructors. We assume that the thinking processes occurring while paying attention might be receiving and storing information. Although it may be possible for students to be thinking deeply while processing instruction (such as making connections to other course concepts or revising one's representation of the concept), ICAP assumes that a student is *more likely* (but not with 100% certainty) to be simply receiving and storing information. Thus, the student is more likely to be engaged in the *Passive* mode when only paying attention and not displaying any other activities.

Active

Learners' engagement with instructional materials is classified as *Active* when students *physically manipulate* some parts of the instructional materials, such as *pointing to* or *gesturing at* parts of what they are solving or reading (Alibali & DiRusso, 1999), *pausing and rewinding* parts of a videotape (Chi et al., 2008), *underlining* certain text sentences (Katayama et al., 2005), *copying* some problem solution steps (VanLehn et al., 2007), *mixing* certain chemical amounts in a hands-on laboratory (Yaron et al., 2010), *choosing* a justification from a menu of options (Conati & VanLehn, 2000), and *bookmarking* a page in a textbook. The *visible outputs* produced from manipulating can be identified as information *already existing* within the content materials. For example, if students are highlighting a text, the highlighted sentences already existed within the instructional materials.

The advantage of manipulating parts of the instructional materials is that it gives students opportunities to re-focus and pay attention to the selected information again, thus allowing additional thinking processes of re-activating relevant related information and thereby strengthening it. Selection of the parts of the instructional materials to manipulate can be based on syntactic cues within the instructional materials, such as important words like "the principle," or "the most important equation," and so forth.

Constructive

ICAP defines the *Constructive* mode as having the characteristics of *physically generating* some *external outputs* and the external outputs contain *additional information* that goes beyond what was provided in the learning materials. To meet these criteria for *Constructive*, the outputs of generative interactions must contain new ideas or minute inferences not identifiable verbatim in the instructional materials. An important caveat: when we say an inference or “new” idea, we are not referring to an innovative or never-before-discovered novel idea in the content domain of instruction. Instead, we mean that the generated information is new in relation to the instructional materials provided. For example, suppose a student creates a concept map. If the student creates a concept map in her notes that makes new connections between the nodes and such connection information was not already presented, then the student is engaging in the *Constructive* mode. However, if the student copied a concept map already existing in the textbook, then the student would be engaged more in the *Active* mode, as the original concept map was merely manipulated by being copied.

Many different learning activities fit into our definition of *Constructive* (generative) activities. Examples include drawing a concept map (Biswas et al., 2005; Novak, 1990a; 1990b); taking notes in one’s own words (Trafton & Trickett, 2001); asking questions (Graesser & Person, 1994); comparing-and-contrasting cases; integrating two texts (Britt & Sommer, 2004), text and diagrams (Butcher, 2006), or across multimedia resources (Bodemer et al., 2004); inducing hypotheses and causal relations (Suthers & Hundhausen, 2003); drawing analogies (Chinn & Malhotra, 2002); generating predictions (Schauble et al., 1995); reflecting and monitoring one’s understanding or other self-regulatory activities (Azevedo et al., 2006); constructing timelines for historical phenomena (Dawson, 2004), and self-explaining (Chi et al., 1994). These examples can all be classified as *Constructive* activities because they satisfy the two indices in our definition: (1) they require students to be generative, and (2) the outputs must include additional information not available in the original learning materials (e.g., asking students to compare-and-contrast two examples requires the learners to say what is the same or different between the examples, when the instructional materials may not have mentioned their similarities and differences; similarly, asking students to integrate text and a diagram obviously requires them to articulate relations about them that were not explicitly presented).

We surmise that the thinking processes involved in being generative is to reason in various ways that can produce new knowledge, such as inferring new relations, revising one’s existing knowledge, deducing causal consequences, and so forth. Thus, the *Constructive* mode involves the fundamental cognitive processes of learning, consisting of making sense of instructional inputs by activating relevant prior knowledge, connecting new information with prior knowledge, inferring new knowledge, revising prior knowledge, and so forth.

Interactive

We define the *Interactive* mode as collaborations/interactions between students (such as through dialoging) and with instruction that meet two criterial indices: (1) two (or more) students are engaging in *reciprocally co-generative behaviors*; and (2) the outputs contain information that *goes beyond the instructional materials* and *beyond what each partner contributes individually*. The *Interactive* mode refers to a unique form of collaboration that is reciprocally co-generative, meaning that not only is each partner generative in the *Constructive* sense of going beyond the presented instructional information, but, moreover, each partner should be generative by building upon the partner’s contributions.

This concept of mutually, reciprocally exchanging ideas can occur in natural dialog or in specifically formatted dialogs such as debating (defending or arguing a position, Schwarz et al., 2000), critiquing each other by requesting justification (Okada & Simon, 1997), asking and answering each other’s questions (Webb, 1989), peer tutoring (Roscoe & Chi, 2007), and elaborating on each other's contributions, such as clarifying, building upon, correcting, and so forth (Hogan et al., 1999). While numerous definitions exist to define collaborative behaviors, our definition of *Interactive* or *reciprocally co-generative* collaborative dialogs is more specific by requiring both partners to make *Constructive* contributions in a reciprocally co-generative way. However, it is more difficult to determine whether the second index is met: that the outputs from reciprocally co-generative collaboration are in fact novel and cannot be produced by one partner alone. In fact, reciprocally co-generative interactions can produce innovative outputs.

The *Interactive* mode requires a significant degree of turn-taking so that it allows each partner to incorporate her partner's understanding of the domain into her own thinking and to make more frequent adjustments to her own mental model (Chi, 2000). That is, two students who take long turns giving mini-lectures to each other, even if they are being *Constructive*, will likely not reap the same benefits as two students who take multiple short turns interjecting to ask each other questions, make clarifications, and so forth. The *Interactive* mode in ICAP refers to this kind of *co-generative* collaborative dialogs.

Table 1

Heuristics of Two Indices to Operationally Define the ICAP Modes

2 Heuristic Indices	ICAP Modes			
	Passive	***Active***	***Constructive***	***Interactive***
What physical behaviors are present?	Orienting or attending behaviors	Manipulating behaviors	Generating behaviors	Reciprocally co-generating behaviors
What visible outputs (if any) are produced?	No visible outputs produced	Visible outputs contain information provided in the instructional materials	Visible outputs contain information that goes beyond the existing instructional materials	Visible outputs contain information that goes beyond 1) the instructional material and 2) a partner's contributions
	Plausible cognitive or thinking processes			
	Storing new information	Activating, thereby strengthening relevant prior knowledge	Inferring new knowledge	Inferring new knowledge and building upon partner's knowledge

ICAP's Main Hypothesis

The central hypothesis of the ICAP theory is that the levels of learning outcomes are predicted by the ordering *Interactive* > *Constructive* > *Active* > *Passive*. That is, an *Interactive* activity leads to deeper and more learning than a *Constructive* activity, and *Active* activities lead to more learning than *Passive* activities. This hypothesis is based on both the subsuming hierarchy of the physical interactions and the plausible hypothetical thinking processes underlying each mode. But the biggest improvement in learning outcomes occurs between *Active* and *Constructive* modes. That is, when students are *Interactive* or *Constructive*, they learn more deeply than when they are *Active* or *Passive*. Details on the thinking process underlying cognitive engagement are described in Chi et al. (2018).

Two important points need to be noted about the ICAP hypothesis. The first is that the deeper learning achievable in the *Constructive* and *Interactive* modes can only be detected if deeper assessment questions are designed to test students' understanding. Shallower questions are perfectly adequate to detect learning from the *Passive* and *Active* modes. For example, students are more likely to demonstrate generated knowledge when answering open-ended questions than answering multiple-choice assessment items. The second important point to note is that ICAP predicts learning effectiveness for activities across modes; ICAP cannot make accurate predictions for activities within the same mode. This is because ICAP's analyses of engagement are based on overt physical interactions and produced outputs, indices that can be used in a classroom context. However, in order to make predictions of the relative benefits of activities within the same mode, an analysis of the underlying cognitive processes is required.

Empirical Support

The main hypothesis of the ICAP theory is supported by hundreds of laboratory and classroom studies carried out by other investigators, often comparing two conditions. For many of these studies, we can typically map the study's manipulated and control conditions to an ICAP mode and see if the learning effectiveness is consistent with ICAP's pair-wise predictions. That is, I>C>A>P implies that pairwise comparisons should be consistent with ICAP's predicted descending direction, such as I > C, I > A, I > P, C > A, and so forth. We describe a simple example from a study that contrasts two conditions to show how they are easily mapped to two ICAP modes. Henderson and Canning (2013) examined the use of *Interactive* activities in college students' responses to conceptual physics questions that were administered using classroom clickers. After controlling for all demographic and performance variables, students who were given an opportunity to verbally discuss their clicker votes with each other (*Interactive*) performed significantly better on the Force Concept Inventory than students who received a supplemental lecture (*Passive*) between clicker votes. This is just one example of the numerous studies reviewed in our publications (Chi, 2009; Chi et al., in press; Chi & Wylie, 2014; Fonesca & Chi, 2011). At the college level, the ICAP hypothesis is consistent with a meta-analysis of 225 college classroom studies (Freeman et al., 2014). Those 225 studies essentially showed that *Interactive*, *Constructive*, and *Active* activities are all better than *Passive* activities of students listening to lectures only.

In conclusion, the strength of the ICAP framework is twofold. First, the framework provides a means of differentiating between numerous "active learning" strategies outlined in the literature based on simple heuristics using two indices. That is, ICAP divides "active instruction" or non-lecturing into three modes and ranks them by effectiveness. Second, the theory applies across content domains, school subjects, tasks, and is applicable for all age groups and individuals. Thus, ICAP can help instructors decide on class activities and tasks that optimize students' cognitive engagement and learning levels.

How to Use ICAP to Design Activities and Exercises, Choose Strategies and Ask Questions

How can the distinctions pointed out by ICAP in terms of the two heuristic indices of each mode—students' physical interactions with instruction and students' produced outputs (shown in Table 1)—allow us to systematically translate the four modes (*Interactive, Constructive, Active,* and *Passive*) into ways that we can apply ICAP toward the design of activities and exercises, choose learning strategies, and frame how questions should be asked in class discussions.

How to Design Activities and Exercises Using Verbs Differentiated by ICAP

Activities or exercises undertaken by students are often explained through directives using verbs. The type of verbs used to explain or describe what students need to do in an activity or exercise can play a significant role in the level of student learning. We will refer to such explanations as "instructional directives." One of our recent ICAP studies (Chi et al., 2018) found that the type of verbs used by teachers when giving directives significantly impacted the mode of students' engagement and, thus, their level of learning in the classroom. ICAP can classify the type of verbs used by teachers into ICAP's four different modes. For example, the two components of *Passive* mode require students to be *paying attention,* and *no external outputs are produced*. *Passive* verbs are ones that lead students to enact *attentive* behaviors, such as "listen to me," "look at the board, or "watch the video." In these directives, the verbs only require students to *pay attention* to the task at hand, but do not require students to produce any output. More examples of *Passive* verbs are shown in Table 2.

On the other hand, *Active* mode verbs should require students to engage in some behavior that manipulates the course materials and requires an output of some kind that can be identified as from within the course content. So, *Active* verbs should lead students to *manipulative* behaviors. Examples of *Active* verbs include describe, match, and pick (see Table 2 for a list of ICAP verbs). Following the operational definitions and heuristics of ICAP, *Constructive* verbs should lead student to enact generative behaviors and produce outputs that contain new information. Examples of these ICAP verbs include design, evaluate, explain, and paraphrase in your own words, as shown in Table 2.

It is important to remember that the biggest jump in learning level is from the *Active* to the *Constructive* mode. Because of this, changing the verbs used in directives and worksheets from *Active* to *Constructive* can be easily done and can significantly improve the student engagement mode and the level of students' learning outcomes. For example, suppose an instructor originally used a worksheet that was in the *Active* mode because it asked students to *match* photos of a molecular model to the correct chemical name. *Match* is an *Active* verb and only requires students to *choose* a photo from the ones presented. However, the teacher could upgrade this activity to *Constructive* by asking students to *draw* the molecular model based on the name of the chemical. Assuming that the students do not have access to the image of the model in their textbook or notes, the students are now generating a new output not already given in the course material. Thus, these students are engaging at a higher mode.

Finally, *Interactive* verbs should require students to engage in *reciprocally co-generative* behaviors and produce *outputs* that are *beyond both the course content* and their peer's contributions. Examples of these phrases include "exchange ideas," "debate with a peer," "answer peer questions," and "expand on your peer's reasoning." These phrases can lead students to engage with a partner in a reciprocally co-generative way. One important caveat about the *Interactive* mode is that instructors have a common tendency to try to upgrade an activity to *Interactive* simply by adding the phrase "work with your partner" to an *Active* or a *Constructive* activity. "Work with your partner" is a very general directive; it does not specify how students should work with a partner in order to be reciprocally co-generative.

In sum, the fact that verbs can be differentiated into the four ICAP modes means that when designing an exercise or activity for students to carry out, instructors can choose the verbs that correspond to the mode of engagement (and its corresponding level of learning) that they wish to obtain from students.

Table 2

Classifying Verbs Using ICAP

Passive **Verbs**	***Active*** **Verbs**	***Constructive*** **Verbs**	***Interactive*** **Verbs**
Verbs that can lead students to *attentive* behaviors	Verbs that can lead students to *manipulative* behaviors.	Verbs that can lead students to *generative* behaviors.	Verbs that can lead students to *collaborative* behaviors
• Listen • Look • Observe • Read • View • Watch	• Arrange • Assign • Classify • Describe • Duplicate • Fill in • Indicate • Mark • Match • Number • Pick out • Point	• Analogize • Compose • Decipher • Design • Differentiate • Evaluate • Explain • Hypothesize • Invent • Paraphrase • Propose • Rationalize	• Agree upon • Answer peer's questions • Argue • Consult with • Critique • Debate • Discuss • Exchange ideas

How to Select Which Strategies to Use

Instead of designing one's own activities, instructors often implement conventional activities and strategies that have been used extensively in classrooms and explored in a multitude of research studies. However, there has not been any systematic or theoretical way of differentiating the comparative benefits of these strategies for learning. In principle, we can now examine a strategy by analyzing the verbs or verb phrases used in the strategies in terms of their ICAP modes. But many of these conventional and well-used strategies are described by some non-verb labels such as "clickers." Therefore, in order to know the ICAP mode of these strategies, we need to analyze what the students are supposed to do in these activities in terms of ICAP's heuristic indices of physical interactions and outputs. In this section, we evaluate the ICAP mode of three common strategies by considering how the students interact with instruction and what outputs they produced in their physical interactions, the heuristic indices listed in Table 1.

The first example is a common classroom activity—fill-in-the blank worksheets (or guided notes, Konrad et al., 2009; Kotsopoulos et al., 2022; Neef et al., 2006). Guided notes require students to write down information that is being displayed during a lecture onto the provided worksheets with blanks, which clearly indicate where and what to write. The physical interactions of the students are manipulative because they are only copying information onto the worksheet that was already presented. Therefore, they are not providing any new information outside of the given instructional materials. Thus, this activity can be considered engaging in the *Active* mode.

But not all forms of notetaking are *Active.* For example, taking notes using the Cornell note-taking format (Pauk & Owens, 2010, in which a structure is provided on each page, is a much more *Constructive* activity. The structure provided by Cornell notes consist of segmenting a blank page with different sections allocated for different goals, such as reserving the left column, which is about 30% of the page, for students to write questions and main points. The right column, which is the other 70% of the page, is reserved for students to take their primary notes from lecture or reading, which corresponds to those questions or key terms. At the bottom of the page, students are asked to summarize the main points and notes from the page (Quintus et al., 2012). It is obvious that Cornell notes is an activity in the *Constructive* mode because it asks students to produce questions, main points, and so forth. Thus, it is not surprising that taking Cornell notes is more effective for learning than taking guided notes (Jacobs, 2008).

A second example is the “muddiest point” activity. The “muddiest point” learning strategy requires students to reflect on a point of uncertainty existing in the instructional materials covered in that class (Akhtar & Saeed, 2020). This requires students to think about what aspects of the instructional materials were unclear, manifested in the physical behavior of pausing and reflecting on what they do not understand, and then writing down what aspects of instruction were confusing. The output produced in this instance is the articulated statement of the muddiest point. This muddiest point is likely not explicitly stated in the instructional materials. Thus, this learning activity can be considered *Constructive.*

The third commonly used activity is clickers. Clickers can be used by students to respond to a question the instructor posed, often by choosing one of four provided answer choices. The way clickers were used originally and that showed substantial learning benefits (Hake, 1998), start with students in a class choosing an answer from the four options. Once chosen, the instructor can display everyone’s combined answers and determine whether the correct option was chosen by a majority of students, thereby indicating if the students have understood the materials embedded in the question. If the responses were distributed across various incorrect options, then the next step of using clickers is to ask students to discuss with their neighbors, especially a neighbor who had chosen an opposing option. The students are presumed to discuss and resolve their different responses. Carried out this way, using clickers is definitely an *Interactive* mode of co-generative collaboration. Unfortunately, instructors often reduce clickers to an *Active* mode activity by only having students choose a response and omitting the collaborative discussion. Consistent with ICAP’s predictions, using clickers the correct way to include collaborative activities (the *Interactive* mode) seems to be better for learning than without (the *Active* mode; Chien et al., 2016; MacArthur & Jones, 2008). Thus, depending on how they are used, clickers can be an *Active* or an *Interactive* activity.

The heuristics of analyzing what students are asked to do, and what they produce to determine the ICAP mode of a strategy, can be applied to analyze almost any learning strategy for classifying it as either *Interactive, Constructive, Active* or *Passive.* Table 3 below provides several additional examples of learning strategies for each mode. A more complete list of learning strategies can be found in Chi et al. (in press).

Table 3

Classifying Examples of Learning Strategies Using ICAP

Passive	***Active***	***Constructive***	***Interactive***
• Listening (Feng & Webb, 2020) • Observing and watching and looking (Cocco et al., 2021) • Reading and re-reading (Rawson & Kintsch, 2005) • Tactile learning (Savaiano et al., 2016) • Turn-taking reading (since as a whole, each individual student only speaks aloud for a short portion) (Duffy, 1983)	• Clickers and polling (Arthurs & Kreager, 2017) • Following step-by-step instructions (Liefooghe et al., 2018). • Guided notes with fill-in-the-blank (Kotsopoulos et al., 2022) • Listing (generating a list) from memory (Epstein, 1969; Roberts, 1972) • Mapping or aligning two sets of given information (Yin et al., 2005).	• Concept-mapping (Chang et al., 2002; Novak, 1990a; 1990b) • Explaining to another (Biswas et al., 2005; Roscoe & Chi, 2007) • Hypothesizing explanations for a set of data (Hulsizer et al., 2018) • Self-explaining and elaborating (Chi et al., 1989; 1994) • Taking notes or paraphrasing in own words; writing interpretive summary (Trafton & Trickett, 2001).	• Asking and answering each other's questions (Rivers et al., 2017); or reciprocal questioning (King, 1990a; 1990b). • Debating with a partner, offering claims and justifications (Schwarz et al., 2000) • Improv theater (Rossing & Hoffman-Longtin, 2016) • Peer tutoring (Beasley, 1997) • Reciprocal learning (Palinscar & Brown, 1984)

How to Ask Questions in the Classroom

Constructive questions should be the most common type of question asked in the classroom, but in practice we often primarily see *Active* questions (Morris & Chi, 2020). The learning benefits of moving from asking *Active* questions to *Constructive* questions indicate a need for teachers to prioritize increasing the proportion of *Constructive* questions asked in the classroom in relation to *Active* questions.

ICAP can also classify questions using the same heuristics as applied to our classification of verbs. *Active* questions lead students to respond in a manner that only manipulates the course materials and not to provide new information, such as asking student to recall or re-state information already provided (e.g. "*Describe* what we talked about yesterday,") or asking students to choose an option from a set of provided options or to make a perceptual comparison or judgment of what is presented (e.g., such as "Can you *identify* which one is bigger?"), or asking students to do a simple calculation (e.g., "Can you tell me the number of mice in location A?"). Retrieving and carrying out an already known computation is *Active*.

On the other hand, *Constructive* questions ask students to generate beyond the given materials, often requiring students to infer information or to justify their explanation (e.g., "What evidence do you have to support that?"), or requiring students to make a connection or link between given course materials (e.g. "How does this concept relate to what we learned yesterday?"), or requiring students to make a prediction based on the given information or perhaps by combining the given information with some prior knowledge to make an educated inference (e.g., "What do you think will happen to the mice that have the darker color mutation?"). Commonly, *Constructive* questions require students to predict, justify, explain, plan, or make connections in their responses.

We have identified a few types of *Passive* questions from middle school teachers (Morris & Chi, 2020). *Passive* questions do not expect students to answer the question, besides perhaps a shake of the head. For example, rhetorical questions (e.g., "Does this make sense?") are often asked by teachers who are taking a brief pause to "check in" before moving onto the next part of the lesson, without waiting to receive a response. Another common *Passive* question occurs when a teacher asks a question, but then immediately answers the question—essentially turning the question into lecture (e.g., "How many polygons are there? Four, right?"). *Passive* questions should be avoided in the classroom because they do not offer substantial value to students' engagement or learning.

Interactive questions are questions that elicit students' interaction with their peers or other collaborative behaviors (e.g., "Does anyone disagree with Student A, why or why not?"; "What do you think about Student B's opinion?"; "How can you defend Student C's answer?"). *Interactive* question-asking often occurs when teachers are helping to guide a group discussion or debate in a facilitated manner. When asking *Interactive* and *Constructive* questions, it is important that instructors allow sufficient time for students to think and answer the questions because generating new ideas tend to require more think-time than *Active* responses.

Examples of Upgrades from Post-secondary and K-12 Classes

We describe briefly two examples of how two college instructors (Professor Semken and Professor Krause at Arizona State University) chose to upgrade their course activities, and one example from a K-12 class, from *Active* to *Constructive,*

Professor S. Semken (personal communication, October 17, 2019) teaches a geology course every semester which originally consisted of two, short in-class activities during each class meeting. In one instance of this in-class activity, students were asked to match sedimentary depositional environments and sediments to the correct rock type. Matching is an *Active* activity because students only manipulate the existing course content. After ICAP-upgrading his course, the same in-class activity was changed so students were asked to: 1) *identify* (*Active*) the sedimentary rock specimen, 2) *predict* (*Constructive*) what type of environment that rock could be found in, and 3) then *interpret* (*Constructive*) which environment matches their own prediction for each rock. While the activity still includes some *Active* components, the overall ICAP mode of the task moved from *Active* to *Constructive*.

Our second example comes from a class taught by Professor Krause in an undergraduate engineering course. Originally, one type of activity Professor Krause gave his students required them to match the property and change, unit cell transformation, condition for change, and original processing method—which were each provided in content banks organized by each topic—to five provided objects. In the upgraded version, the students were provided with the same five objects and their corresponding conditions for change. Based on this information, for each object, students had to 1) *state* and *explain* the properties and change structure, 2) *draw* the unit cell transformation, and 3) *state* and *explain* the original processing method. Because students were now generating answers and drawing the molecular structures rather than matching the same information, students were engaging in the *Constructive* mode rather than the *Active* mode (Menekse et al., 2013).

The third activity is a pre-college ICAP upgrade example. In this math class, the instructor improved a worksheet on fractions from *Active* to *Constructive.* The original worksheet provided students with tiles that had written on them various fractions, decimals, and percentages. For example, the tiles said .75, 3/4, 75%. The students had to organize the tiles so all of the values that represented the same numerical amount were grouped together. When the worksheet was upgraded, the tiles were removed. Instead, students were given one value (3/4, .8, 9%, etc.) and had to generate various different versions of the given decimal or fraction. For example, a student sees 3/4 written on the worksheet and then needs to generate different ways to represent the same numerical amount.

ICAP in Practice: Issues and Challenges

We discuss several caveats and challenges that can arise as instructors think about implementing activities, guided by ICAP, to improve student learning.

Deciding on Which ICAP Mode to Implement

Although ICAP emphasizes the importance of learning in the *Interactive* and *Constructive* modes, not all-learning objectives require a high-level of cognitive engagement. For example, when students need to memorize a set of procedural steps or memorize associated information, *Active* is sufficient (e.g., learning the name of a word in another language). This also applies to some domains for which no generative inferences, justifications, or reasoning can be provided, such as the rules of grammar. In learning such domains, such as formal logic, activities in the manipulative *Active* mode is adequate.

Moreover, there is some interesting evidence to show that sequencing of different engagement modes might make the *Passive* mode more effective. For example, the *Passive* mode (lecturing) can be valuable to learning if a *Passive* activity comes after a *Constructive* activity, such as having students struggle to solve a problem first and then listening to an instructor's explanation (Kapur, 2012; Schwartz & Bransford, 1998; Kapur & Roll, this volume). One explanation might be that by allowing students to be generative first, before hearing a lecture, provides the opportunity for students to figure out what gaps they have and what they misunderstand, which can then be filled in or corrected by the subsequent lecture. Not enough research exists to deeply explore various sequencing effects of one mode followed by another mode of activity.

Ambiguity of a Mode

Sometimes it is somewhat ambiguous which ICAP mode an activity is. There are several reasons for such ambiguity, such as students' prior knowledge, additional conditions or constraints, and activities that are simply ambiguous between modes.

Ambiguity in terms of students' prior knowledge can be illustrated by the task of problem solving. Suppose an instructor assigns a set of problems for her students to solve. If a student already knows how to solve the assigned problems and she is simply applying the steps in a methodical manner, then for her this problem-solving task is only *Active* because she is only recalling information she has learned from instruction and not producing any new information. However, if the problem is considered a transfer problem, and the student does not know how to solve the problem without making further reasoning, then the student is generating changes to a known procedure to adapt the procedure for this new type of problem. Then the student would be generative and in the *Constructive* mode. Thus, the ICAP mode of a problem is individualized to the students' prior knowledge. A simple solution is to provide a range of problems in difficulty.

A second way that an activity can be ambiguous is when additional conditions or constraints are needed for accurate classification. A good example is sorting items into categories. If a student is given a set of items to sort, with the categories to sort them into, then this is an *Active* task because all of the materials are given, and students are merely manipulating the to-be-sorted items into categories. On the other hand, if students are given a set of items and asked to sort them into categories that they have to create, then this is clearly a *Constructive* activity.

Ambiguity can also occur for some activities that are genuinely difficult to classify, because they have characteristics of two modes, such as asking students to read out-loud an entire passage. Although this seems to be an *Active* activity because students are articulating the words on a page, it also seems *Passive* because it lacks the re-focusing opportunities to manipulate portions of instruction, as provided by other *Active* activities, since the entire passage is being read out-loud rather than a selected portion. The ambiguity in the modes for such examples can be easily addressed by considering an activity as falling in between two modes (in this reading case, between *Passive* and *Active*). In practice, instructor need not worry about the precise mode of an ambiguous activity. Rather, instructors should focus on upgrading the mode of an ambiguous activity, such as from an in-between *Passive-Active* activity to a *Constructive* activity.

Students' Compliance

Another challenge in practicing ICAP includes student compliance issues. That is, students themselves can downgrade a higher-mode activity—intentionally or unintentionally. For example, if an instructor asks her students to summarize a text in their own words (a *Constructive* activity), a student may instead use the copy-paste method of summarizing (which is an *Active* activity). In these instances, an instructor can check compliance by examining the student-produced output. Unfortunately, ICAP cannot handle the compliance issues associated with students not following directions.

However, ICAP underscores the findings in Chi et al. (2018) that even with frequent non-compliance, giving students higher ICAP mode activities improves the odds that students are *more likely* to respond within the higher modes of cognitive engagement and should improve the students learning overall. It is safe to assume that a majority of the students are likely to comply, or that the individual students might comply a majority of the times.

Conclusion

ICAP is a theory that can define and differentiate active learning and recommend how to put these classifications into practice, such as designing in-class and homework activities, selecting learning strategies, and framing questions. Moreover, ICAP can also be used in myriad other ways that are not discussed in this chapter, such as evaluating videos, digital tools, and lesson plans. In short, ICAP allows instructors to know how to evaluate their own classrooms and how to apply ICAP in their classrooms, so that they will be better able to guide their students toward higher cognitive engagement and, ultimately, higher learning gains.

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