ICAP: How Students Engage to Learn

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ICAP is a theory of how students engage with instructional materials, often referred to as "active learning." Engagement has been explored mostly as a motivation construct or assessed by large grain-sized behavioral outcomes, such as the frequency of students' class attendance, or the frequency that they do their homework, and so on. ICAP takes a cognitive approach, and defines cognitive engagement by smaller grain-sized behavioral measures in the context of students' interactions with instructional materials that can be presented either as text passages, teacher lectures, videos of materials, exercises or problems to solve, and other classroom activities. That is, ICAP assumes that the small grain-sized behavioral measures can serve as indicators of cognitive engagement, resulting in differentiated learning outcomes as a function of students' level of engagement.

ICAP consists of three components: First, it defines a taxonomy of four behavioral ways/modes that students can engage: *Passive, Active, Constructive* and *Interactive*. In the *Passive* mode, students can be *passively* receiving instructional information by paying *attention* to it, but not doing anything else. In the *Active* mode, students can be *actively manipulating* the instructional materials without adding any new information, such as underlining certain text sentences or copying teachers' power point slides. In the *Constructive* mode, students can be *constructively* interacting with the instructional materials by *generating* inferences and other elaborations, such as providing explanations or justifications. Finally, in the *Interactive* mode, students can learn the materials *interactively* by *collaborating* with another student.

Some behaviors do not discriminate between engaging in the *Constructive* and the *Active* mode. For example, if a student is taking notes, one cannot tell which mode she is engaging in unless her notes are analyzed. However, we can determine that *constructive generation* has occurred by comparing whether the generated knowledge contains new information that was not presented in the instructional materials. If there is no new information added, such as when the student just repeated the instructional materials, then her note-taking behavior is considered participating *actively* only, and not *constructively*. Thus, the operational definition of each mode is to first look at the small grain-sized behavior of how students interact with instructional materials, and then if the behavior is not definitive in determining a mode, students' products can be analyzed to confirm which mode students are in fact engaging.

The second component of ICAP is the postulated underlying cognitive processes associated with each behavioral mode. As an exercise, suppose at least one of these four elementary knowledge-change processes occur when students engage with instructional materials: "store" new information, "activate" prior knowledge, "link" new information with activated or newly stored knowledge, and "infer" new knowledge from activated knowledge or from newly linked knowledge. We can assume which of these four elementary "knowledge-change" processes occur in the four modes of engagement. For example, in the *Passive* mode, we might assume that when students do nothing other than paying attention and receiving instructional information, no prior knowledge was "activated," so new information may be "stored" in an isolated way, resulting in inert knowledge. On the other hand, being *Active* means that students are manipulating some aspects of the instructional materials, and such manipulations can "activate" prior knowledge relevant to what was being manipulated. Thus, for the *Active* mode, because prior knowledge was "activated," new information can be "stored" by "linking" it with prior knowledge. The *Constructive* mode means students are generating a piece of knowledge that was not presented, and this suggests that the "infer" process is occurring, in addition to "storing," "activating," and "linking." Inferring allows the learner to have a richer representation. For the *Interactive* mode, not only is the "infer" process occurring, but inferring can be based on the articulated inferred knowledge of one's partner. This suggests that novel knowledge can be created that neither partner could have generated alone.

Based on these four knowledge-change processes, it appears that the richness of students' knowledge representation depends on which of the four behavioral modes students engage in, such that the *Interactive/*collaborative mode enhances learning more than the *Constructive/*generative mode, which is superior to the *Active/*manipulative mode, with the *Passive/*attentive mode as the least effect way to learn; that is, I>C>A>P. The constraint of this hypothesis is that the *Interactive* mode is better for learning than the *Constructive* mode only if both the students of a dyad in the *Interactive* mode is *generative* individually. Moreover, they must each be *generative* in a way that responds to the partner's contributions. That is, they must collaborate in a mutually-and-reciprocally generative way that is responsive to each other's contributions. Thus, the third component of ICAP is a hypothesis that predicts decreasing learning outcomes or other performance measures in this I>C>A>P direction.

This hypothesis can be tested by various existing studies in the literature for which the conditions of the studies can be interpreted to map onto a specific ICAP mode. For example, in a study of 5-year-old children, Legare and Lombrozo (2014) found that children who were asked to *explain* how a crank works while watching the experimenter turns the crank, performed significantly better later when they were asked to explain the causal mechanism, than children who merely *watched* the experimenter turned the crank, for the same amount of time with no feedback in either conditions. Such results support ICAP's prediction in that the children in the *watch* condition were engaging *Passively*, whereas the children in the *explain* condition were engaging *Constructively*. Overall, there are hundreds of published results in the literature that support ICAP's predictions (summarized in Chi, 2009; Chi & Wylie, 2014). In addition, we have manipulated activities across all four modes for college students in learning engineering concepts. We found that students' learning to decrease significantly from mode to mode, in the predicted direction.

In this talk I will present some of the results from our five-year project, in which we attempted to translate ICAP into practice by teaching 13 middle school teachers about ICAP using an online module. We measured the success of our translation in five ways: (a) teachers' understanding of ICAP after completing the module, (b) their successes at designing lesson plans using different ICAP modes, (c) fidelity of teachers' classroom implementation, (d) level of students' enacted behaviors, and (e) students' learning outcomes.

Although students' learning was significantly better when teachers designed activities requiring generative engagement, teachers had difficulty designing their lesson activities in the *Constructive* mode. Instead they ended up designing their lesson activities in the *Active* mode even though they intended them to be in the *Constructive* mode. This difficulty was detected across teachers, across various content domains they taught, and grade level, by analyzing the verb segments they used in their instruction or directives given for the activities they had designed. This finding is shown in Fig. 1.

The x-axis of Fig. 1 indicates whether an activity is intended to be an *Active, Constructive,* or an *Interactive* one. The numbers in the parentheses indicate the number of segments available for scoring in that intended mode. The y-axis indicates the proportion of mode-appropriate verb segments for activities intended for each of the three modes.

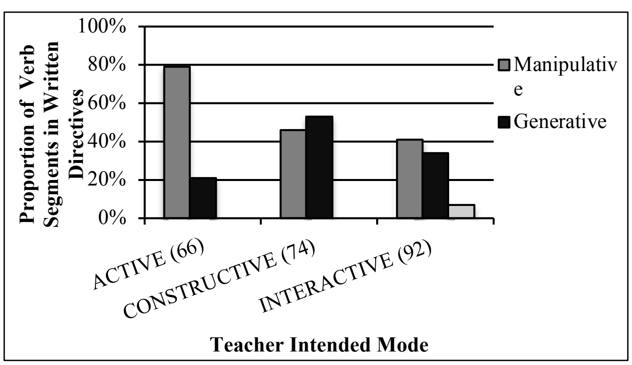

Fig. 1: Proportion of verb segments in the written directives for activities designed by the teachers.

For example, a verb such as "Connect the two concepts" would be considered a *manipulative* verb segment since the two concepts are already provided in a concept map. On the other hand, a verb segment such as "Explain your choice" in the directive would be considered a *generative* verb segment since the explanation would be new information not already presented in the instructional materials. Fig. 1 shows that for activities intended to be *Active,* teachers did design about 80% of them to be *manipulative*. Complete accuracy would be 100%, as shown by the dotted lines. However, for activities intended to be *Constructive,* only a little over 50% of the activities were designed to be *generative*. And for *Interactive* activities, less than 10% were designed to be *collaborative*. Thus, teachers' accuracy in their design was the best for *manipulative* activities, least for *collaborative* activities, and mediocre for *generative* activities.

Interactive engagement was the most difficult for teachers to design in part because our instruction to teachers were inadequate in providing detailed explanation for how they can guide students to collaborate in an optimal mutually-and-reciprocally generative way.

References

Chi, M. T. H. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*, 73-105.

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*, 219-243.

Legare, C. H., & Lombrozo, T. (2014). Selective effects of explanation on learning during early childhood. *Journal of Experimental Child Psychology, 126*, 198-212.

Six Publications Relevant to this Abstract

Chi, M. T. H. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*, 73-105.

Chi, M. T. H., Adams, J., Bogusch, E. B., Bruchok, C., Kang, S., Lancaster, M., Levy, R., Li, N., McEldoon, K., Stump, G.S., Wylie, R., Xu, D. & Yaghmourian, D. L. (In press). Translating the ICAP theory of cognitive engagement into practice. *Cognitive Science.*

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*, 219-243.

Fonseca, B. A., & Chi, M. T. H. (2011). Instruction based on self-explanation. In R. E. Mayer & P. A. Alexander (Eds). *Handbook of Research on Learning and Instruction* (pp. 296-321). New York: Routledge.

Menekse, M., Stump, G., Krause, S., & Chi, M. T. H. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education, 102*, 346-374.

Stump, G. S., Li, N., Kang, S., Yaghmourian, D., Xu, D., Adams, J., McEldoon, K. L., Lancaster, M., & Chi, M. T. H. (2018). Coding dosage of teachers' implementation of activities using ICAP: A video analysis. In E. Manalo, Y. Uesaka, & C. A. Chinn (Eds). *Promoting spontaneous use of learning and reasoning strategies: Theory, research, and practice for effective transfer* (pp. 211-225). New York: Routledge.