Applying the ICAP Theory of Cognitive Engagement to Active Geoscience Learning

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Agenda

- ➔ Introduction to the ICAP theory and its four modes
- ➔ ***Exercise*** on classifying active-learning methods according to the ICAP framework, and discussion
- ➔ Overview of the ICAP theory and its theoretical and research bases
- ➔ Case study of ICAP application to teaching geoscience
- ➔ ***Roundtable discussion*** of application of ICAP to participants' own teaching

Introduction to the ICAP Theory and its Four Modes

What is ICAP?

The **ICAP** Theory of Cognitive Engagement (Chi & Wylie, 2014) states that student learning changes across a progression, differentiated by student behavior:

Interactive Engagement	>	**C**onstructive Engagement	>	**A**ctive Engagement	>	**P**assive Engagement
(*co-constructing*)	>	(*generating*)	>	(*manipulating*)	>	(*receiving*)

ICAP Mode Determination is Based on Student Behaviors

Why student behaviors?

- We can't see what students are **thinking**
- We can see what students are **doing**
- We can see the work that students are **producing**

By observing student behaviors and work products, we can use **ICAP** to assess the engagement level of our students.

ICAP Modes

Interactive mode - students work together to build off of each other's ideas and **co-construct** new knowledge (e.g. think-pair-share, debating).

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).

Active mode - students **manipulate** the given content/curricular materials (e.g. copying verbatim notes, answering questions with wording from a text).

Passive mode - student **pay attention** and **receive information**, without doing anything else with the information, as is typical in lecture classes.

Engagement with Learning Tasks

Students can engage in a given learning task in four different modes

For example, with Concept Maps:

ICAP Mode	Engagement with Learning Task
Interactive	Co-Creating their own concept map from a list of vocabulary words
Constructive	Creating his/her own concept map from a list of vocabulary words
Active	Copying a concept map without adding other information
Passive	Reading a map created by someone else

Active Learning in ICAP:

Interactive Engagement	>	Constructive Engagement	>	Active Engagement	>	Passive Engagement
(*co-constructing*)	>	(*generating*)	>	(*manipulating*)	>	(*receiving*)

Active Learning

Passive Learning

Note: At all four levels the student is **cognitively engaged**. This is all **on-task** behavior.

What is Cognitive Engagement?

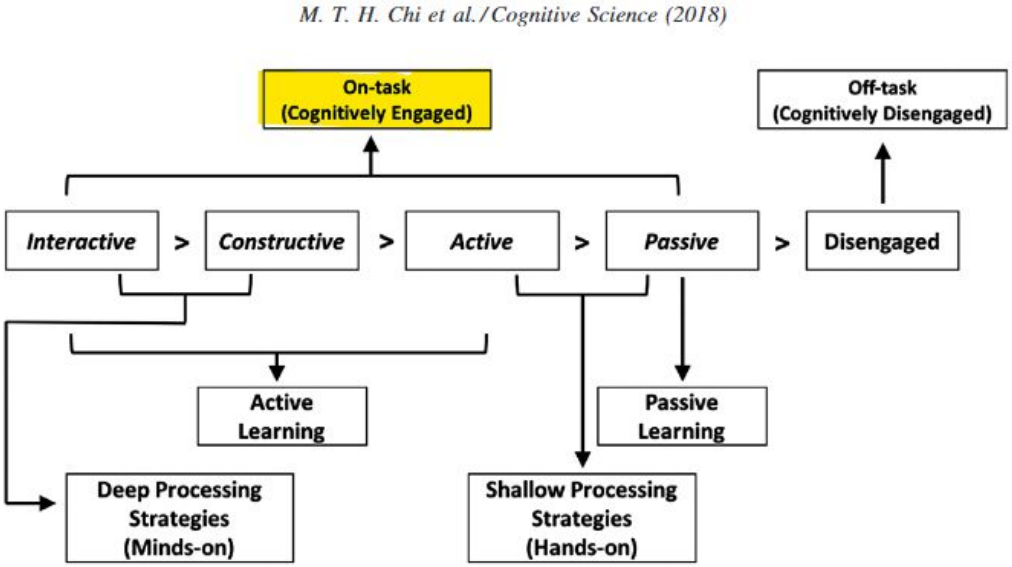

Fig. 1. Terminologies corresponding to ICAP.

Time for our activity! Remember the ICAP modes:

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McConnell, D. A., et al. (2017). Instructional utility and learning efficacy of common active learning strategies. *Journal of Geoscience Education, 65,* 604-625.

Active Learning Strategy	Brief description of strategy	Strategy Score	Participant I-C-A-P Poll
Case studies/problems	Students analyze an authentic narrative or problem in order to find solutions.	21	67% C, 22% A, 11% I
Concept maps	Students create and/or analyze graphical representations of knowledge of a concept or system.	26	81% C, 15% A, 4% I
Concept sketches	Students depict and label the main aspects (features, processes, etc.) of a concept or system.	22	67% C, 30% A, 4% I
Gallery walks	Students move among a series of posters or other types of prompts and provide responses at each station.	18	54% I, 31% A, 15% C
Jigsaw	Students form small expert groups to collectively solve one part of a problem, then reform into distributed groups in which each student teaches the others.	21	93% I, 4% C, 4% A
Lecture tutorials	Students provide responses to structured prompts designed to target misconceptions, during an interactive lecture.	26	79% A, 11% I, 11% C
Minute papers	Students provide brief written responses to a few questions that probe their learning.	28	64% A, 36% C
Peer instruction	Students respond individually to a question, then (based on % correct) compare and discuss responses with classmates before responding a second time.	33	75% I, 14% A, 11% C
Role-playing	Students simulate an event by taking on the roles of people who variously affect or are affected by the event.	13	81% I, 15% C, 4% A
Teaching with models	Students handle physical models while an instructor manipulates models during a demonstration.	21	79% A, 14% C, 4% I
Think-pair-share	Students individually think of a response or a solution and then compare their ideas with those of a classmate.	29	89% I, 7% A, 4% C

Active Learning - McConnell et al. (2017)

Includes one or more the following elements:

(1) students participate in activities (either doing or observing) in addition to, or instead of, listening to direct instruction;
(2)activities provide opportunities for student reflection on their learning or facilitate student–instructor interaction and assessment of learning; and
(3) peer-to-peer interaction occurs as students complete the activity.

Comparing ICAP and McConnell et al.

Doing what? Doing makes it at the least **A**ctive mode , but it is what they are doing which distinguishes between **I** - **C** - **A**

Both are **P**assive mode.

(1) students participate in activities (either doing or observing) in addition to, or instead of, listening to direct instruction;
(2)activities provide opportunities for student reflection on their learning or facilitate student–instructor interaction and assessment of learning; and
(3) peer-to-peer interaction occurs as students complete the activity.

Constructive Mode

Not necessarily **ICAP I**nteractive. Stay tuned for more on this!

Overview of ICAP Theory and its Theoretical and Research Bases

Knowledge Change Processes

"Dynamic processes that students engage in while learning new information." (Chi & Wylie, 2014)

Co-Infer		Infer		Integrate		Store
Interactive Engagement	>	**C**onstructive Engagement	>	**A**ctive Engagement	>	**P**assive Engagement
(*co-constructing*)	>	(*generating*)	>	(*manipulating*)	>	(*receiving*)

Expected Cognitive Outcomes

Co-Create		Transfer		Apply		Recall
Interactive Engagement	>	**C**onstructive Engagement	>	**A**ctive Engagement	>	**P**assive Engagement
(*co-constructing*)	>	(*generating*)	>	(*manipulating*)	>	(*receiving*)

Learning Outcomes

Deepest Understanding		**Deep** Understanding		**Shallow** Understanding		**Minimal** Understanding
Interactive Engagement	>	**C**onstructive Engagement	>	**A**ctive Engagement	>	**P**assive Engagement
(*co-constructing*)	>	(*generating*)	>	(*manipulating*)	>	(*receiving*)

Summary (Chi & Wylie, 2014)

ICAP Mode	Interactive Engagement	>	Constructive Engagement	>	Active Engagement	>	Passive Engagement
What the student is doing	*Co-constructing*	>	*Generating*	>	*Manipulating*	>	*Receiving*
Knowledge Change Processes	Co-Infer		Infer		Integrate		Store (isolated)
Cognitive Outcomes	Co-Create		Transfer		Apply		Recall
Learning Outcomes	Deepest Understanding		Deep Understanding		Shallow Understanding		Minimal Understanding

(For more detail, see Chi & Wylie, Table 2, p. 228)

Empirical Backing

Types of evidence:

1) Lab studies
2) Re-interpreting studies published pre-**ICAP** which compare different types of learning, explaining the results by applying **ICAP** mode
3) Studies conducted post-**ICAP** comparing learning outcomes designed in different **ICAP** modes

A Note About Interactive Mode:

- Just because students are interacting with each other doesn't mean they are in **I**nteractive **ICAP** mode.
- The **ICAP** Framework is hierarchical.
- In order to be engaged **I**nteractively, both students need to be in **C**onstructive mode.
- There are four ways that students can be working together that are not **I**nteractive, and only one combination that is **I**nteractive, when both students are in **C**onstructive mode.

Partner 1	Partner 2
Active	**P**assive
Active	**A**ctive
Constructive	**P**assive
Constructive	**A**ctive
Constructive	**C**onstructive

ICAP Applied - Chi & Menekse, 2015

Research indicates that in approximately 28% of “collaborative learning” studies, collaborative learning does not result in greater learning compared with solo learning.

ICAP can explain why:

- An individual working alone could be in **C**onstructive, **A**ctive, or **P**assive modes.
- Combining these with each of the 5 possible collaborative pairs in the previous slide yields 15 possible combinations
- In four of those 15 combinations (26.6%), the individual is at an equal or greater **ICAP** level than the pair (for example, the individual is **C**onstructive, and the pair are **A**ctive and **P**assive.)

Case Study of ICAP Application to Teaching Geoscience

Upper-division Southwest place-based course in geology and sustainability of Arizona and the Southwest open to majors and non-majors (intro geology or physical geography prerequisite). Enrollment 50.

Interactive-lecture format: 15 min lecture-15 min activity-15 min lecture-15 min activity-10-15 min lecture; students submit in-class activities for nominal class points.

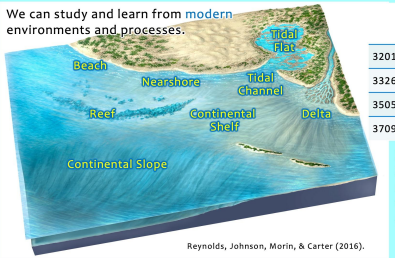
ICAP strategies:

- Scaffolding student notetaking and inquiry with designed “outline” handouts submitted for class points.
- Deliberate use of ICAP verbs during interactive lectures and in-class activities.

Case Study of ICAP Application to Teaching Geoscience

3.2.12 *What kinds of sediments were deposited in these changing Paleozoic marine and shoreline environments?*

We can study and learn from modern environments and processes.



Reynolds, Johnson, Morin, & Carter (2016).

	Rock type?	Dep Envt?
32010		
33260		
35050		
37090		

Identify these four Paleozoic sedimentary rock specimens and *interpret* their depositional environments.

5.1.4 *What Triassic rocks are found in Arizona (and the Southwest)?*

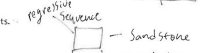
Study the *Geologic Highway Map of Arizona* (Kamilli & Richard, 1998), and *write* answers to these questions on your outline in the space provided:

a. What Triassic map units occur in Arizona?
b. What types of rock are these map units?
c. What Earth-system processes are typically encoded by rocks such as these? Be as thorough as you can!
d. Where in Arizona do these rocks crop out?

Trcs Chinle Formation
Trm Moenkopi Formation

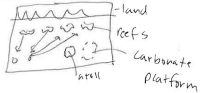
Kamilli & Richard (1998).

5. Across Arizona and the Southwest, Paleozoic rocks are mostly sedimentary strata deposited on a surface eroded on Proterozoic rocks: the Great Unconformity.
   - Pervasive eroded surface all throughout the "SW"
   - We can find it at the bottom but it is very difficult to see.
   - Grand Canyon is where it is very apparent.
   - Horn Creek
   - East Verde river near payson
   - Sandia Crest, Nm
6. As sea levels rose and fell in the Early and Middle Paleozoic Era, the Laurentian passive margin was periodically flooded and re-exposed. • Two end-member types of sea-level changes are eustatic & tectonic
   - rocks deposits are climatically determined
   - Sea-levels have always gone up and down.
   - eustatic - climate - ice
   - tectonic - continent subsides or uplifts
7. Throughout the Early and Middle Paleozoic Era: SCISWO
   - Laurence Sloss - geologist
   - "transgressions or sequences"
   - up & down
   - Inversions of sea-level that trigger massive depositions on continental
   - Jim Facet - Seas came in Seas went out (SCISWO)
8. Each transgression of the sea over the land left deposits of marine and shoreline sediments. Passive margin



9. Migrating seas deposit characteristic sequences of sediments.

10. Offshore, where seas are warm, carbonate platforms and reefs can form.



$Ca^{2+}(aq) + CO_3^{2-}(aq) = CaCO_3(s)$

11. What are your questions so far?

Carbonate (lime) precipitation increases with water temp. as CO_2 becomes less soluble

12. What kinds of sediments were deposited in these changing Paleozoic marine and shoreline environments? Identify these four Paleozoic sedimentary rock specimens and interpret their depositional environments.

	Rock type?	Depositional environment?	Rock unit	Map unit
32010	Shale Mudstone	Nearshore	Cambrian	mc
33260	Sandstone Very course	Beach	↓	mE
35050	limestone (Fizz)	reef/shelf	m	mE
37090	Chert	Shelf/reef associated	P	PP

13. The paleo-Southwest in the Cambrian Period circa 510 Ma.
    - SCI →

14. Tonto Group rocks encode the Cambrian transgression.
    - Sandstone → mudstone → limestone
    - MWAN → Bright Angel Sh → tapeats

15. Animal life appeared during the late Neoproterozoic Era and "exploded" during the Cambrian Period. Animal life appeared about 630 million years ago

16. Fossils are tangible remains or traces of ancient organisms in the geologic record (i.e., part of rock masses).
    - Body
    - petrified wood
    - Ammonite
    - Chinle formation
    - trace
    - theropod tracks
    - Bioturbation tapeats

17. The paleo-Southwest in the Ordovician Period circa 470 Ma.
    - SWO
    - most of it was high and dry.

18. The paleo-Southwest in the Silurian Period circa 430 Ma.

How to Identify a Student's ICAP Mode in Earth Science Classes? See what the student is doing:

	Interactive	Constructive	Active	Passive
Students in this mode could be doing: ***Think about: what work products would students be generating in each example?**	• Discussing the identity of a mystery sample • Creating a collaborative concept sketch • Debating the use of fossil fuels versus renewable energy sources	• Creating a cross-section from a geologic map. • Drawing a concept sketch to explain their understanding of a concept • Identifying minerals using a dichotomous key	• Taking verbatim notes • Copying a sketch • Drawing the view through a microscope or telescope • Answering questions with clickers	• Listening to a lecture • Reading a map • Studying a cross section • Looking through a microscope or telescope

Identifying ICAP Mode Using Verbs

Interactive	Constructive	Active	Passive
Debate	Create	Calculate	Read
Discuss	Predict	Choose	Listen
Exchange	Summarize	Order	Look
Share	Argue	Recall	Observe
Help	Defend	Find	Watch

Thanks!!

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