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Opinion: Course Design in the Time of Coronavirus: Put on your Designer's CAP

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ABSTRACT

The recent pandemic forced most faculty to move from face-to-face to remote instruction, sometimes necessitating a redesign of content and assessment, as well as the mode of instruction. This opinion piece presents the Content-Assessment-Pedagogy (CAP) triangle, a course design framework adapted from backward design, that parallels the engineering design process, and can guide deliberate course redesign decisions. The CAP triangle provides a guiding framework for making design decisions about what content must be emphasized and what might be omitted, what needs to be assessed, and how to design activities that maximize learning. The critical feature of the CAP framework is the alignment of each component (content, assessment, and pedagogy) with each other. And we propose that alignment is operationalized by placing what you want learners to retain long after instruction (the enduring outcomes) at the center of the design. We assert that the assessment and pedagogy need to flow from the enduring outcomes. And we also assert that *feedback* (not "grading") is the most important aspect of assessment and that *practice* is the key feature of pedagogy.

Key words: course design, backward design, alignment

INTRODUCTION

> "We never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference." (John Dewey 1916)

> "It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments." (James Duderstadt 2010)

The Covid-19 pandemic recently forced countless courses to be taught remotely, and this trend is likely to continue. Although grappling with uncertainty and change is stressful, this mandate also provides an opportunity to reassess the structure of our courses and more fully incorporate evidence-based practices. As Singer and Smith wrote "Discipline-based education research (DBER) dispels myths about learning and yields results – if only educators would use it" (Singer and Smith 2013a, and elaborated upon in 2013b). Our goal in this piece is to share a way of *thinking* about course design that was invaluable to us during the rapid move to remote learning. For more specific pedagogical suggestions, see Prince, Felder and Brent (2020). We offer the Content-Assessment-and-Pedagogy (CAP) triangle as a framework to help faculty redesign and perhaps re-imagine their courses.

When redesigning for remote instruction, it is tempting to focus all one's attention on the most recent educational technology tools. Many of our institutions have very able instructional technology consultants and this opinion piece does not mean to duplicate their services here. Instead, we discuss a *way of thinking* about course design that, for us, has been an invaluable tool in making design decisions. Our model has been refined by over ten years of using it to help future and current faculty design or redesign their courses and to help those creating "universities" in industry. Although the CAP model is always a useful framework for course design, we contend it is even more essential when course design decisions need to be made quickly – as they were with the recent rapid switch to remote learning.

Since our title asks you, the reader, to put on your designer's CAP, it is important to provide insight into some design thinking research that has informed and influenced this work.

Larry Leifer and colleagues (Meinel and Leifer 2014) stressed the iterative nature of both design and education and argued that all design is re-design and all education is re-education. Leifer (2000) defined design as "a social process that identifies a need, defines a problem, and specifies a plan that enables others to manufacture the solutions" and he summarized the parallels between design and learning in Table 1.

Table 1. Parallels between Design and Learning (from Leifer 2000).

Design and Learning	
Design	**Learning**
Engineering design is a social activity	Education is a social activity
Designers require ambiguity	Learning requires ambiguity
All design is re-design	All education is re-education
Design occurs in a context	Learning occurs in a context

Current descriptions of design note that "Engineering design is a process of devising a system, component, or process to meet desired needs and specifications within constraints. It is an iterative, creative, decision-making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources into solutions. Engineering design involves identifying opportunities, developing requirements, performing analysis and synthesis, generating multiple solutions, evaluating solutions against requirements, considering risks, and making trade-offs, for the purpose of obtaining a high-quality solution under the given circumstances." (ABET 2020). The Content-Assessment-Pedagogy (CAP) triangle parallels this iterative engineering design process where the content is parallel to developing requirements, assessment is parallel to evaluating solutions against requirements, and pedagogy is parallel to the process of devising a system, component, or process.

The CAP triangle is an adaptation of the backward design model popularized first for the K-12 community by Wiggins and McTighe (2005) and later for tertiary education by Hansen (2011). In CAP, what is to be learned (the content) must be *aligned* with the feedback provided on the learning (the assessment), and both must be aligned with how the learners practiced what they are to learn (the pedagogy).

But what does it *mean* to align content, assessment, and pedagogy? How does one operationalize alignment? And how is alignment useful when redesigning for remote instruction? The rest of this article aims to flesh out our ideas about how to answer those three questions.

The next sections elaborate on content, assessment and pedagogy separately; however, it is crucial to keep in mind that they are highly interdependent and each area needs to be closely coordinated with others.

CONTENT: WHAT SHOULD LEARNERS KNOW, DO, OR CARE ABOUT?

In design, one starts with the end in mind. In designing a course, one needs to start with determining what is to be learned. How can we view what learners need to know through the lens of the big ideas of the discipline? At this step, disciplinary knowledge intersects with the learners' prior knowledge and experience can be represented as the overlap of the knowledge-centered and learner-centered aspects of the *How People Learn* framework (Bransford, Brown and Cocking 2000). As a first step in the design process it is critical to ask: How will what the learners know, do, or care about change as a result of the class? [Sullivan 2005 calls these the apprenticeships of the head, hands, and heart]. One should visualize how the learners will be different after the class has ended. As you brainstorm your answers to this question, prioritize and place your list into the following three categories created by Wiggins and McTighe (2005):

1. Enduring Outcomes - What do you want your learners to retain long after the course is over? (Note that Wiggins and McTighe used the term enduring *understandings,* but we prefer the more inclusive term enduring *outcomes* to make room for non-cognitive outcomes.)

2. Important-to-know Outcomes - What are the complementary building blocks needed to achieve the enduring outcomes?
3. Good-to-be-familiar-with Outcomes - Are there things you feel your learners would benefit from seeing or hearing about, but which are not crucial to the learning experience?

The entire course design is then built to support the enduring outcomes and the important-to-know outcomes that complement them. The enduring outcomes are the driving force for the whole design: the lodestar. When redesigning for a remote format, faculty are often asked to create a series of brief videos that capture the essence of the course content. Therefore, the first design decision usually centers around what should those few, brief videos contain. The quick answer? The enduring outcomes!

However, determining the enduring outcomes can be the most difficult part of the whole design process. A particularly challenging task can be admitting that not *everything* is essential. It is often not easy to dig into our mountains of content to uncover what is important, to see past our expert blind spots (Nathan, Koedinger, and Alibali 2001) and all our assumptions about what the learners 'should know', past all the embedded jargon of our field, past the symbols we use so automatically. What is *really* important? And how do our learners make sense of the content?

Since enduring outcomes can be difficult to determine, we offer four techniques that can help.

1. Ask: What are the big ideas that lie at the heart of the discipline?
   - Where big ideas are defined as "major theories in a given discipline" (Wiggins and McTighe 2005), and those which "revolutionized the thinking in that discipline" (Hansen 2011).
2. Ask: What do learners typically get wrong or misunderstand? What concepts, principles, procedures, etc. typically require 'uncoverage' rather than coverage?
   - Uncoverage is "a teaching approach that is required for all matters of understanding. To 'uncover' a subject is to do the opposite of 'covering' it, namely to go into depth" (Wiggins and McTighe 2005, 352).
3. Ask: What are the questions that experts in the area ask about a situation?
   - These are what Hansen (2011) calls the 'essential questions' of the discipline.
4. Create concept maps or other graphic organizers that show relationships among parts of the content and then ask: Where do the concepts/pieces intersect or converge? These convergent areas may point to the big ideas. Concept maps may evolve during the iteration process. For a good example see Streveler, Smith, and Pilotte 2011, 2012. Workshop slides are available at https://karlsmithmn.org/wp-content/uploads/2017/08/FIE%20CAP%20mini-workshop%20slides%20v6.pdf

We highly recommend building what Robin Adams has called an "intellectual neighborhood" (personal communication 2004) as a way to work through these thoughts with others. We need critical friends – some of whom are outside our circle of expertise - who can help us begin to uncover the difficult concepts that experts often overlook.

After you have created your list of enduring, important-to-know, and good-to-be-familiar-with outcomes, determine how your learners will practice and get feedback on the enduring and complementary important-to-know outcomes. Remember, the enduring outcomes are the core of your design, and practice (pedagogy) and feedback (assessment) flow from them.

ASSESSMENT: PROVIDING FEEDBACK TO LEARNERS

Assessment is a rather loaded term and therefore we want to be clear that our emphasis will be on using assessment to provide FEEDBACK on learning. We are not focusing on assessment as "grading." Often, and especially when done poorly, grading fits Paul Dressel's definition of a grade as "an inadequate report of an inaccurate judgment by a biased and variable judge of the extent to which a learner has attained an undefined level of mastery of an unknown proportion of an indefinite material" (Smith 1986).

When using the CAP triangle, the crucial point for assessment is to ask: how will the learners get feedback on how they are doing on their journey to reach the learning goal? What kind of formative feedback can they be given to know if they are on the right track? Formative feedback informs the learner (and the instructor) of the status of their mastery and often provides guidance about ways to improve. It is not summative, that is, it is not intended to sum up or grade the learner. In order to learn, one must get feedback on one's performance. Is the learner proceeding towards successful performance or veering away from it? In many instances, you will want specific metrics about how progress will be measured – and this entails the creation of measurable learning objectives. Some people start course design by immediately creating detailed learning objectives but we contend that you need to take a big-picture perspective about *what* you want to measure before you decide the specifics of *how* you will measure it.

Learning Objectives

Advice on how to write learning objectives abounds, so we will not provide detail here. But we will offer the SMART heuristic where SMART stands for **s**pecific, **m**easurable, **a**ttainable, **r**elevant, and **t**ime-bounded. Keep in mind that learning objectives are indirect *indicators* of learning. Just as the unemployment rate and the consumer confidence index are indicators of the strength of the economy (but not the economy itself) so learning objectives are indicators of learning. It is possible to have many useful indicators which, taken together, can give one a fuller picture of the phenomenon you are measuring. This is the case with our example of "the economy" and it is equally true with learning. There can be many appropriate, useful learning objectives to measure something like "problem-solving skill." We mention this as a caution against writing learning objectives too soon in the course design process. It is easy to fixate on one particular measurement and forget about the larger outcome one is hoping learners will achieve. Be very clear about the enduring outcomes first. Then figure out an appropriate learning objective to indicate if that enduring outcome has been achieved.

Taxonomies of Learning Objectives

As a check to help be sure your learning objectives are measuring what you hope they are measuring, it can be useful to place learning objectives into a taxonomy. A taxonomy is simply a framework to categorize things. So, a taxonomy of learning objectives is a way to categorize learning objectives. Bloom's taxonomy (1956) and the later revision by Anderson and Krathwohl (2001) are the most familiar taxonomies but many of the future faculty we have worked with found the significant learning outcomes taxonomy by Fink (2013) to be very useful when assessing non-cognitive factors such as "human dimensions" and "caring."

Place your learning objectives into the taxonomy and observe the kinds of learning your assessments are measuring. There is no particular pattern the learning objectives should fall into. Placing learning objectives into a taxonomy is a way to check alignment of your design. For example, you might intend for learners to develop analysis skills, but discover you are actually measuring learners' recall of specific questions. If this happens, you want to change your learning objectives to match your pedagogical intentions.

What Should Be Assessed?

We now ask a critical question for course design - what should be assessed? In what areas should feedback be given?

We assert that feedback must *always* be given on enduring outcomes - at least as informal, formative feedback. Since enduring outcomes are the core of the learning experience, and feedback is vital for learning, an instructor has an obligation to provide feedback to the learners on their movement toward the enduring outcomes. Likewise, feedback is *usually* provided on important-to-know outcomes, but feedback on good-to-be-familiar-with outcomes is optional.

For summative assessment, one must determine a benchmark level of mastery that learners must reach to "pass" and then decide how one will know when the learners have reached that benchmark. With some kinds of skills, the level of mastery needed may be rather obvious, but this is a more difficult issue with intellectual skills, and even more problematic with non-cognitive outcomes. Guides for review and feedback, commonly called 'rubrics' are often used to provide transparency on the scope and quality levels of learners' work and to provide feedback on their degree of mastery of the enduring outcomes. A variety of online tools have been created to help faculty create their own rubrics.

Notes For Remote Learning

Deciding what to assess is always a crucial question, but it becomes even more pertinent in the switch to remote instruction since the logistics of assessment can become more complex in remote environments. One common thing we noticed in the past few months when face-to-face instruction suddenly went remote, was that faculty jettisoned some of their planned assessments. So, one needs to ask - which assessments might be discarded and which should be retained? The enduring outcomes can become the guide for these decisions.

Likewise, many institutions switched from A/F to Pass/Fail grading during the pandemic. Schneider (2020) noted that "This pandemic has surfaced a dilemma frequently ignored: A-F grades are used poorly and for too many different purposes." Systemic problems with A/F grading, especially grading on a curve have been noted for years, prominently for example, by Bloom (1984) and, more recently, by Grant (2016). These issues point out the urgent need to look closely at what is assessed and how it is assessed. The pandemic has created an opportunity to stop and re-evaluate what is assessed and how it is assessed.

Concern about academic honesty in remote settings has led some faculty to employ elaborate monitoring mechanisms, which can lead to an atmosphere of distrust between faculty and students. The decision to use monitoring protocols is very context-dependent and should be thought-through deliberately.

Most Learning Management Systems have automated systems to provide feedback both to the learner and the instructor. Embedded questions in learning modules can test for understanding and learners can receive instantaneous feedback about the correctness of their answers.

And instructors can monitor which students have opened various aspects of the course content, when they opened it, and how long it was open.

PEDAGOGY: PRACTICING ENDURING AND IMPORTANT-TO-KNOW OUTCOMES

> "The aim of teaching is … to transform students from passive recipients of other people's knowledge into active constructors of their own and others' knowledge.… Teaching is fundamentally about creating the pedagogical, social, and ethical conditions under

which students agree to take charge of their own learning, individually and collectively." (Christensen, Garvin and Sweet 1991)

Pedagogy also flows from the enduring outcomes. We need to ask ourselves: how do we help learners practice the process needed to move toward mastery of the enduring outcomes? The answer to this question becomes the pedagogical piece of our design. Again, the pedagogy needs to be focused on the enduring outcomes. The enduring outcome is not something people acquire by osmosis or pick up along the way…. it must be deliberately practiced. And the practice should be distributed over time and mode (visual, audio, kinesthetic, self-explanation, explaining to others). Ericsson (2008) emphasized the importance of deliberate practice for developing expertise, and memory researchers like Kandel (2007) have shown that repeated practice is needed for long-term memory storage. By adding these two research results together we assert that instructors should provide **deliberate, distributed practice** of the enduring outcome for their learners. A practical guide for implementing these ideas is available in Brown, Roediger, and McDaniel (2014).

As a designer of instruction, how does one create materials and activities that allow learners to practice the enduring outcomes? We recommend one consult one's institution's instructional support office for the nuts and bolts of creating clear materials that are accessible to all learners. Putting on a designer's hat, the vital point is to be sure the materials explicitly address the enduring outcomes. We will focus the rest of this section on the kinds of learning activities to create, and when to implement these activities.

We have found Chi's (2009) Interactive-Constructive-Active-Passive (ICAP) framework to be invaluable, both for increasing the granularity of how to define "active" learning and for deciding when to use which kind of activity. The framework categorizes kinds of overt learner behaviors as interactive, constructive, or active, and compares learning gains that result from each category. Table 2 describes active, constructive, and interactive activities. Note we have replaced "active" with "attentive" to avoid confusion between Chi's use of "active" and the common usage of this term in engineering education (Streveler and Menekse 2017).

Table 2. ICAP framework adapted from Chi 2009.

Attentive	Constructive	Interactive
Doing something physically Paying attention	Producing outputs that go beyond presented information	Dialoging substantively on the same topic, and not ignoring a partner's contribution
Engaging activities	Self-construction	Guided-construction
Attending processes	Creation processes	Joint creation processes

With regard to learning gains, Chi documented that interactive activities are more effective than constructive activities. Constructive activities are more effective than attentive activities. And all of them are more effective than passive approaches.

The effectiveness of interactive activities has also been validated in STEM settings. Two recent meta-analyses summarize the importance of interactive learning for (1) reducing the failure rate (Freeman, et.al. 2014) and (2) narrowing the achievement gap for underrepresented students (Theobald, et.al. 2019). A large-scale classroom observation study of over 2000 STEM classes noted that "a large body of evidence demonstrates that strategies that promote student interactions and cognitively engage students with content lead to gains in learning and attitudinal outcomes" (Staines, et.al. 2018).

In the ICAP framework, each successive level builds upon the proceeding one. First, attention is the gateway to learning as one must pay attention to anything one wants to explicitly learn. And an individual learner must self-construct before two or more people can engage in co-construction. For example, consider the commonly used "think-pair-share" activity. First, learners are asked to think about a topic (this is an attentive activity), and come up with their answers to that question (constructive), and then to discuss their ideas with a partner (co-construction). Thus, we can see that interactive activities also require attention and self-construction.

We will describe attentive, constructive, and interactive activities and discuss when to use them.

Attentive Strategies

What are they

Attentive activities focus learners' attention on what we want them to learn. According to Chi (2009) attentive activities prompt the learner to *do* something, usually physically. Examples of attentive behaviors are taking verbatim notes, repeating what was said, or highlighting text. In an online environment, activities such as steering a virtual bike through a virtual landscape, or working with a haptic device to feel the "weight" of a virtual object would be considered attentive.

When to use them

Attentive activities might be all that is needed for good-to-be-familiar-with outcomes

Notes for remote learning

Note that in online environments the learner may well be used to being passive - watching funny YouTube videos to release stress. So, when learning online we may need to deliberately encourage learners to move from a passive to an attentive mindset. What can faculty do to help? First, explicitly point out the tendency to be passive and tell learners what to pay attention to. What are they looking for? What questions should they be able to answer?

In face-to-face settings, learners have the time to prepare themselves for learning by walking to class, entering a specific classroom, sitting in a seat they always sit in, seeing their classmates and the professor. All these things give learners cues that it is time for learning. But in an online setting, learners may be in rooms where lots of other things happen. Instead of classmates, there may be family members or pets. Learners (and professors) might want to pause and take time to mentally "get themselves to the classroom". Maybe closing their eyes for a moment, taking a deep breath, and opening their eyes with the intention to learn. They might also want to develop their own environmental cues to remind them they are in a learning space such as using a particular mug or water bottle when it is time to learn.

Constructive Activities

What are they

With constructive activities, the learner **adds** to the material, not just repeats it. Some examples of constructive behaviors are providing an example of a concept or idea, summarizing or paraphrasing in our own words, elaborating or explaining, self-reflection and self-monitoring, creating a concept map, generating a hypothesis, or making a prediction.

When to use them

Best used with enduring or important-to-know outcomes.

Notes for remote learning

A variety of methods can be used in an online environment for prompting constructive behavior in learners. In synchronous online classes, the chat function, or threaded discussion are often used for this purpose. New applications are constantly being created which allow one to instantaneously assemble ideas from learners in real-time or aggregate over time. And, as noted earlier, automated systems have been developed that give learners feedback on their solutions to problems. Check with your institution's instructional designers to see what is available at your institution.

Interactive Activities

What are they

Interactive activities require joint or **co-construction**. According to Chi (2009, 77) interactive behaviors occur when at least two learners are "dialoging substantively on the same topic, and not ignoring a partner's contribution." Interaction is *not* synonymous with "group work". The learning gains of interaction only accrue to those who truly co-construct. If a group member sits back and doesn't contribute, or just blindly agrees with a dominant voice, then that learner will have only the learning gains of a passive learner. Thus, simply putting people into pairs or a group without clearly articulating the purpose, structure, and process of the group's work does **not** ensure individual learning, or a productive team experience.

Creating high-quality interactive learning environments takes thought and effort. Therefore, we provide elaborated examples of interactive learning to help faculty create high-quality activities. One important consideration in this high-stress time is to ensure that there is a balance between high expectations (challenge) and high personal and social support - called "security" by Pelz and Andrews (1966) and Pelz (1976) and "psychological safety" by Edmondson (2008). Psychological safety essentially is freedom from fear of humiliation and abuse and team psychological safety is defined as a shared belief that the team is safe for interpersonal risk-taking (Edmondson 1999). Edmondson (2008) noted that the learning zone is where there is high accountability for meeting demanding goals and high psychological safety. Cooperative learning, especially cooperative base groups, emphasizes the importance of academic and personal support (Johnson, Johnson, and Smith 2006 and see https://karlsmithmn.org/wp-content/uploads/2017/08/cljigbase.doc and https://karlsmithmn.org/wp-content/uploads/2020/07/Smith-clbase-915.pptx). One common way to provide psychological safety is through the implementation of cohort groups. (See http://www.ncsall.net/index.php@id=254.html). Cohort groups are common in professional education and are especially important when learners are not co-located and/or when they have lots of demands or stresses in addition to their degree program (Kegan 1994).

The most extensively researched approach for implementing interactive learning is the formal cooperative learning model, which includes cooperative problem- and project-based learning, cooperative jigsaw (https://www.jigsaw.org/) and constructive controversy discussion (Johnson, Johnson, and Smith 2014; Smith, Sheppard, Johnson, and Johnson 2005; Smith, 2000, 2010, 2011; https://karlsmithmn.org/wp-content/uploads/2020/07/Smith-CL-College-Notes-817-1.pdf). We will next discuss the definition and key features of cooperative learning, and then describe cooperative problem- or project-based learning.

Cooperative learning: There is often confusion between cooperative and collaborative learning. Both cooperative and collaborative pedagogies are aimed at "marshalling peer group influence to focus on intellectual and substantive concerns" (Matthews, et.al 1995). However, there are significant differences between them. The principal differences are that cooperative learning provides a clear conceptual structure and a set of clear procedures for instructors, and requires carefully structured individual accountability; whereas collaborative learning does not. Either can be implemented in or outside classrooms.

Cooperative learning is the instructional use of small groups so that learners work together to maximize their own and each other's learning (Johnson and Johnson 1974; Smith, Johnson and Johnson 1981a, 1981b; Johnson, Johnson and Smith 1998). Carefully structured cooperative learning involves people working in teams to accomplish a common goal, under conditions that involve both positive interdependence (all members must cooperate to complete the task) and individual and group accountability (each member individually as well as all members are collectively accountable for the work of the group).

Smith (1996) described five basic elements of designing and implementing high fidelity cooperative learning and the first three are elaborated on below. The simultaneous presence of positive interdependence and individual accountability is essential and needs to be apparent to the learners as they engage in promotive interaction.

1. Positive interdependence. The heart of cooperative learning is positive interdependence. Learners must believe that they are linked with others in such a way that one cannot succeed unless the other members of the group succeed (and vice versa); they are working together to get the job done.
2. Individual accountability/personal responsibility. The purpose of cooperative learning groups is to make each member a stronger individual in their own right. To ensure that each member is strengthened, learners are held *individually accountable* to learn and do their share of the work.
3. Promotive interaction: Once an instructor establishes positive interdependence and individual and group responsibility, they must ensure that learners interact to help each other accomplish the task and promote one another's success.

The instructor's role in designing cooperative learning activities involves the following steps (Smith 1996):

1. Make pre-instructional decisions, e.g., learning outcomes and objectives, group size and composition.
2. Explain the task and cooperative structure, e.g., assignment and criteria for success, structure positive interdependence, and individual accountability.
3. Monitor and intervene, e.g., monitor each learning group and intervene when needed to improve taskwork and teamwork.
4. Evaluate and process, e.g., assess the quality and quantity of student learning and the effectiveness of their learning groups.

Cooperative Problem-/project-based learning (PBL/PrBL): The most frequently implemented cooperative learning practices in engineering education are two kinds of challenge-based learning (Bransford, Vye, and Bateman 2002): problem-based and project-based learning. The format for both problem-based and project-based learning is similar; however, the goals are different. In problem-based learning, the goal is to formulate and solve the problem, whereas in project-based learning the goal is to complete the project. In this piece, we are specifically referring to Cooperative PBL/PrBL, which means that the formal cooperative learning model is being used. As the following list illustrates, this kind of interactive learning requires a great deal of planning to execute and evaluate effectively. For further information on cooperative problem/-based learning see https://karlsmithmn.org/wp-content/uploads/2017/08/NDTL81Ch3GoingDeeper.pdf

Implementation plan for Cooperative Problem- or Project-Based Learning:

- TASK: Formulate and solve the problem(s) or complete the project.
- Individual: Develop ideas, approaches, alternatives, initial models and estimates. note strategy.
- Cooperative: One set of answers or one project report. strive for agreement, make sure everyone participates and can explain the strategies used to solve each problem or the project details
- Expected Criteria for Success: Everyone must be able to explain the model and strategies used or the alternatives considered for each problem, and the reasons for the choice of the final design for the project.
- Evaluation: Internal – best answer/design within the available resource or constraints. External – feedback based on rubrics.
- Individual Accountability: Individual assessments, e.g., exams, quizzes, written products. One member from your group may be randomly chosen to explain how you solved each problem or the rationale for your design decisions.
- Expected Behaviors: Active participation, checking, encouraging, and elaborating by all members.
- Intergroup Cooperation: When it is helpful, check procedures, answers, and strategies with another group.

When to use them

Interactive activities are best used with enduring and important-to-know outcomes. Interactive activities require co-construction and can be challenging to implement. When you design a structure you carefully decide where to use an expensive engineered beam. You do not use an engineered beam where a 2 x 4 would do. When designing instruction, you should carefully decide where to use interactive activities. You do not expend the time and resources needed to create and conduct interactive activities for 'good-to-be-familiar-with' outcomes. Be judicious about where you put those activities. They take time – especially in online environments – so choose when to use them wisely.

Notes for remote learning

Our brains may need to work harder when meeting online since we don't have as many non-verbal cues to interpret what is being communicated. Therefore, meeting online can require more effort. We may want to schedule online meetings to be shorter than a "normal' face-to-face meeting. We may also want to be sure to be explicit and verbalize what we are thinking, since others may not be able to "read" our facial expressions as well.

In platforms like Zoom, the instructor can assign or randomly place students into pairs or break-out groups. If the learning is synchronous, the instructor can visit the various groups while students are meeting and report outs can be made in real-time. If meeting asynchronously, the report outs can take the form of a video that summaries the group's key discussion points, and instructors can respond in writing, or by attaching an audio or video file.

If learners write documents or reports together online and asynchronously, a tool like Google docs is very useful. Research by Perova-Mello (2015) found that careful use of the comment function in google docs can aid co-construction. However, learners might need to learn how to effectively use the tools, a skill Perova-Mello called *tool usage metacognition*, to appropriately use features such as the comment function.

One area that virtually requires co-construction is teaching engineering design. But teaching engineering design at a distance is particularly challenging. A useful resource for articles and ideas, Distance Design Education, can be accessed at https://distancedesigneducation.com/.

Remember that although we have discussed content, assessment, and pedagogy separately, the essence of the CAP triangle is bringing the three elements together in an aligned design. Our summary section describes how to operationalize alignment of content, assessment, and pedagogy.

SUMMARY: OPERATIONALIZING CAP

We have presented a framework for an aligned course design called the Content-Assessment-Pedagogy (CAP) triangle that is parallel to engineering design. To align content, assessment, and pedagogy, make the enduring outcomes the driver of your course design. Figure 1 provides

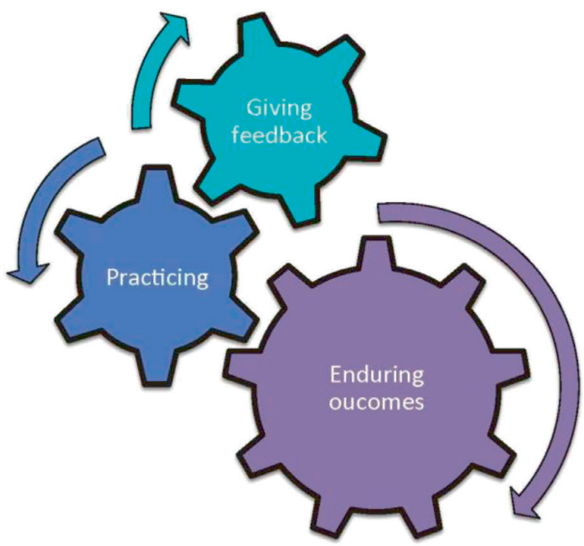

Figure 1. Operationalizing CAP.

Table 3. Summary of core ideas of the CAP triangle.

	Enduring Outcomes	Important-to-know Outcomes	Good-to-be-familiar-with Outcomes
Content: What should learners **know, be able to do, or care about**?	The core of the content and the driving force behind the course design	Should complement enduring outcomes	Optional - Can be omitted or learned off-line.
Assessment: When does **feedback** need to be provided?	Feedback should ALWAYS be given	Feedback is usually given	Feedback is optional
Pedagogy: What kind of activities should we design to help learners **practice** what we want them to learn?	Use interactive or constructive activities to practice enduring outcomes	Use interactive or constructive activities to practice important-to-know outcomes	Attentive activities are usually sufficient for good-to-be-familiar-with outcomes

a visual representation of the relationship of the enduring outcomes (content) to the feedback given (assessment) to the learning environment where what is to be learned is practiced (pedagogy). Table 3 displays the alignment of the content, assessment, and pedagogy depending on the level of learning outcome (enduring, important-to-know, or good-to-be-familiar-with outcome).

In Table 3, one can see the primacy of the enduring outcomes and how they drive the rest of the design.

In conclusion, the major points about using the CAP triangle for designing online instruction are:

- We urge faculty to develop the mindset that they are designers of learning experiences rather than conveyors of content. When thinking about course design we ask faculty to put on their designer's CAP (aligning content, assessment, and pedagogy).
- The enduring outcomes are the core of the course design. See Figure 1 and Table 3.
- The rest of the instructional experience (the complementary 'important-to-know' outcomes, the pedagogy, and the assessment) should be designed to be in service of, or aligned with, the enduring outcomes.
- Assessment should be thought of as providing feedback to learners on the trajectory of their learning. Are they moving closer to the enduring outcomes or farther away?
- Feedback should always be provided for enduring outcomes, even in informal learning environments.
- The ICAP framework proposed by Chi can help us decide what kinds of activities are best used in which situations.
- Creating a design where the content, assessment, and pedagogy are aligned is always critical but becomes even more essential when making choices about online course design.

To double-check if your design is aligned, ask yourself these questions:

What are the enduring outcomes?

- What do you want learners to know, be able to do, or care about long after instruction has ended?
- What 'important-to-know' outcomes complement the enduring outcomes?

How will learners get feedback on enduring outcomes?

- What types of assessment tasks will allow the learners to demonstrate what they have learned, can do, or care about?

How will learners practice the enduring outcomes?

- What types of constructive or interactive activities can you design to help learners gain experience with the enduring outcome?

Our final point is to remember that both design and learning are social activities. As much as possible, involve the intended learners in your course design and build an intellectual neighborhood to help you determine the enduring outcomes of your course.

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