

Brain-Based Scaffolding for Project Based Learning: Executive Function, Cognitive Load Theory, and Retrieval Practice



WAETAG
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Gabrielle Plastrik

Brain-INFORMED Scaffolding for Project Based Learning: Executive Function, Cognitive Load Theory, and Retrieval Practice

Invitation to Set an Intention

What is the purpose of school?

What do you hope to learn here that will help you work toward that purpose?

OR

What problem are you trying to solve that has come up in your particular teaching situation?

Think about the last time you learned how to do something new.



List the steps of your learning process.



What role did direct instruction play in your learning process?

Gabrielle Plastrik, WAETAG 2021



What's happening in your brain?

- Activating schema
- Forming potential connections to prior knowledge
- Encouraging curiosity and motivation

Session Overview

- The purpose of our work today
- Introductions, Check-in, and Questionstorming
- Mindful Movement Break
- PBL Steps
 - We'll go through them as you learn about CLT, RP, and Supporting EF Skills as they relate specifically to gifted learners
- Questions

Note: Resources are collected on final slides

Why Project Based Learning?

With project based learning, there's a lot to think about...

PBL Gold Standard

Does students' work align with required standards?

An authentic audience?

Voice and Choice?

Are you using the design process?
Are you starting with empathy?

Who needs what scaffolding?

Are you doing a project or using project based learning?

Is student inquiry at the center?
Included at all?

Which students are demonstrating master? Of what?

Experts?

Brain-based research suggests PBL is problematic for most learners

Cognitive load theory (Paas & van Merriënboer, 2020) supports direct instruction. In order to reduce the burden on working memory during initial learning, cognitive load theory recommends providing models and examples upfront, and then slowly fading these supports as learners grow in expertise. Problem solving without direct guidance in the form of models and examples is highly cognitively demanding for learners (Kirschner, Sweller, & Clark, 2006)..."

BUT . . . Gifted Learners Aren't Most Learners

"...with the possible exception of students who already have prior knowledge about the content, or are blessed with exceptionally strong working memory abilities."

Why we're here!

So go back to the beginning...

What is your purpose?

Students Learning

What do we know about how
k-12 students learn?
&

What do we know about
gifted brains?

From psychology

From neuroscience

From your classroom
expertise

What's happening in your brain?

- Activating schema
- Forming potential connections to prior knowledge
- Encouraging curiosity and motivation



Exercise Caution

Any time someone asks you to change what you, an expert, are doing with students, it is a BIG ASK, so . . .

EXERCISE CAUTION!



Evaluate the BIG ASK:

- Does this work for my students?
- Does this work in my school situation?
- Is there research I can access?
- Is it necessary to help me and/or my students work toward our goals or is it just a shiny gem?

I am coming to you with ideas that would likely involve changing your practice, but it is also a BIG ASK, so . . . who am I?

- Not an academic researcher
- 16th year as a teacher in a classroom
- 13th year as a middle school teacher
- 11 years teaching in schools specifically for gifted and talented students
- Two years of teaching twice exceptional learning in scaffolded/supported classes
- An educator with a deep investment in MBE
- An educator committed to revising my practice to improve experiences and outcomes for students

In giving this presentation, I am a translator: "Here is what the research says, and here is what I have seen."

Your job is to choose how to use this information and what other information you need.

Element 1 of PBL for Gifted Learners: Assess Prior Knowledge



This might be both the most important and most time bound step.

- It will happen throughout
- It **MUST** happen at the beginning.

Who are you?

Chat Poll: Yes or No in chat

1. Have you used projects as summative assessments?
2. Have you done project based learning?
3. Consider self a PBL expert (1=expert, 5=novice)

Please complete a short [Google Form](#).

(link in the chat)

Tip: Pre-testing

- Triggers memory
- Helps you know what level of expertise your gifted learners are bringing to the table: don't assume expertise or lack thereof
- Is worth your time
- Another way to do this with gifted learners is through question storming

Question Storming Example:

What questions do you have about project based learning with gifted students?

Checklists are a
good strategy for
EF skill scaffolding!

- ❑ Please put at least one question in the chat!
- ❑ You may put an unlimited number of questions.
- ❑ Please hold off on answering anyone's questions just for right now.

PBL for Gifted Learners: Element 1

- ❑ Assess prior knowledge (potentially through initial question storming)



We'll build a model
as we go.

Mindful Movement Break



Element 2: Make Information Available



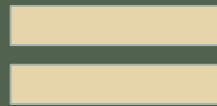
Think back to the beginning. . .

PBL is more productive when the learner has expertise OR there is direct instruction

- in part because of common sense
- in part because of Cognitive Load Theory.

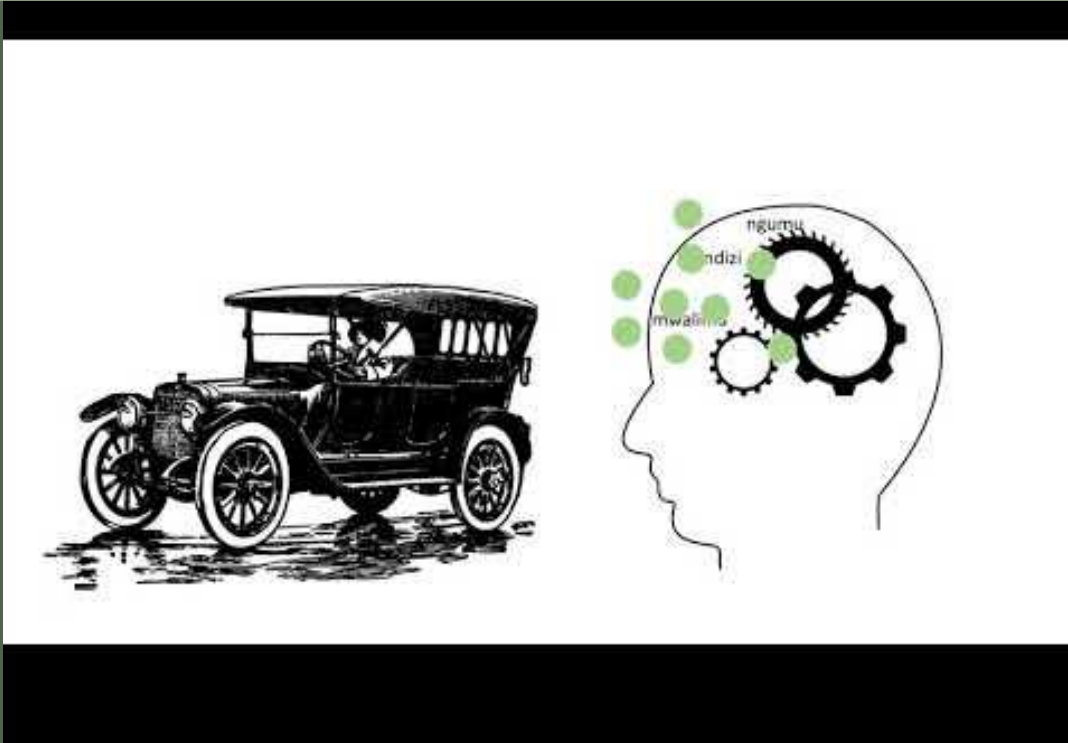


Cognitive Load



$$\frac{\text{Task Demand}}{\text{Available Resources}}$$

As we listen for a general overview of CLT, consider the implications for general ed classrooms and the questions you have for working with gifted learners.



A Synthesis of Some CLT Research Worth Unpacking...

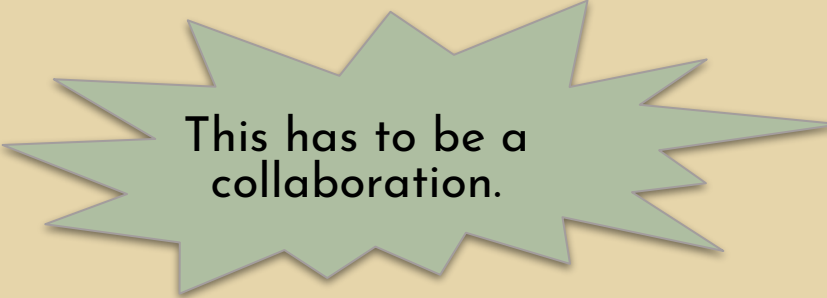
“As working memory plays a critical part in learning new information, the greater processing capacity of students with higher intelligence (Engle et al. 1999; Vandervert 2009) can help them progress faster and with greater complexity (de Jong 2010; Baddeley 2010). Cognitive load-oriented teaching strategies, such as explicit instruction and worked examples are just as necessary for gifted students to learn new skills and content as for all students (Carroll 1994). However, high ability students may be able to move through heavily-structured learning more quickly and can then go broader and deeper into concepts and topics. A learning effect known as the “expertise reversal effect” shows us that over-scaffolding can be counter productive once students have gained expertise (Yeung, Jin & Sweller 1998; Leslie et al. 2012). Once the basics have been mastered, research suggests that it is better to transition to more independent problem-solving tasks in order to further learning (Pachman, Sweller & Kalyuga 2013).”

Center for Education Statistics and Evaluation (2019), *Revising Gifted Education*, NSW Department of Education, <https://www.cese.nsw.gov.au/publications-filter/revisiting-gifted-education>

Our Job as Educators of Gifted Learners

Assessing prior knowledge and experience so that we can work with gifted learners to determine

- what they need to learn/don't know
- when they need to know it for it to be most useful
- what supports and scaffolding they will need and when



This has to be a
collaboration.

Check for Understanding:

Why do teachers of gifted learners need to assess prior knowledge and skills?

&

Why does PBL work for gifted learners even when it might not work for mainstream learners?

What's happening in your brain?

- Connecting information to schema ("neurons that fire together wire together")
- Forming potential connections to prior knowledge



Assessing prior knowledge

and then doing targeted
& potentially
differentiated
direct instruction
as a lead-in to
and throughout a project

vs.

I do, we do, you do

A fun project at the end of
a direct instruction unit to
assess knowledge or skills

More Direct Instruction ...

Overview of Executive Function Skills

Check in: Do you feel a little burdened in terms of your cognitive load?

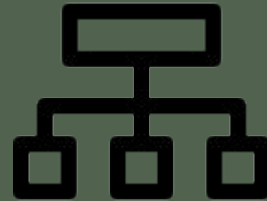
Strategy: do a brain dump: write down what you most want to remember about CLT.



Emotional
Regulation



Goal
Setting



Organization
(Materials
& Ideas)



Prioritization



Metacognition
&
Self-checking

EF Processes: Working Memory, Mental Flexibility, Self-Control



Simple image
and text to dual
code and reduce
cognitive load.

EF and the Gifted

What do you anticipate?

What's happening in your brain?

- Preparing schema
- Forming potential connections to prior knowledge



EF and the Gifted

- Difficulties Not Uncommon
- Potentially caused by asynchronous development
- Potentially caused by bad habits and school experiences
- Potentially related to twice exceptionality
- Potentially an effect of gifted traits like high processing speed
- Potentially caused by discrepancy between processing speed and other cognitive processes

Kaleel, Madeline & Kircher-Morris, Emily. "Gifted Learners and Executive Functioning." National Association for Gifted Children, NAGC.org.

EF and the Gifted

Executive functioning is loosely defined and difficult to test for at a research level.

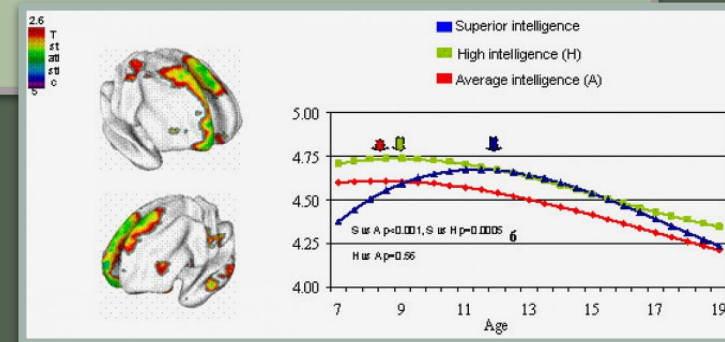
Executive dysfunction may be a major reason for a gap between high potential and performance.

Strong executive function skills are often linked to high intellectual ability.

Viana-Sáenz, L., Sastre-Riba, S., Urraca-Martínez, M. L., & Botella, J. (2020). Measurement of Executive Functioning and High Intellectual Ability in Childhood: A Comparative Meta-Analysis. *Sustainability*, 12(11), 4796. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/su12114796>

EF and the Gifted

"The researchers found that the relationship between cortex thickness and IQ varied with age, particularly in the prefrontal cortex, seat of abstract reasoning, planning, and other "executive" functions. The smartest 7-year-olds tended to start out with a relatively thinner cortex that thickened rapidly, peaking by age 11 or 12 before thinning. In their peers with average IQ, an initially thicker cortex peaked by age 8, with gradual thinning thereafter. Those in the high range showed an intermediate trajectory (see below). While the cortex was thinning in all groups by the teen years, the superior group showed the highest rates of change."



EF and the Gifted:

Why We Need to Scaffold PBL with Gifted Learners

Takeaways:

- EF Skills vary by age, especially in gifted children
- Gifted children experience periods of rapid brain change
 - Need additional EF support or scaffolding
- Gifted children need scaffolded support based on current needs
 - Teachers should assess and adjust or offer optional scaffolding)
- EF skills tend to be an area of asynchronous development

Check for Understanding:

Can you list the three executive function processes?

Can you summarize the reason teachers of gifted learners need to assess current executive function needs?



What's happening in your brain?

- Connecting information to schema ("neurons that fire together wire together")

Another Brain-Informed Teaching Practice: Retrieval Practice

Retrieval practice = targeted retrieval of information and skills to encourage brain pathways

People learn best when they are asked to recall information and skills as they becomes a little rusty.

RP is a win-win. It benefits all learners: in strength areas and growth areas. It is also a skill students can learn to do independently to study more effectively.

Truly Useful Resource: [Retrieval Practice](#)



Retrieval Practice and Gifted Learners

Identifying rustiness = difficult for teachers

ASK THE STUDENTS! Involve them in the process of assessing what they remember. It is important that they learn how their brains work.

Make tools available for retrieval practice and encourage independent use!

Teachers should “organize learning around complex underlying concepts, principles, and strategies for self-regulated learning within and across domains so it is easier to retrieve and apply in varied circumstances” (APA 2017).

Sounds like PBL!

Ask gifted children to identify abstract and complex connections as part of the retrieval process.

PBL Works Well for Gifted Learners if

We attend to

- Students' prior knowledge
- Students' cognitive load and working memory capacity
- Students' varying executive function needs

And if we provide

- Tools for self-directed retrieval practice
- Opportunities for required retrieval practice
- Scaffolding to support executive function skills
- Scaffolding to reduce cognitive load demands

Some Examples

Digital Project Research Notebooks

Digital Design + Content = Choose
Your Own Adventure Story

Model Texts & Practice (Creative
Nonfiction)

Teaching Classmates (Economics)

Worked Examples: Accelerated Options

Making Worked Examples **Not Boring** for Gifted Learners:

- Evaluate Exemplars for Choices
- Create a Rubric
- Critique Flawed Examples

Evaluating Exemplars + Worked Examples: A 2 for 1 Strategy w/ Gifted Students

What are the characteristics of this exemplar that make it "work"?

What is one choice that you think the creator made intentionally?

What are some characteristics of this exemplar that show how it is not working?

What seems to have mattered the most to the person creating this exemplar?
(Adapted from a values inventory from Lauren Porosoff in *Two for One Teaching*)

PBL for Gifted Learners

- ❑ Assess prior knowledge (potentially through initial question storming)
- ❑ Make Information Available (Targeted & Differentiated Direct Instruction)



Element 3: Checking for Understanding & Retrieval Practice

Retrieval Practice (ish) (Is it rusty yet?)

Working
Memory

Cognitive
Load

Neurons

Processing
Speed

Emotional
Regulation

Flexibility

Retrieval

Scaffolding



Consider the difference between this retrieval practice and the checks for understanding earlier.

PBL for Gifted Learners

- ❑ Assess prior knowledge (potentially through initial question storming)
- ❑ Make Information Available (Targeted & Differentiated Direct Instruction)
- ❑ Checking for Understanding and Retrieval Practice



Element 4: Inquiry

Inquiry (Activities Chosen for Gifted Best Practice)

Questionstorming (Rothstein and Santana, *Make Just One Change.*)

Gallery of Questions



Movement!

Ask students: based on what we learned about ____, what more do you want to know? (Adapted from Ritchhart and Church, *Making Thinking Visible*)

- 5 questions
- 3 big takeaways
- 1 metaphor



Schema Enhancer: Connects to prior knowledge

Inquiry (Activities Chosen for Gifted BPs, Continued)

Passion-based Questions

- Invite students to use passions as lenses for asking questions
- Caution: provide a space, but don't require it

Values -based questions (Handout)

Empathy and interviews: If you were _____, what would you need to know?



Using lenses to ask questions adds a depth and complexity and encourages retrieval. It encourages connections to emotional experiences, which enhances memory and learning.

WORKED EXAMPLES REDUCE COGNITIVE LOAD ON FUTURE WORK.

PBL for Gifted Learners

- ❑ Assess prior knowledge (potentially through initial question storming)
- ❑ Make Information Available (Targeted & Differentiated Direct Instruction)
- ❑ Checking for Understanding and Retrieval Practice
- ❑ Inquiry (Also an opportunity for Retrieval Practice)



Element 5: Establishing Goals or Intentions



Establishing Goals or Intentions: Your Choices, Their Goals

If you were planning a PBL unit right now, what would be the most important learning (content or skills)?

Having a priority

- focuses your direct instruction
- maintains some student voice and choice
- can improve students' goals

Establishing Goals or Intentions: SCAFFOLD & PRIORITIZE

Look at your intention or goal from the opening of this session.

Consider:

What is the relationship between quality and quantity of information or skills and the goals students set?

When is the right time for goal setting in gifted PBL?
With your students?

PBL for Gifted Learners

- ❑ Assess prior knowledge (potentially through initial question storming)
- ❑ Make Information Available (Targeted & Differentiated Direct Instruction)
- ❑ Checking for Understanding and Retrieval Practice
- ❑ Inquiry (Also an opportunity for Retrieval Practice)
- ❑ Establishing Goals or Intentions



Learning is happening. Metacognition is happening. The “project” now has a strong foundation.

Element 6: Ideation



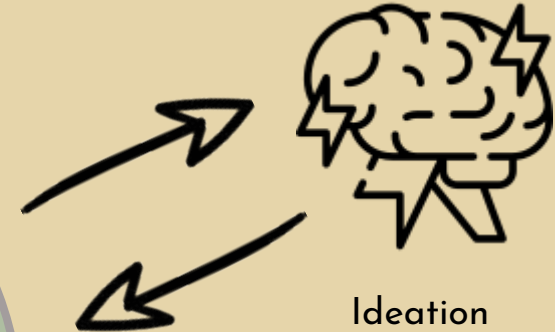
Ideate: Scaffold This

Encourage students to find the brainstorming processes that work for them

- Potential time for direct instruction
- Mindmapping
- Walking
- Talking
- Using manipulatives, like playdough or cardboard
- Just giving something a try
- Working on puzzles
- Playing Minesweeper
- Drawing
- Freewriting

Tip: Ask experts to provide feedback or even just listen and ask questions during ideation.

PBL for Gifted Learners



Element 7: Planning

Make a Plan: This Is Work Both You & Students Should Do

The Part Teachers Do: Scaffolding and Support

- What are the learning priorities? What can you remove from their cognitive load?
 - Post visible calendars with check-ins
 - Assist in checklist creation
 - Keep project folders
- Give every learner the option for full scaffolding, and pare it back for those who don't need it.
- Model: what is the first task and what does it look like to be doing that?

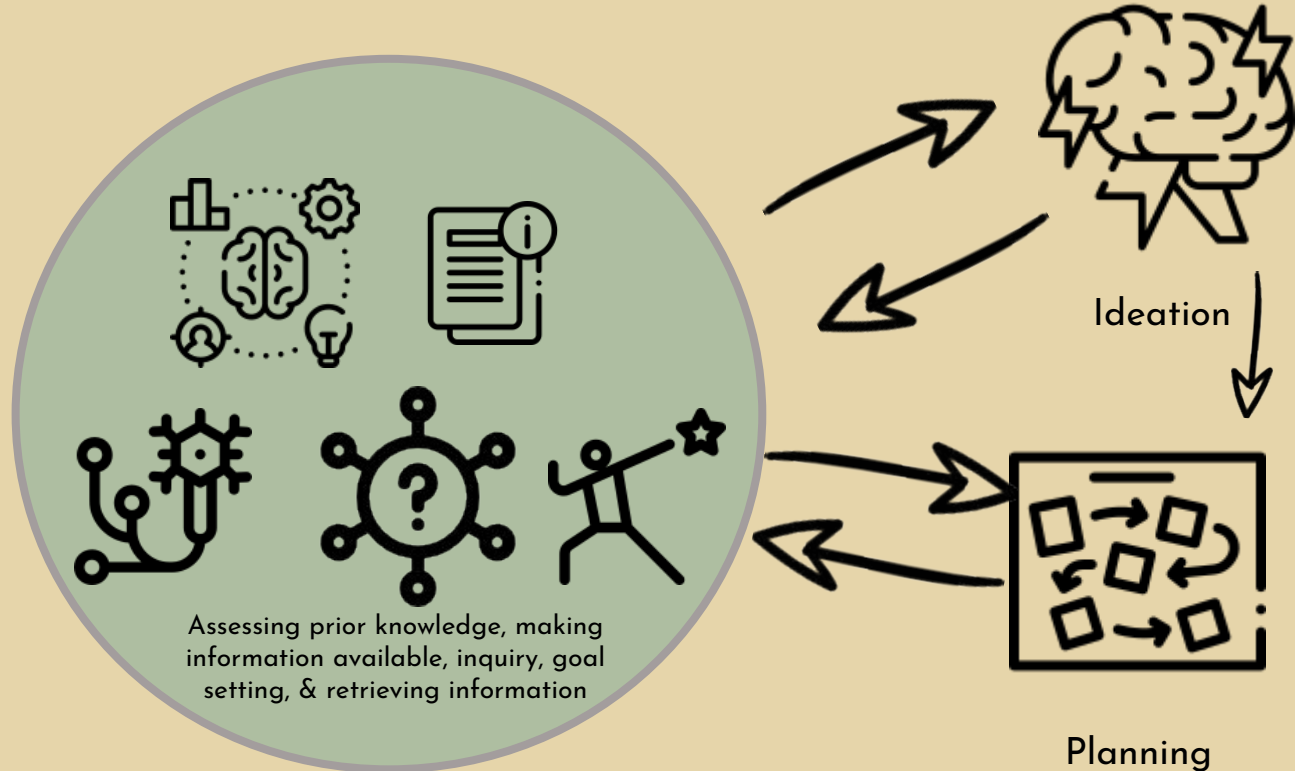
Remember CLT!

Student Work:

- Prioritization: What are the most important steps?
- Metacognition: When will they need the most support?
- Self-Assessment: What will I need to learn that I don't already know?
- Planning: What can I reasonably complete by when?

EF Skills!

PBL for Gifted Learners



Element 8: Iteration

Iteration

Long Term Scaffolding

Weekly Student-Teacher
Conferences about goals

Reminders about deadlines

Co-created anchor charts for
processes

Posted Questions from Inquiry

Self-directed retrieval practice

Daily Work Scaffolding

- Ask students to determine a purpose for each work period at the beginning of the work period
- Consider visible clock timers during work periods
- Dedicate time at the end of a work period for assessing progress and establishing what needs to happen next

Mid-Iteration: Metacognition and Reflection

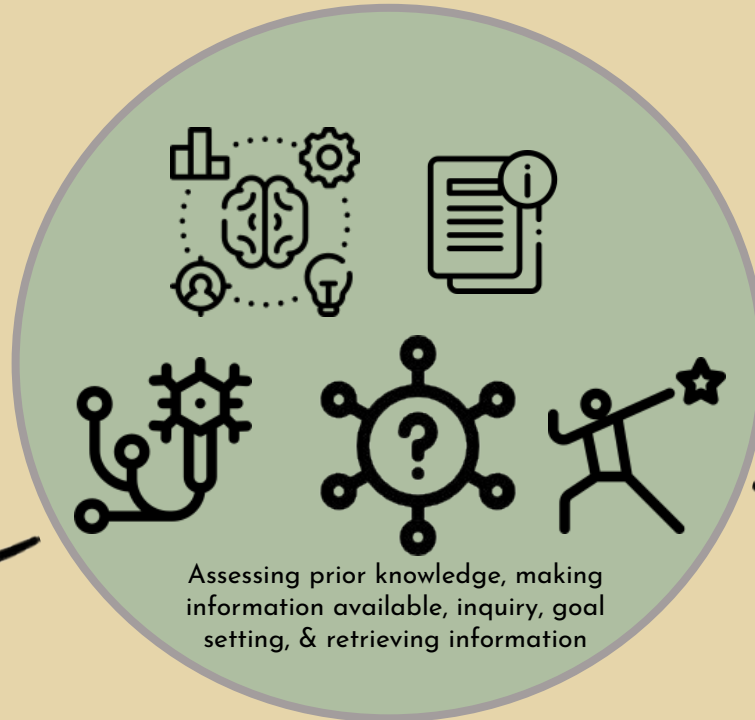
Encourage self-questioning throughout the process:

Research shows that students who ask themselves metacognitive questions such as . . .

- What should I do
 - How is this similar to a previous task
 - What can I do better next time
- while completing a task perform better academically.

We can train students to make these questions habit!

PBL for Gifted Learners



Ideation



Planning



Iteration

Element 9: Revision/Reiteration

Feedback and Revision/Reiteration

Begin with goals: what is the intention of revision or reiteration?

Another opportunity for retrieval practice

(Don't do it at every opportunity, but know that many opportunities exist.)

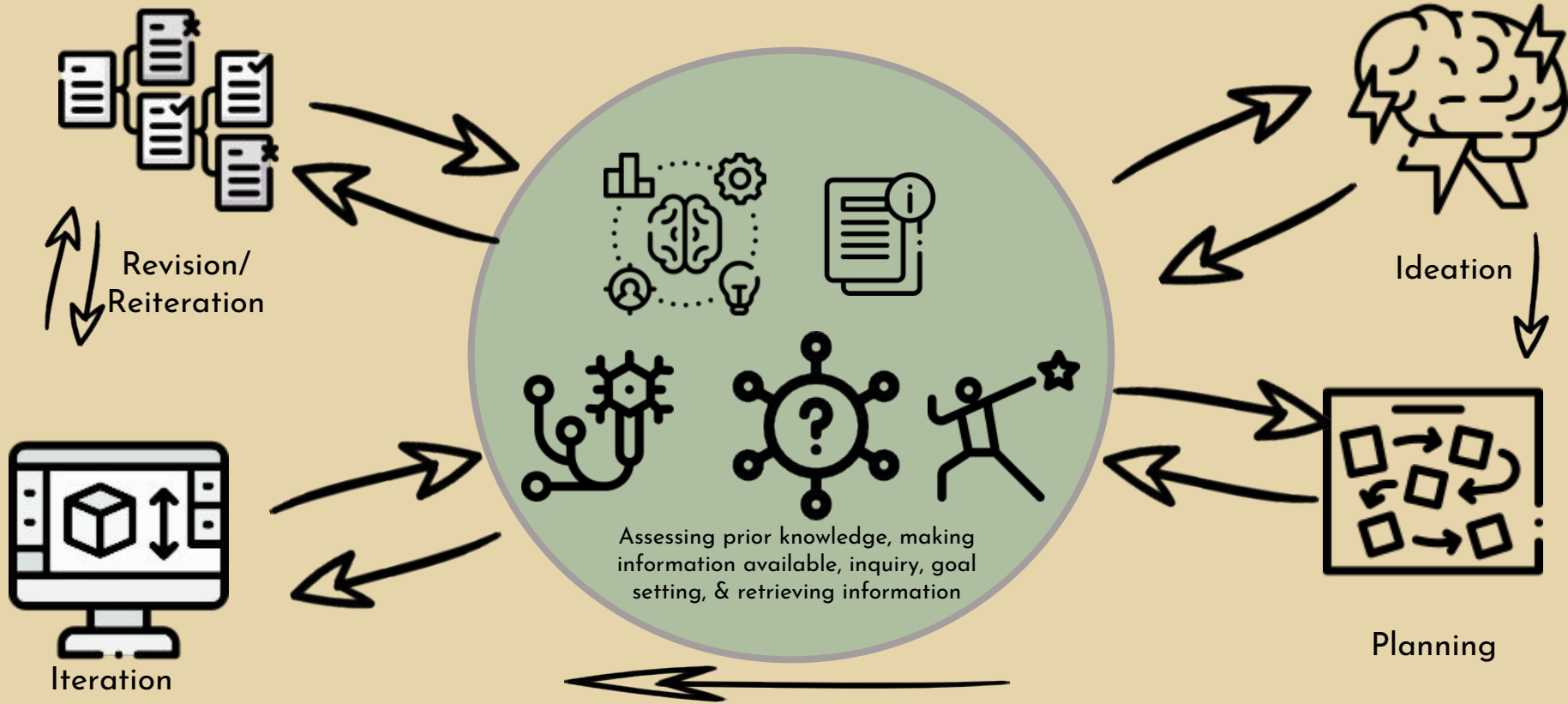
Feedback throughout the process with opportunities for revision

Feedback from experts with time to act on that feedback

Expert panels that ask questions are particularly effective

Time to think

PBL for Gifted Learners



Element 10: Metacognition

Metacognition and Reflection

Sample Questions to Ask:

Which part of this process went most smoothly for you? What does that show you about yourself as a learner?

If you had another week for this project, what would you hope to do?

Which part of this process pushed you outside of your comfort zone or challenged you? How are you feeling about that?

What skills did you improve over the course of this project?

What are the 5 most important things you learned while working on this project?

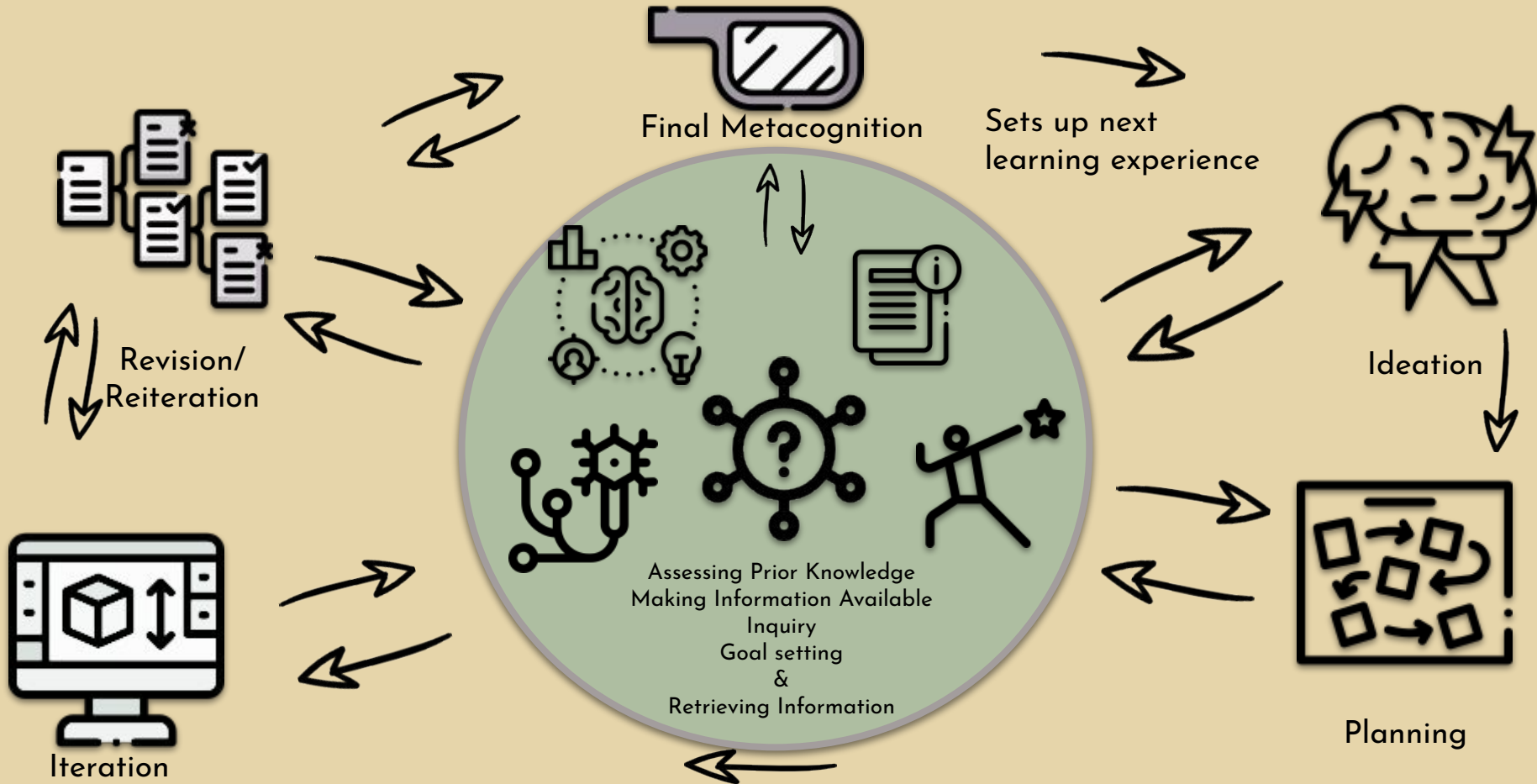
If your project process was a weather pattern, how would you describe it?

A modeling question: Was there anything I could have done to have helped with your project that would have been more useful to you?

Return to empathy and values: did you achieve what you set out to achieve?

Return to inquiry: did you answer your questions?

PBL for Gifted Learners



Questions?

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