Intro to Learning Sciences

Lectures 24 and 25, Nov 6 and 11, 2025
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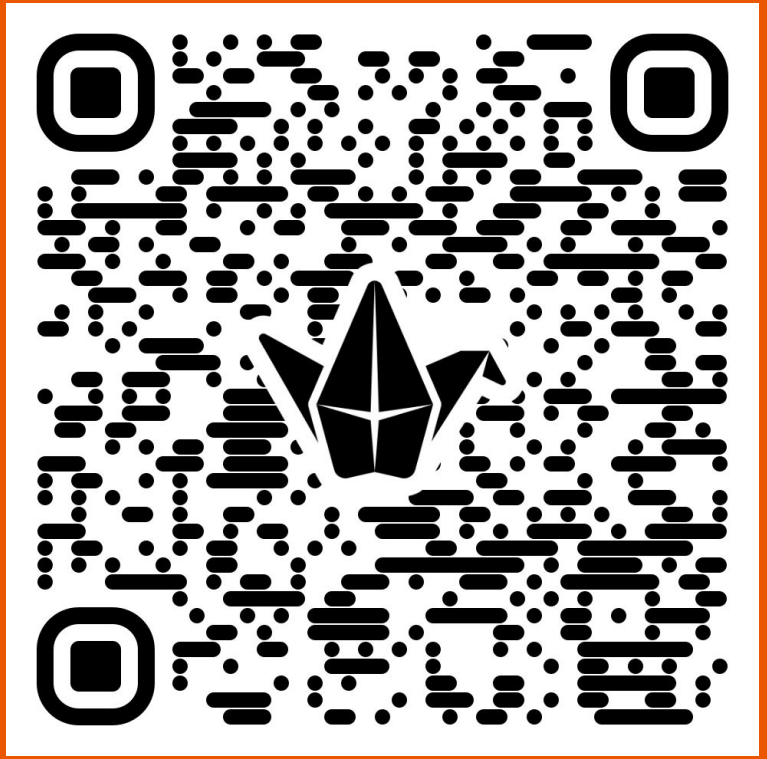
PAIR ACTIVITY: Three different lesson designs



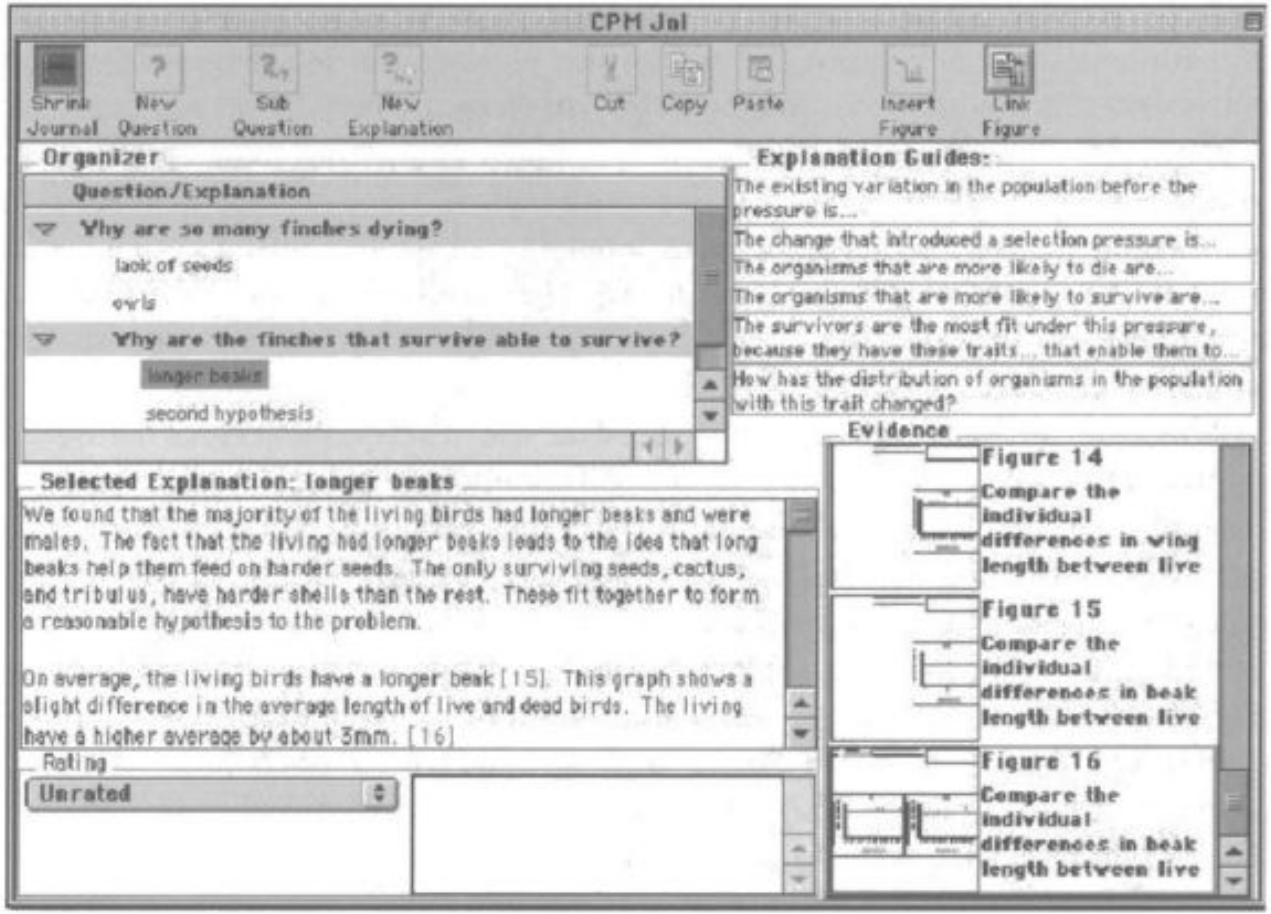
Debrief: Strengths and weaknesses of each design

1. Strengths: Easy to follow and do
    a. Weaknesses: Non reflective work
2. Strengths: It does not limit the kinds of problem to be identified, better for higher ed students, teaches how to plan and execute the research, how and where to start
    a. Weaknesses: Cognitive load
3. Strengths: Layered problems, different factors introduced, overall understanding of the problem, metacognition, Directed learning + subset discovery with prompts, can't see the broader picture
    a. Initial questions are very directed, but the reflection prompts are general and make you think broader - prompts pre-empt the missing links that students are likely to miss
    b. Weaknesses: Too many scaffolds - simple to complex - which grade decides

Structuring

1) Adding constraints or decreasing degrees of freedom to reduce the complexity of the task.
2) Decomposing complex tasks:
    a) Overcome challenge of unfamiliar strategies by indicating important goals
    b) Help with non reflective work
    c) Help groups organize work for themselves
3) Focusing Effort: Restricting the problem space by narrowing options or offloading routine parts of the work
    a) Overcome challenge of unfamiliar strategies
    b) Help working together more effectively
4) Monitoring: Keep track of plans and monitor progress (criteria)
    a) Helps with the tendency for nonreflective work
    b) Tie in relevant disciplinary ideas during sense-making and communication

Example of structuring



Problematizing

- Purposes of problematizing:
  - Focusing attention on something that needs resolution - Get students to notice critical features/conflict
  - Engaging students, creating dissonance or curiosity, eliciting a “commitment of attention and resources” - grapple with complex and important disciplinary ideas, problem solving processes, decision making
  - Affective - Creating interest/getting students to care
- Add difficulty in the short term, but in a way that engenders productive learning processes
- Balance between active engagement and frustration, nonproductive “floundering”
- Collaborative problem solving and the need to be explicit can be a way to problematize

Influence of Problematizing

- **Elicit articulation**
  - Addresses challenges of non reflective work and superficial analyses
  - “Force” students to be explicit in their reasoning
- **Elicit decisions**
  - Address challenges of unfamiliar strategies
  - Require productive disciplinary decision-making
- **Highlight gaps and disagreements among team members that are critical to disciplinary learning**
  - The specific structure imposed or representation provided highlight the disciplinary frameworks and norms
  - Sparks productive disciplinary discourse around epistemic norms and disciplinary frameworks
  - But, depends on inclination of students and classroom norms set by teacher

Example of problematizing

Evan: (Reading prompt on framework) "Environment causes …"
Janie: No!
Evan: Yeah, "to be selected for …"
Janie: Yeah, but that means like …
Evan: // what food they eat //
Janie: … organism with these trait
Evan: // the trait being the food
Franny: Yeah, that's right.
Janie: No, because like, if my trait is to eat steak, and there's no steak, I'm immediately gonna go to something else.
Evan: If you're only a vegetarian and you only eat … you don't eat meat, you're not gonna eat meat. Well, that depends …//
Janie: Are you insane!?
Franny: OK, OK. Don't think of people. Think of these guys (the finches). If they only eat one type of seed with their beaks and that seed is gone then they can't live anymore.

Example of problematizing

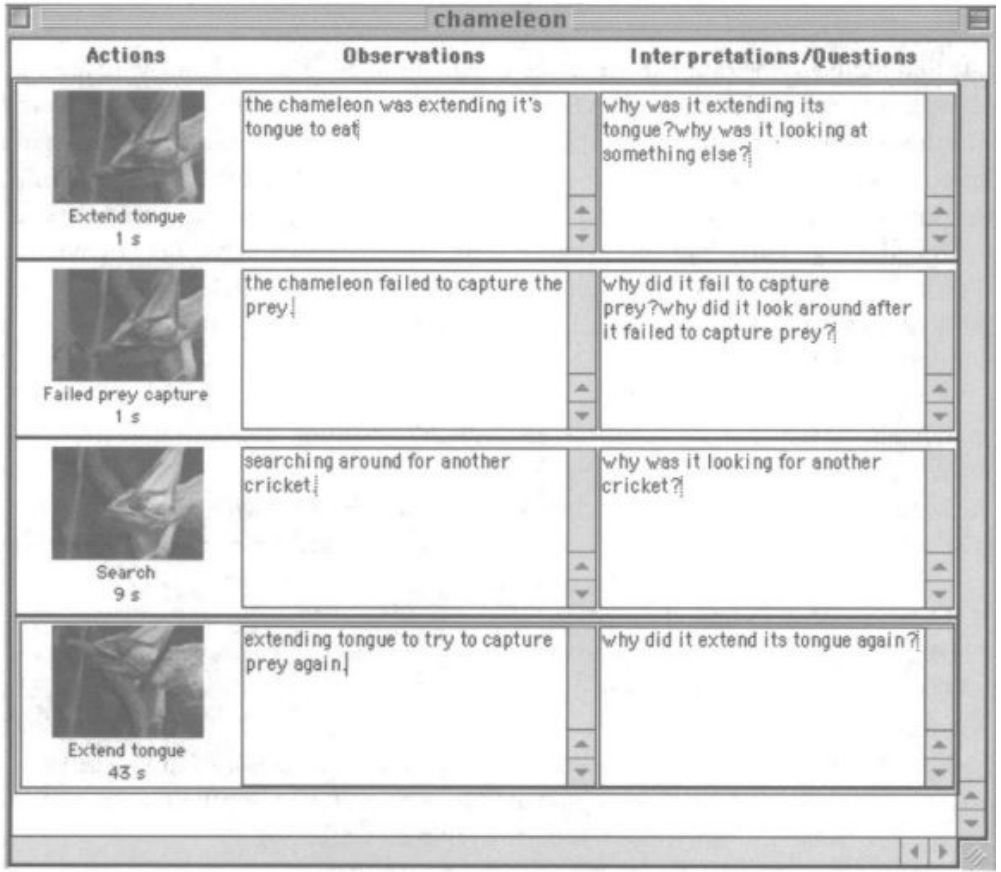
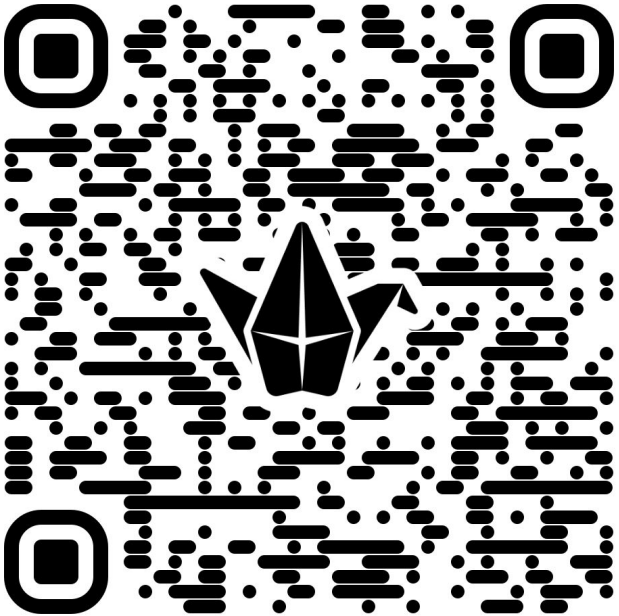


FIGURE 2 Artifacts constructed in the Animal Landlord. Students decompose complex behavior into its constituents, categorize each constituent, and record their observations and interpretations.

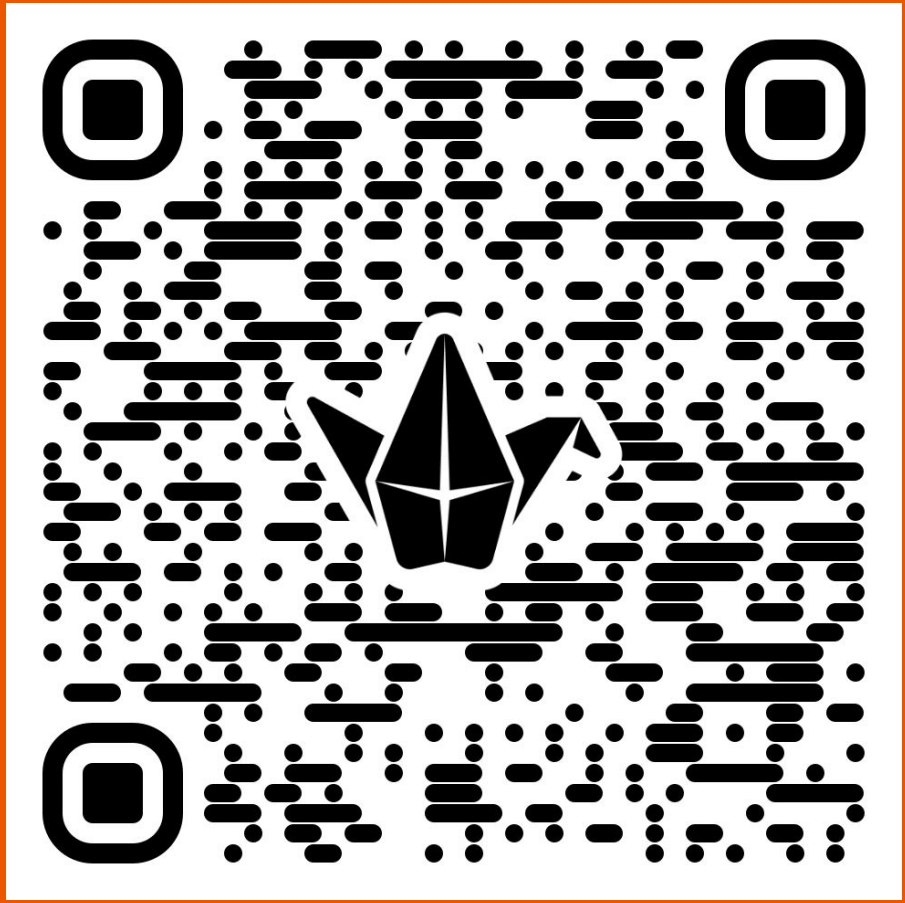
Structuring vs problematizing

- Complementarity: Structure, such as decomposition of tasks, or specific types of representations or formats of responses, can also serve to problematize
- Tension:
  - The support/ structure may not be intuitive, may not be related to students own reasoning strategies, so it will not be adopted and not lead to the desired problematizing effect
  - General support vs specific problematization
  - Providing structure (specific steps to be followed) can lead to nonreflective work, while problematizing important steps can take away control
- Importance of considering the classroom system

Identify structuring and problematizing scaffolds



Group Activity (10 minutes):
When should we problematize and when should we structure? Take the domain of reading comprehension for 8 year olds. Design a learning environment based on the principles of scaffolding you have learned



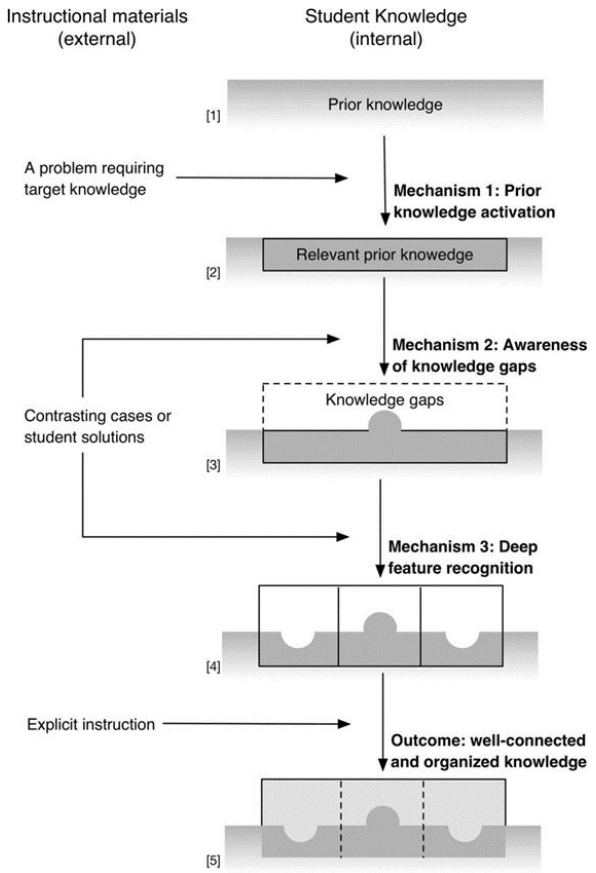
The role of “failure” in learning

- Desirable difficulties - difficulty during training better for long-term performance
- Impasse-driven learning - delay structure until student reaches an impasse
- Time for telling - contrasting cases followed by direct instruction
- Inventing to prepare for future learning - invention activity followed by direct instruction
- Productive failure - ill-structured problem solving followed by debriefing on student solutions and consolidation
- Together efficacy of delaying instruction/structure to allow learners to generate conceptions, representations, understandings -> PS-I approaches

The role of invention in learning

- Perspective: The role of instruction is not just to prepare students to solve a problem, but prepare them to *learn* and solve *future* problems
- Invention activities prepare students to learn from the upcoming instruction
  - Easier for teachers because students are now "prepared"
  - Invention may activate the appropriate resources needed to build knowledge from following "telling" -> *transferring in*
  - Invention may help students develop useful prior knowledge necessary to make sense of the upcoming instruction
    - Let go of old interpretations
    - Develop new interpretations (representations) and structures (solutions)
  - Two kinds: contrasting cases and inventing representations

Possible learning mechanisms of PS-I



Students need:

1) Prior knowledge differentiation to understand representations and methods
2) Why concepts, representations, methods are assembled the way they are

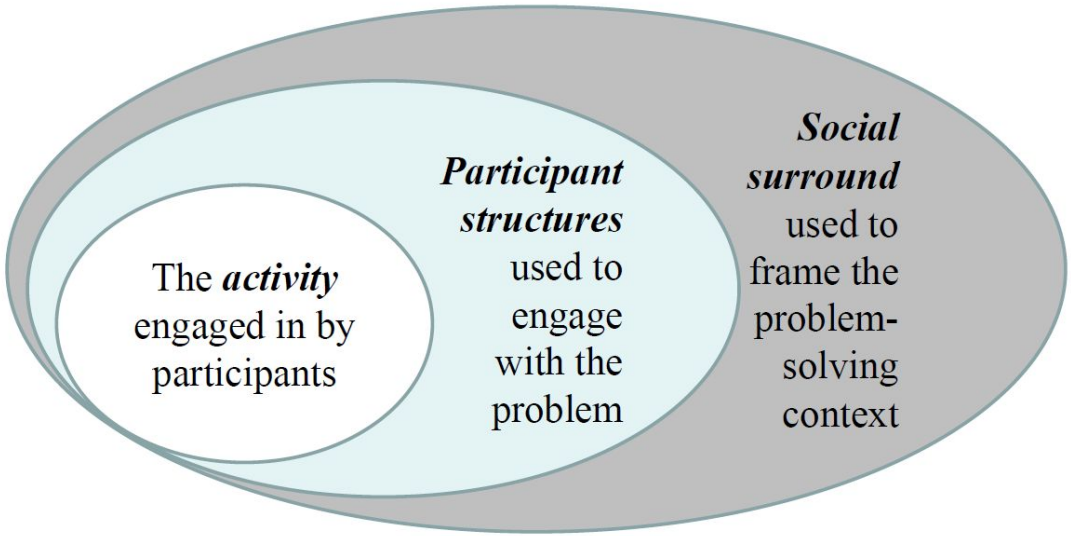
Achieved using 4 mechanisms:

1. activate and differentiate prior knowledge in relation to the targeted concepts
2. attend to critical conceptual features of the targeted concepts
3. explain and elaborate these features
4. organize and assemble the critical conceptual features into the targeted concepts.

Loibl, K., Roll, I., & Rummel, N. (2017). Towards a theory of when and how problem solving followed by instruction supports learning. *Educational psychology review*, *29*, 693-715.

Designing for productive failure: Mechanisms

1. [Phase 1] Problem-solving contexts - don't frustrate but engage (sweet spot), rely on prior concepts, have affective draw
2. [Phase 1] Opportunities for elaboration and explanation
3. [Phase 2] Compare and contrast generated RSMs and assemble canonical RSMs



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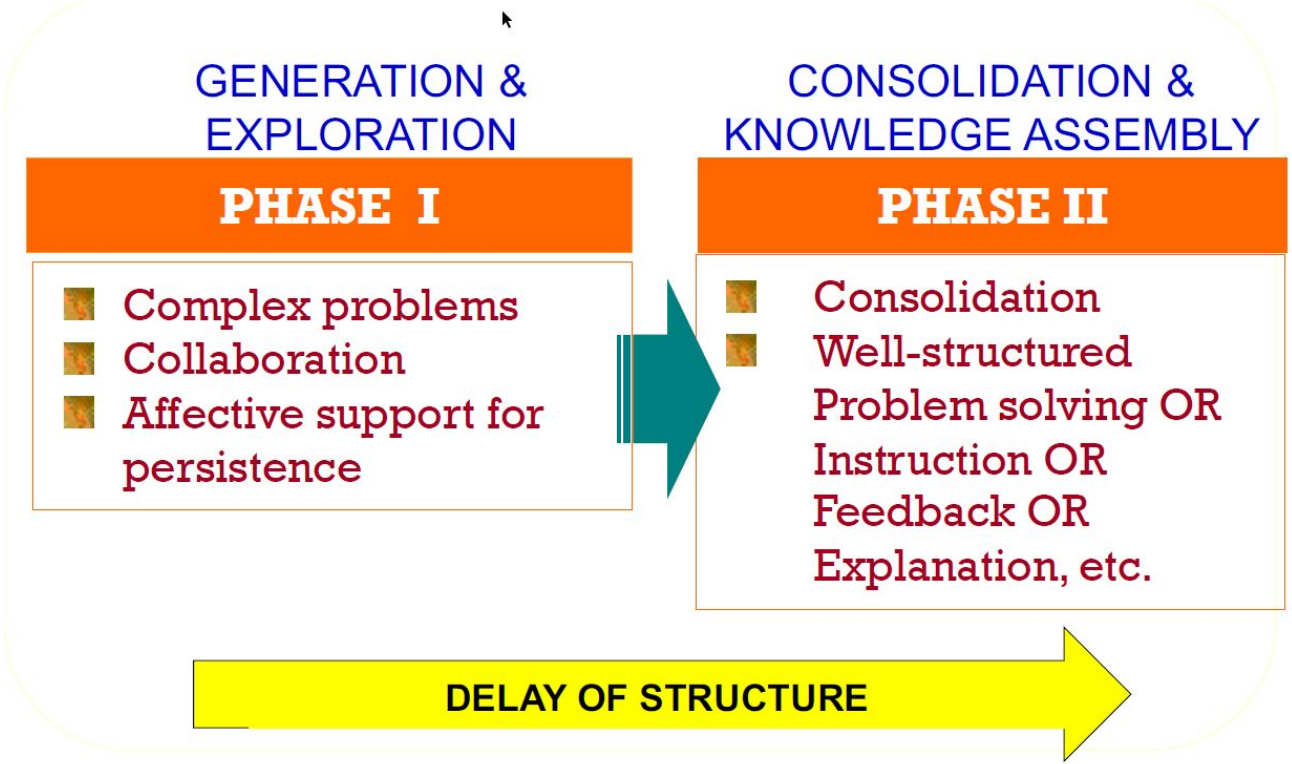
Design Principles for PS-I



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Design Principles for PS-I

Design principles for the Activity

Phase 1: Generation	Phase 2: Consolidation
Create intuitive hooks with an affective draw	Compare and contrast students ideas to distill critical features
Engage students in design	Direct student attention to notice these critical features
Admit multiple representations and solutions	Assemble the critical features into the canonical form
Use variant-invariant features to bring about failure in problem-solving	
Use contrasting cases	
Keep computational load as low as possible	

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Design Principles for PS-I

Design principles for the Participation

Phase 1: Generation	Phase 2: Consolidation
Enable collaboration in mixed ability groups	Have students explain their ideas
Support students to collaborate through an appropriate macro script	Paraphrase student explanations
Push student thinking through the disciplinary facilitation	Draw attention to the critical features and their assembly into the canonical form

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Design Principles for PS-I

Design principles for the Social Surround

Phase 1: Generation	Phase 2: Consolidation
Create a safe space to generate and explore ideas	Create a safe space to explore the affordances and constraints of student-generated ideas
Set and constantly emphasize appropriate socio mathematical norms and values	Focus on idea interrogation towards idea improvement
Provide affective support for persistence	

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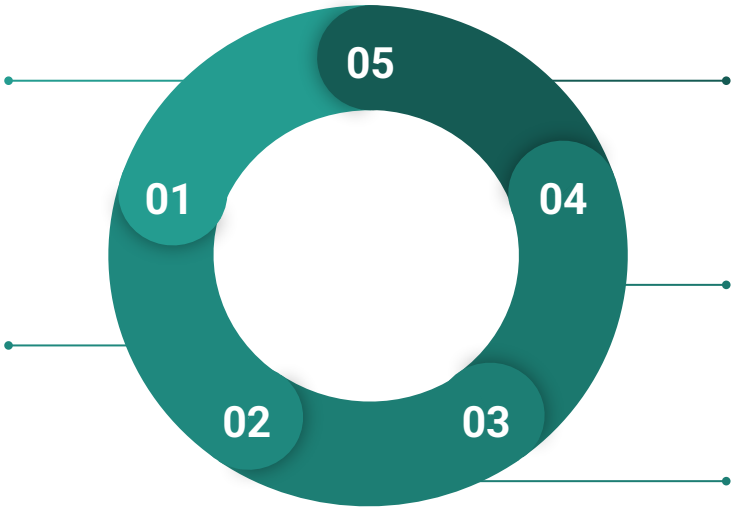
Where we are now: From theory to design and back

Learning theories/ mechanisms
What do we know so far? Constructivism, constructionism, situated learning, sociocultural theory, expansive learning, learning pathways, (science inquiry learning requires problematizing and structuring scaffolds, failure can be productive …)

Design Principles
Derived from theories (eg) authentic tasks, scaffolding, collaboration and so on



Analyse data

Appropriate statistical and qualitative analysis

Collect Data
According to research question, qualitative and quantitative data

Learning Environment
Based on understanding of context and learning problem, instantiate principles into a learning design