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What research questions enable more effective research and development?

Strand maps provide first approximation of developmental sequence of conceptual development. Need an empirical justification /support for developing a developmental sequence for what students should be learning at what time in their development. Curriculum materials instantiate certain big ideas, and empirical research requires stuff to try out. Value added for particular lessons?

Not sure the idea of curricular sequences, activity structures is fully developed. One suggestion is to use explorations of sequences as strong research direction to provide evidence for the presentation of representations and sequence of certain concepts first, second etc.

Pre suggestion: Revise/Adopt systematic framework for empirical evaluation of conceptual and inquiry knowledge development

Table 1: Matrix Attempting to Fill In Minstrell Matrix

	Conceptual idea 1 Reactions-New material has different properties than original material	2 Substances react chemically in characteristic ways	Conceptual idea 3	
Inquiry A (collect relevant data)	XX	XX	XX	
Inquiry B (interpreting data)	XX		XX	
(Inquiry C building explanations from evidence)	XX		XX	

Suggestion 1: Develop quasi-experimental studies to evaluate effectiveness of variations on order, inclusion/removal of particular inquiry ideas, conceptual ideas, and scaffolding approaches.

- a. What learning outcomes are demonstrated with 1, 2, 3 versus 1, 3, 2? What design approaches have the greatest payoff for student learning (e.g. inquiry or other approaches)?
- b. What learning outcomes are demonstrated with scaffolding approach X versus Y for idea 1A? (teasing out 1 from A not necessarily desirable/possible, see later matrix)

- c. What learning outcomes are demonstrated with learning sequence A1, A2, A3 in year one versus XYZ in year 2? (e.g. sequence for building effective inquiry understandings)

Suggestion 2: Build a simple core of curricular activities with interspersed extensions. Use empirical research to make decisions about core/extension decisions

What standards will be used to make judgments?

Suggestion 3: Develop/map assessment system and outcomes to systematic framework above for more sensitive and systematic assessment of learning trajectories

Table 2: Assessment Matrix from BioKIDS Project

Inquiry C building explanations from evidence	1 Degree of complexity of science-simple	2	3 complex science content needed
A Level of scaffolding provided in task/assessment item (high)	A1 simple, highly scaffolded	A2	A3
B (medium)	B1	B2	B3
C no scaffolding provided (student does without guidance)	C1	C2	C3 Complex inquiry task without scaffolding or guidance

Suggestion 4: On multiple representations, more is not necessarily better and careful scaffolding of flexible, productive use of representations is needed.

- a. How are representations linked? How are students guided to understand salient features within a particular representation?
- b. How do students build salient and relevant features between representations?
- c. What is important in various representations relevant to particular learning goals?

Scribner and Cole's (1981) definition of literacy applies to scientific literacy—"not simply reading and writing a particular script but *applying this knowledge for specific purposes in specific contexts of use.*"