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PRODUCTIVE STRUGGLE AND EPISTEMIC EMPATHY AS LEVERS IN PROFESSIONAL LEARNING DESIGN

DEVELOPING TEACHERS' MODELING ORIENTATION IN A COMMUNITY SCIENCE CONTEXT

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Developing a Modeling Orientation to Science

What does it mean to develop a modeling orientation toward science for teachers?

What are the levers that get us there?

- Three-year design-based research project
- Partnership: Bowdoin College, Gulf of Maine Research Institute, Vanderbilt University
- Cohort of 9 teachers, grades 5 through 8
- Community science context, ecosystem investigations: knotweed, invasive crabs, vernal pools
- Co-developing understanding of a modeling orientation towards science (MOS)

PD Program Components

- GMRI-developed curriculum & tools
- Community science investigations & context
- Network of local ecologists
- Professional Learning Community (year-round virtual and in-person meetings; annual three-day Summer Institutes)
- Asynchronous resources & engagement via Google Classroom
- SageModeler and CODAP resources through Concord Consortium
- Scaffolded supports to develop teacher agency and leadership

FOCUSED RESEARCH QUESTIONS

- How does explicitly incorporating productive struggle into professional learning experiences shape teachers' engagement with and growth toward developing a modeling orientation in science?
- How does the inclusion of "empathetic experiences" in professional learning impact both teacher learning and PD design?

METHODS & DATA SOURCES

Comparative mixed methods case study (Yin, 2003)

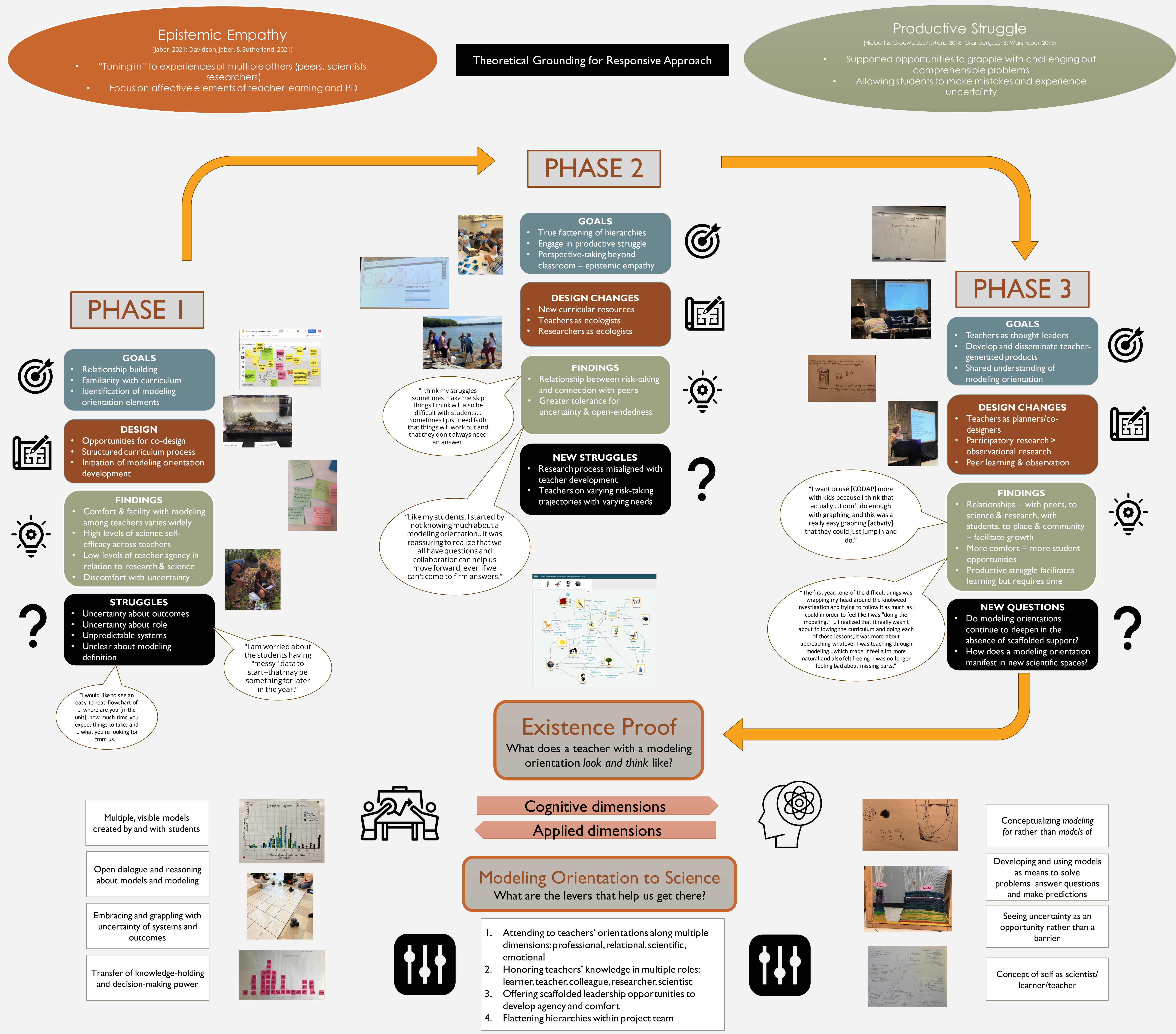**Data Collection & Analysis Methods**

STEBI Questionnaire (pre/post)
Semi-structured teacher interviews (biannually)
Classroom observation & fieldnotes (targeted during ecology units)
Thematic content analysis (teacher-scientist-researcher communications; Google Classroom; PLC & institute dialogue‡)

Data Sources (N)	Key Constructs
PLC Mtg/Institute agendas (15) PLC transcripts (9) Classroom observation video (hours) (140) Teacher interview transcripts (19) Teacher & student artifacts (57) Asynchronous communications (62)	Experience w/productive struggle Empathetic experiences MOS (engagement & conception) Teacher relationships Teacher agency

DBR Cycle & Timeline

Spring 2021:
Plan Summer Institute; baseline data/analysis
Summer 2021:
Year 1 Summer Institute; design Year 1 PLC
Fall/Winter 2021:
Implement Year 1 PLC; ongoing data analysis
Spring 2022:
Continue Year 1 PLC, data analysis, plan Summer Institute
Summer 2022:
Year 2 Summer Institute; data analysis; design Year 2 PLC
Fall/Winter 2022:
Implement Year 2 PLC; ongoing data collection; design project final activities
Spring 2023:
Continue Year 2 PLC; implement project final activities

What is a modeling orientation to science and what professional learning levers support teachers towards a modeling orientation?

Epistemic Empathy
(Jaber, 2021; Davidson, Jaber, & Sutherland, 2021)

- "Tuning in" to experiences of multiple others (peers, scientists, researchers)
- Focus on affective elements of teacher learning and PD

Theoretical Grounding for Responsive Approach

Productive Struggle
(Hiebert & Grouws, 2007; Manz, 2018; Granberg, 2016; Warshauer, 2015)

- Supported opportunities to grapple with challenging but comprehensible problems
- Allowing students to make mistakes and experience uncertainty

PHASE 2

GOALS
- True flattening of hierarchies
- Engage in productive struggle
- Perspective-taking beyond classroom – epistemic empathy

DESIGN CHANGES
- New curricular resources
- Teachers as ecologists
- Researchers as ecologists

FINDINGS
- Relationship between risk-taking and connection with peers
- Greater tolerance for uncertainty & open-endedness

NEW STRUGGLES
- Research process misaligned with teacher development
- Teachers on varying risk-taking trajectories with varying needs

PHASE 1

GOALS
- Relationship building
- Familiarity with curriculum
- Identification of modeling orientation elements

DESIGN
- Opportunities for co-design
- Structured curriculum process
- Initiation of modeling orientation development

FINDINGS
- Comfort & facility with modeling among teachers varies widely
- High levels of science self-efficacy across teachers
- Low levels of teacher agency in relation to research & science
- Discomfort with uncertainty

STRUGGLES
- Uncertainty about outcomes
- Uncertainty about role
- Unpredictable systems
- Unclear about modeling definition

"I am worried about the students having "messy" data to start – that may be something for later in the year."

"I would like to see an easy-to-read flowchart of … where are you [in the unit]; how much time you expect things to take; and … what you're looking for from us."

"I think my struggles sometimes make me skip things I think will also be difficult with students… Sometimes I just have faith that things will work out and that they don't always need an answer."

"Like my students, I started by not knowing much about a modeling orientation…It was reassuring to realize that we all have questions and collaboration can help us move forward, even if we can't come to firm answers."

PHASE 3

GOALS
- Teachers as thought leaders
- Develop and disseminate teacher-generated products
- Shared understanding of modeling orientation

DESIGN CHANGES
- Teachers as planners/co-designers
- Participatory research > observational research
- Peer learning & observation

FINDINGS
- Relationships – with peers, to science & research, with students, to place & community – facilitate growth
- More comfort = more student opportunities
- Productive struggle facilitates learning but requires time

NEW QUESTIONS
- Do modeling orientations continue to deepen in the absence of scaffolded support?
- How does a modeling orientation manifest in new scientific spaces?

"I want to use [CODAP] more with kids because I think that actually …I don't do enough with graphing, and this was a really easy graphing [activity] that they could just jump in and do."

"The first year…one of the difficult things was wrapping my head around the knotweed investigation and trying to follow it as much as I could in order to feel like I was "doing the modeling." … I realized that it really wasn't about following the curriculum and doing each of those lessons, it was more about approaching whatever I was teaching through modeling…which made it feel a lot more natural and also felt freeing- I was no longer feeling bad about missing parts."

Existence Proof
What does a teacher with a modeling orientation *look* and *think* like?

Cognitive dimensions
Applied dimensions

Multiple, visible models created by and with students

Open dialogue and reasoning about models and modeling

Embracing and grappling with uncertainty of systems and outcomes

Transfer of knowledge-holding and decision-making power

Modeling Orientation to Science
What are the levers that help us get there?

1. Attending to teachers' orientations along multiple dimensions: professional, relational, scientific, emotional
2. Honoring teachers' knowledge in multiple roles: learner, teacher, colleague, researcher, scientist
3. Offering scaffolded leadership opportunities to develop agency and comfort
4. Flattening hierarchies within project team

Conceptualizing *modeling for* rather than *models of*

Developing and using models as means to solve problems answer questions and make predictions

Seeing uncertainty as an opportunity rather than a barrier

Concept of self as scientist/ learner/teacher

FINDINGS & IMPLICATIONS

- Multiple & variable paths to MOS may require "layering" options alongside scaffolding
- Empathetic experiences and "leaning in" to productive struggle can offer novel opportunities for teacher learning
- Developing relationships → deeper engagement with modeling activities
- Growth in knowledge & facility about/with modeling and ecosystems
- Growth in use of models, data, and data visualization activities
- Increased comfort with uncertainty
- Compounding benefits to engaging in project alongside teachers - as learners and researchers
- Community science is a fruitful context for developing comfort with uncertainty
- Teacher agency linked with: positive risk-taking outcomes; opportunity for leadership; strong peer relationships within PLC
- Evidence toward an existence proof of developing a modeling orientation

ONGOING QUESTIONS

- What are the opportunities and affordances of community science investigations as context for engaging with modeling practices?
- What PL elements/resources are needed to support greater agency while developing a modeling approach to science?
- How does the development of teacher agency in concert with deepening modeling approaches to science impact students' opportunities to develop their own agency and engagement with modeling practices?

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FOR MORE INFORMATION

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