Supporting the Implementation of Scientific Modeling Instruction in High School Chemistry and Biology in Rural Schools (SIMIRS)

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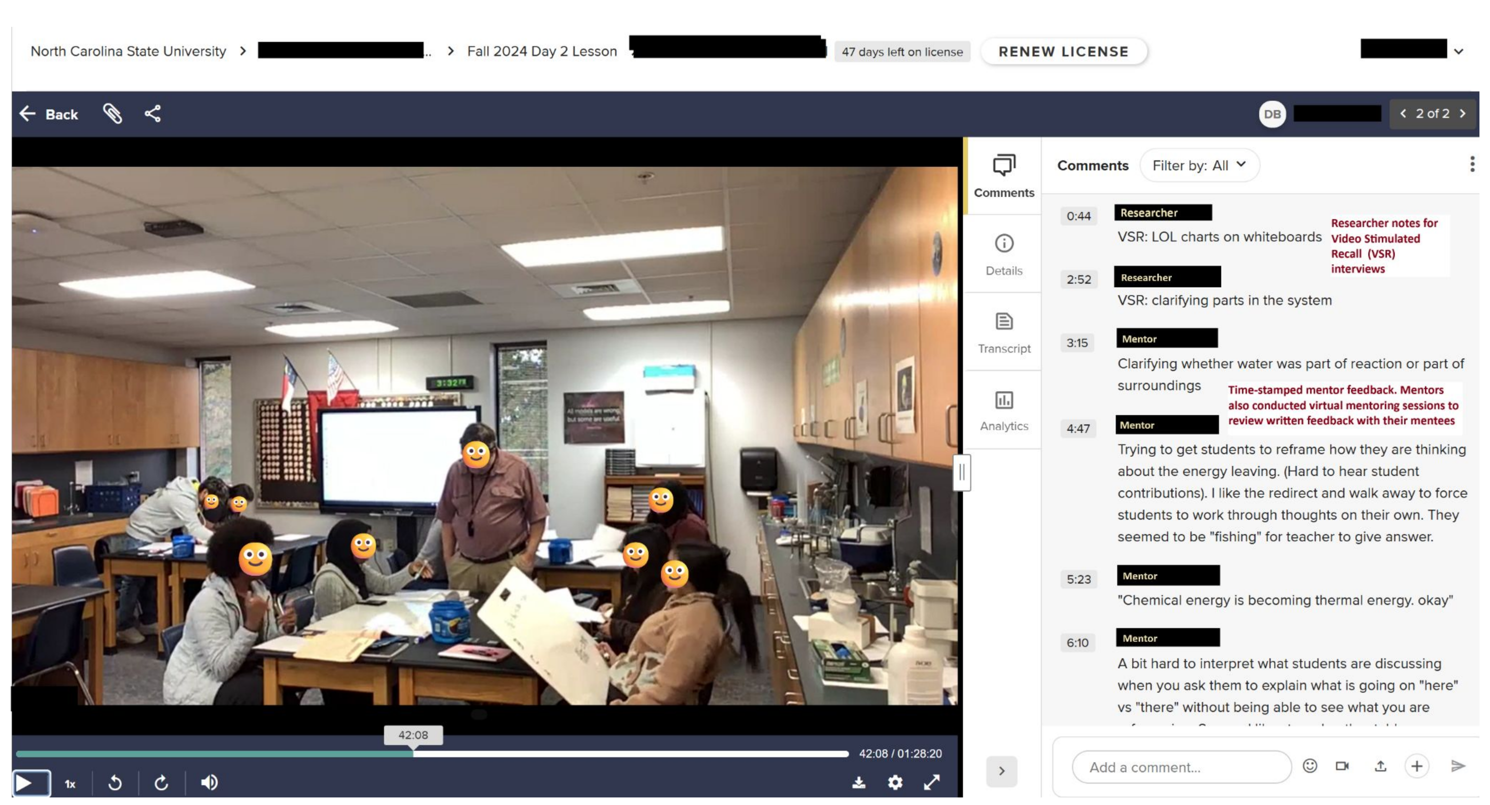
Abstract

SIMIRS is a Level 2 Early Stage Design and Development project led by an interdisciplinary team of researchers and practitioners at NC State University, in partnership with 26 rural school systems across North Carolina. The project has two primary aims: (1) to support rural high school biology and chemistry teachers in implementing an innovative reform-oriented, model-based science teaching approach known as Modeling Instruction (MI); and (2) to generate knowledge about their pedagogical content knowledge (PCK) development and the factors influencing their PCK and teaching practices over the course of three years of MI implementation.

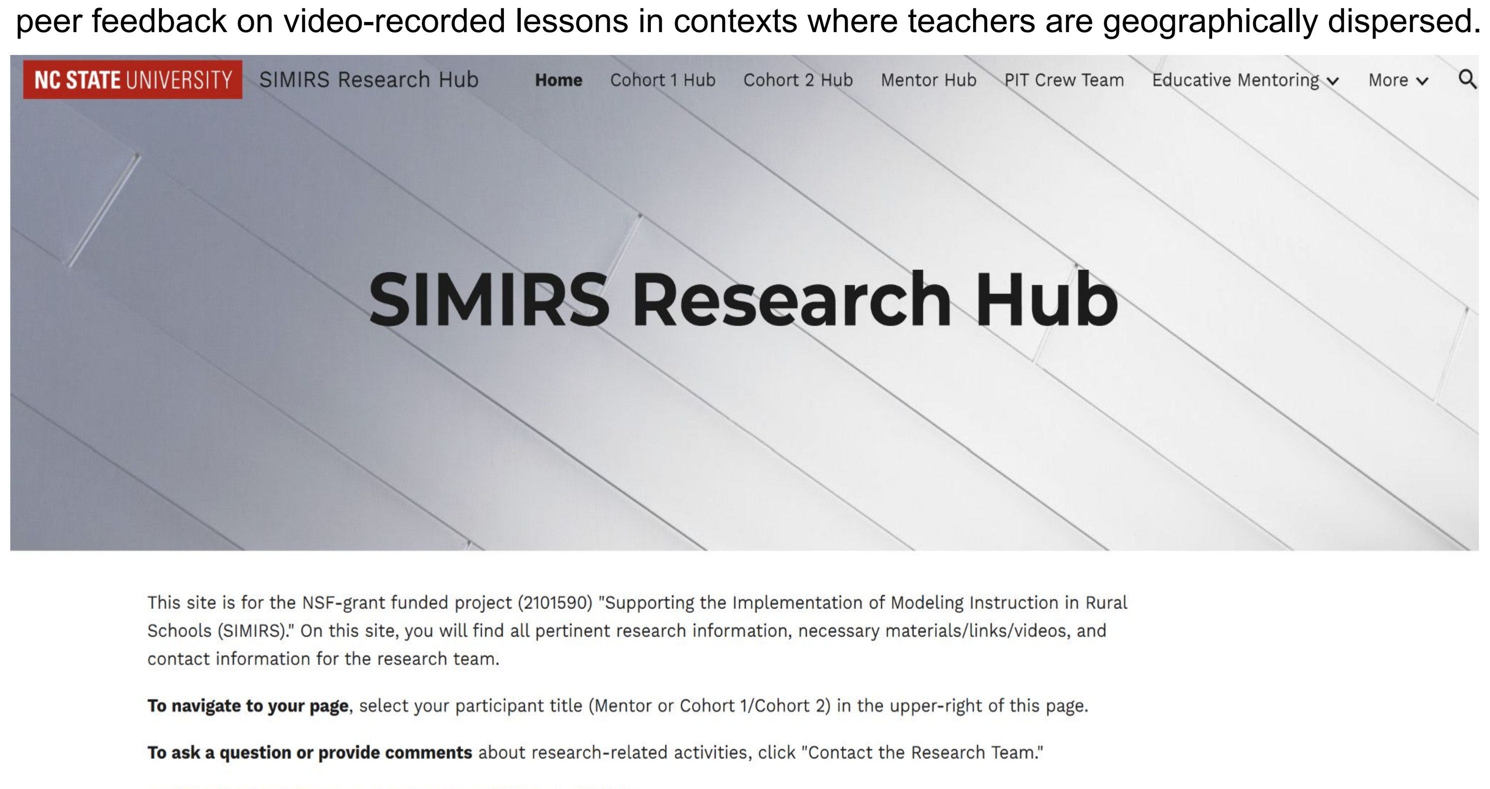
Key Research Questions

1. What critical changes in pedagogical content knowledge (PCK) do science teachers make as they progress from low implementation levels toward higher implementation levels of Modeling Instruction?
2. What are the characteristics of PCK required for high-level implementations of Modeling Instruction that cut across different science disciplines?
3. How does virtual professional mentoring influence the development of teachers' PCK for Modeling Instruction?

Project Resources and Tools



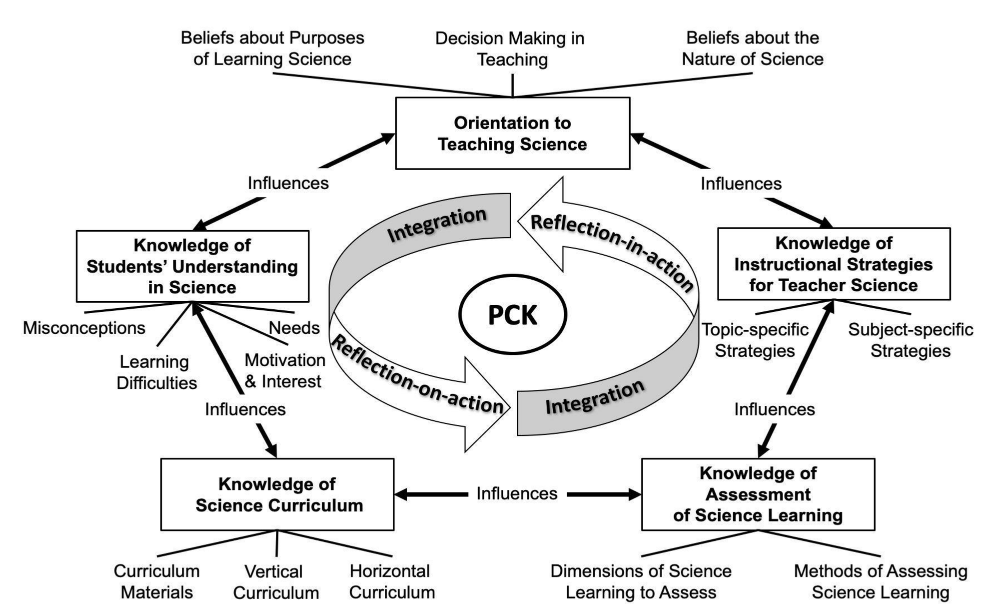
GoReact, a cloud-based video feedback system, is used for both research tagging and video-stimulated recall (VSR) interviews, as well as for providing time-stamped mentor and PLC peer feedback on video-recorded lessons in contexts where teachers are geographically dispersed.



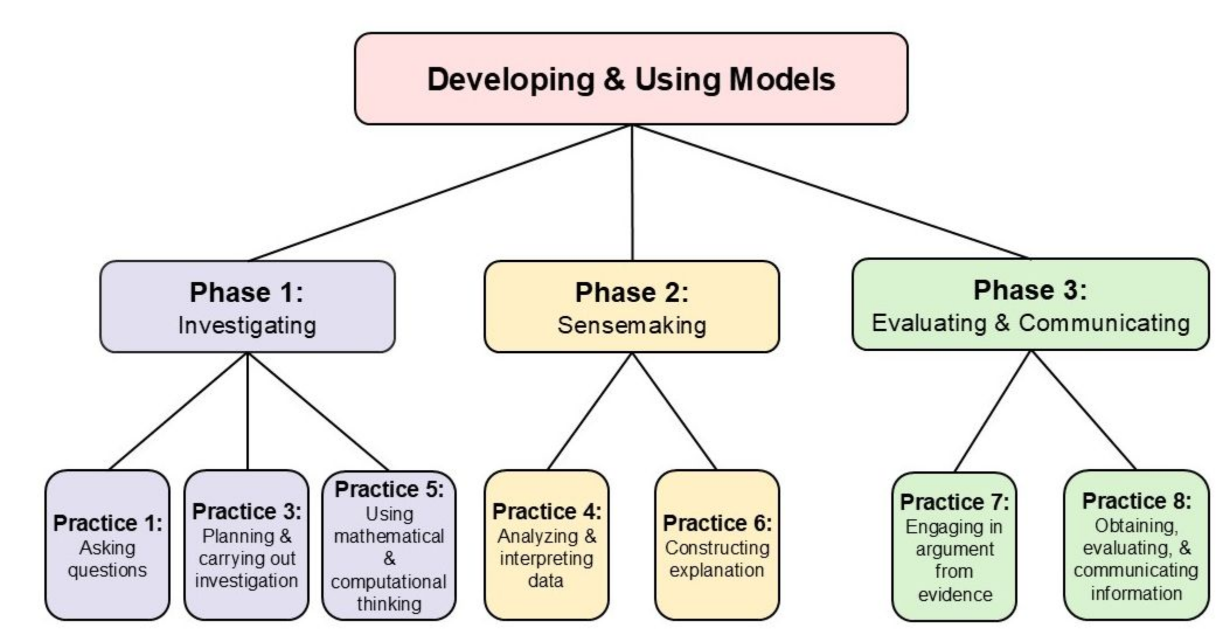
A project website has been developed and is actively maintained to centralize key resources for mentors and teachers (e.g., lesson plan templates, survey links, GoReact support, Google forms for submitting ancillary materials, Google Workspace for collaboration). Each participant group (Cohort 1, Cohort 2, Mentors, and Project Innovation Team) has a dedicated tab for easy navigation. The website also includes a "Contacting the Research Team" tab, where participants can submit a Google form at any time to ask questions related to activities they are completing throughout the school year.

Conceptual Frameworks & Research Methods

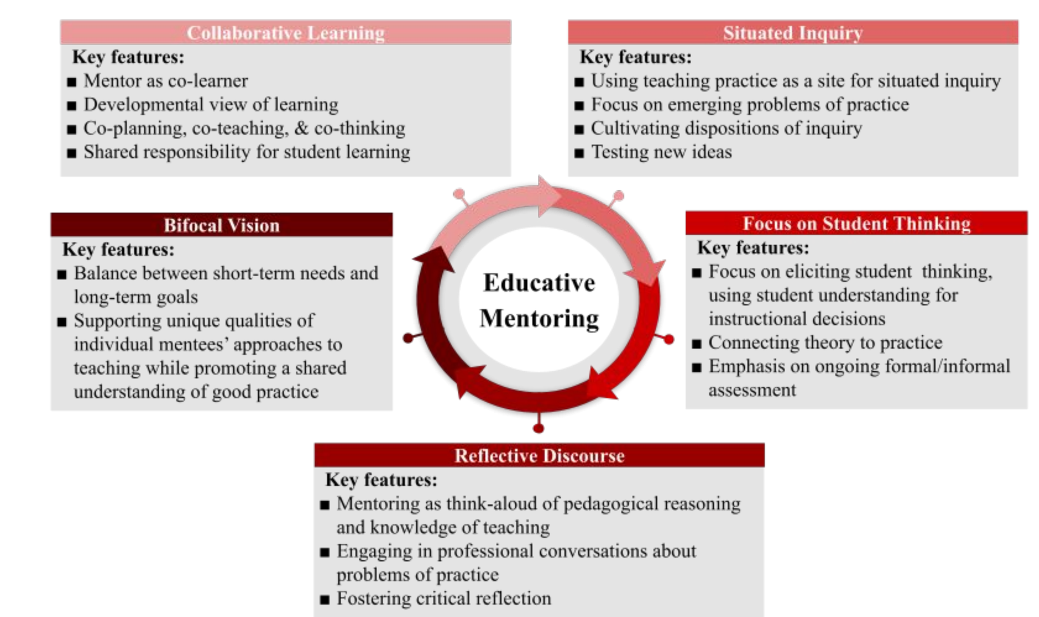
Pentagon Model of PCK for Science Teaching (Park & Oliver, 2008)



SEPs with Modeling at the Core (Carroll & Park, 2023; Modified from Chen & Terada, 2021)

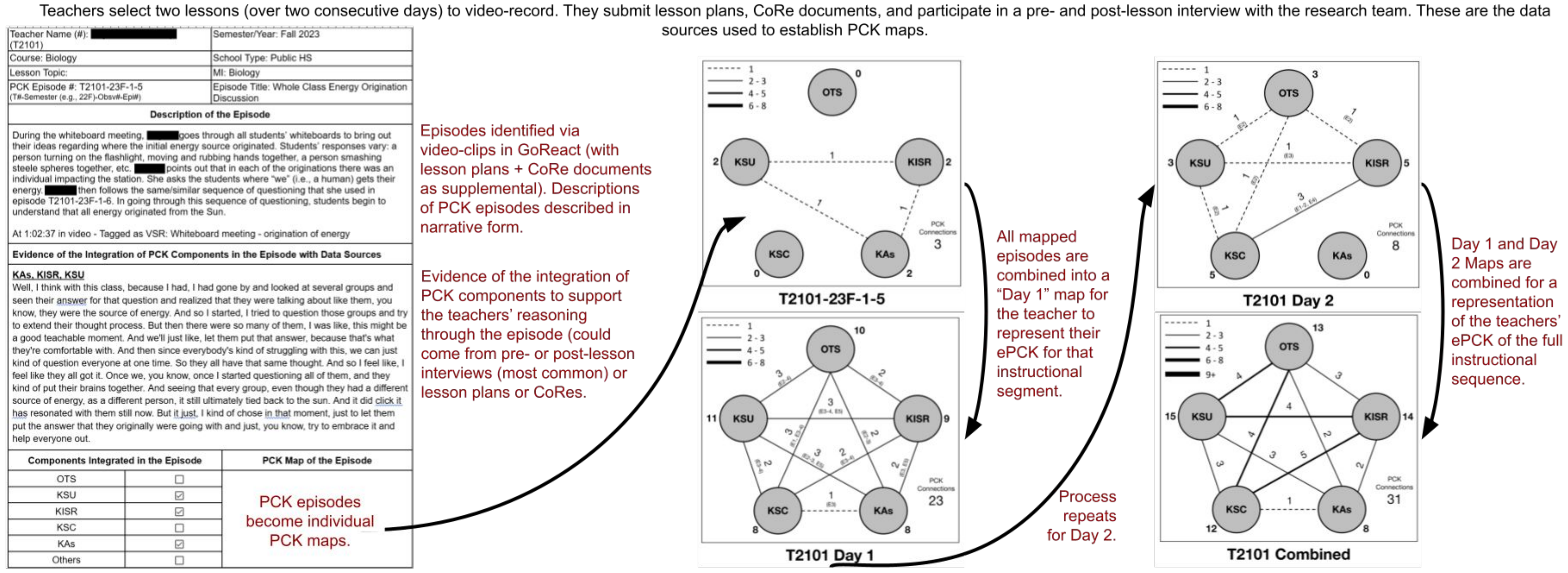


Conceptual Framework for Educative Mentoring



PCK Mapping

Teachers select two lessons (over two consecutive days) to video-record. They submit lesson plans, CoRe documents, and participate in a pre- and post-lesson interview with the research team. These are the data sources used to establish PCK maps.



Survey Instruments

- Science Instructional Practices Survey (SIPS; Hayes et al., 2016)
- Epistemic Orientations to Teaching Science for Knowledge Generation (EOTS-KG; Suh et al., 2022): (1) epistemic alignment, (2) authority relations in learning, (3) nature of knowledge, and (4) student ability
- Knowledge of Models & Modeling in Science Teaching (KMM-ST) survey (Carroll & Park, 2023)

Observations

- MI implementation videos
- Mentoring session videos

Documents

- CoRes (Loughran et al., 2004)
- Mentoring log
- Written feedback on MI instruction

Interviews

- Teacher Belief Interview (TBI; Luft & Roehrig, 2007)
- VSR interview
- Semi-structured interview
- Focus group

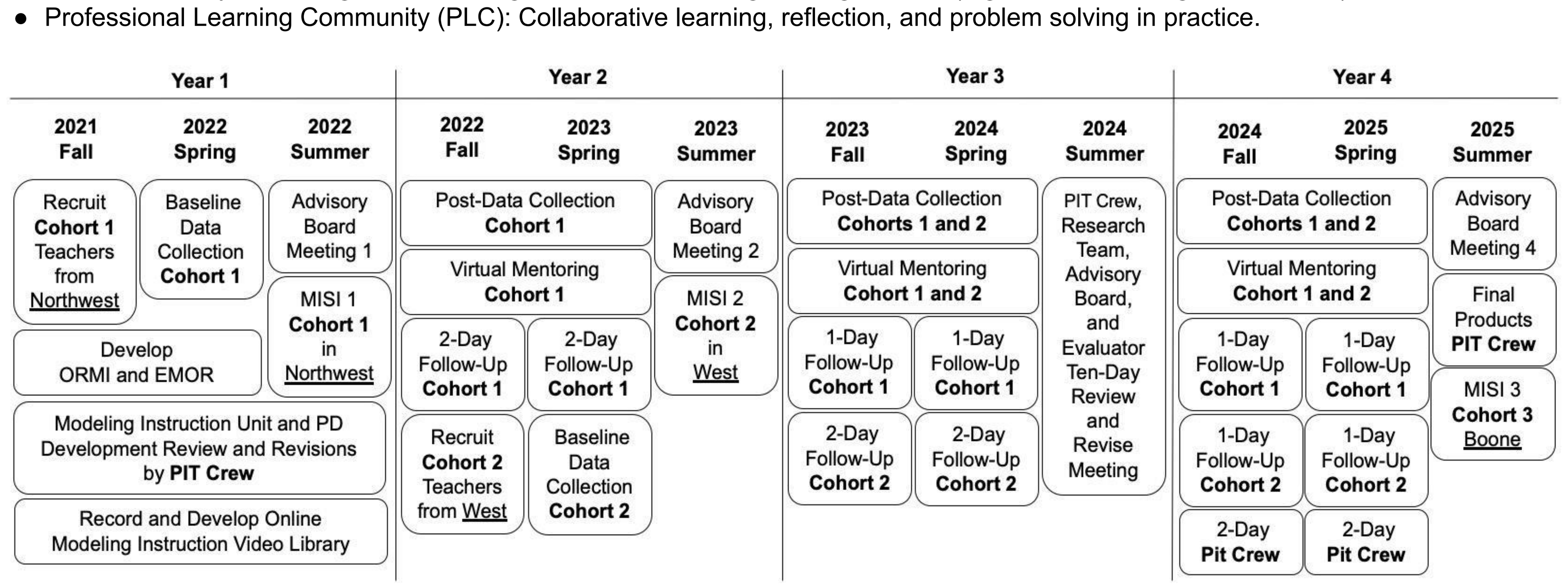
SIMIRS Teacher Support Program

Background

- **MI**: A pedagogical approach wherein conceptual models are created and applied to concrete, physical, biological, and chemical phenomena to promote understanding of scientific/mathematical principles (Jackson et al., 2008); In MI, teachers guide their students through proposing models, conducting investigations that lead to revised models, constructing explanations from evidence, engaging in argumentation, and using models to refine understanding in science (Campbell et al., 2015; Passmore et al. 2009).
- Strong PKC and constructivist epistemology required for effective implementation of reform-oriented science instruction like MI (Park et al., 2011, 2021).
- NC: Ranks 2nd in the US for rural population - 80 out of 100 counties classified as rural, 87 of the 115 traditional K-12 public school districts located in rural counties.

Structure of the Teacher Support Program

- Summer PD: 3-Weeks (90 hours), based on effective PD model (Darling-Hammond et al., 2017; Desimone, 2009; Kennedy, 2016).
- Academic year support: Follow up days (24 hours), curriculum resources support.
- Virtual bi-weekly mentoring model utilizing educative mentoring and digital tools (e.g, GoReact, Google suites, etc.).
- Professional Learning Community (PLC): Collaborative learning, reflection, and problem solving in practice.



Key Findings & Implications

PCK & Implementation of Modeling Instruction (MI)

- Teachers' PCK scores aligned with their MI implementation levels; However, the increase in PCK were not proportional to the increase in MI implementation and varied by teacher.

  Implications: PCK is essential for implementing reform-oriented science teaching, but its translation into practice is complex rather than straightforward; Contextual factors may mediate the impact of PCK on instruction.
- State standards and standardized statewide assessment, especially in non-NGSS states, often hindered teachers' PCK development and MI implementation.

  Implications: Reform-oriented instruction support must attend to local context (e.g., pacing guides, school culture, administrator perceptions and expectations, etc.); Aligning the MI curriculum with state-specific standards in addition to NGSS can ease implementation and enhance fidelity.

Epistemic Beliefs & MI Implementation

- Most teachers initially held constructivist epistemic beliefs, which strengthened over time; However, some teachers who exhibited epistemic misalignment during implementation have experienced a more difficult implementation trajectory than those with tighter alignment.

  Implications: Mentoring should leverage moments of epistemic misalignment as opportunities for reflection, helping teachers refine the beliefs that underlie their implementation of MI and deepen their understanding of the approach; Facilitating belief refinement may improve instructional alignment and promote sustained MI implementation.

Mentor Beliefs and Educative Mentoring

- Mentors' epistemic beliefs are closely related to their approach to mentoring; They have consistently enacted and enhanced the key EM components of Situated Inquiry, Collaborative Learning, Bifocal Vision, and Reflective Discourse, while placing the least emphasis on the Student Thinking.

  Implications: EM-focused mentor training should explicitly address mentors' epistemic beliefs and emphasize integrating student thinking into their mentoring activities and practices.