ABSTRACT

HALL, AMANDA JOYCE FOXWELL. Modeling Educative Mentorship: Exploring the Implementation of Educative Mentoring Practices with Modeling Instruction Science Teachers. (Under the direction of Dr. Soonhye Park).

Science teachers are crucial in fostering scientific literacy, particularly through reform-oriented approaches like Modeling Instruction (MI). Educative mentoring (EM) supports teachers in adopting new instructional methods, yet little research has explored how EM supports in-service secondary science teachers. Guided by social constructivism, this qualitative multiple-case study examines the EM practices and decision-making processes of three mentors guiding teachers in integrating MI across secondary sciences. Data collection included semi-structured reflective interviews, recorded mentoring sessions, and video-stimulated interviews. Findings reveal distinct mentorship experiences, with variation in the frequency and consistency of how mentors engaged the five EM components: situated inquiry, collaborative learning, bifocal vision, reflective discourse, and student thinking. A notable gap their focus on student thinking emerged. Implementation challenges included missed opportunities for deep reflection, exploration of student data, inquiry-guided feedback, and balancing structure with flexibility. Key factors shaping mentors' EM practices included relationships with mentees, balanced CoP leadership, reflection, reform-oriented teaching experience, and prior EM training. The study highlights connections between EM and reform-oriented instruction, emphasizing the importance of strong mentoring relationships. Findings suggest the need for sustained EM-specific training and collaborative support. This study informs professional development initiatives and provides a foundation for future research on pedagogy-based mentor selection, the refinement of the EM Observation Rubric, relational aspects of the EM Conceptual Framework, and comparisons between in-person and virtual EM in science education.

Modeling Educative Mentorship: Exploring the Implementation of Educative Mentoring Practices with Modeling Instruction Science Teachers

by
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DEDICATION

The water of her womb, your first home.

The body she pulled apart to welcome you to the world.

The spirit in you, she helped grow with all she knew.

The heart that she gave you when yours fell apart.

You are her soft miracle.

So she gave you her eyes to see the best in the worst.

You carry your mother in your eyes.

Make her proud of all she watches you do. (Gill, *Mother*)

This dissertation is dedicated to two important mothers who gave me their eyes to carry with me as I venture into every wild dream, including this advanced degree. I never imagined having to live a life without their unwavering support, challenging perspectives, or safe spaces to process my interpretation of the world. Yet, with very little notice, this was the reality I was left to navigate. My grief persists, not just for their physical absence, but also for the realization that there will forever be moments of my continuing existence that I will not get to share. At times, the grief is so overwhelming that I feel as though I am battling Archimedes' principle, and only an equal force will prevent me from succumbing to full submersion. Therefore, it is essential for my personal healing to note that although they are not here to witness this specific accomplishment, those fierce, loud, loving women infused persistence, tenacity, and creativity into my spirit that is stronger than any tragedy I will ever suffer. While I feel the loss of both of these women in each breath I take, their memories motivate me to make my life the best it possibly can be. They would not accept any less from me, so I cannot accept any less for myself. After all, they are watching me… and I must make them proud.

In memory of my grandmother, Grace Louise Reilly Schaefer, who instilled the belief in me that hard work and good ideas result in achievable dreams, from the day I was born through the moment I held her hand during her last breath.

In memory of my mother, Suzanne Elizabeth Schaefer Foxwell, whose sense of wonder and wandering set the expectation that every norm should be challenged to allow for growth, even as we unknowingly embarked on her final adventure together–just two years ago.

In honor of my sisters, Bonnie Lynne Foxwell Manjang and Audrey Christine Foxwell, whom I have known and loved for every single day of their lives, and will continue to support them as our mother would have, from here to eternity.

BIOGRAPHY

Amanda JF Hall is a dedicated educator and researcher committed to advancing inquiry-based science education in K-12 schools. Amanda has a decade of K-12 teaching experience, most recently as a 5th-grade science teacher in western North Carolina. She has taught in diverse settings, including public and private elementary schools, a charter school, and a Montessori school. During her tenure as an educator, Amanda has also served as a Science Fair Coordinator, Science Olympiad Event Evaluator, and STEM-E Coach. After earning the exciting Smokey Mountain Elementary Teacher of Year, and at the cusp of Covid-19, Amanda and her loyal husband, Bradley, embarked on a new educational journey, pursuing a Ph.D. in Science Education at North Carolina State University (NCSU), Amanda's research primarily focuses on exploring the role of experienced science teachers as educative mentors and the effect that has on encouraging more teachers to include questioning, experimentation, critical thinking, and reflection in their science classrooms. While at NCSU, Amanda taught the undergraduate courses, Introduction to Science Teaching and Introduction to Instructional Technology for Educators. She was also the Digital Learning Graduate Assistant at the Media and Education Technology Resource Center (METRC), where she was part of an incredible team. Amanda is currently a research assistant on an NSF DK-12 Grant project, focusing on the professional development of science teachers using Modeling Instruction (MI). Her responsibilities include designing and leading professional development sessions for mentoring and communities of practice and conducting interviews with mentor participants. With the Ph.D. journey in the rearview, Amanda will be seeking a new place of learning to call home.

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It is important to frame this work with an understanding that it was born during a period of my life that was shrouded in the heavy darkness of compounded losses, the heaviest of which was also the most recent. As I was searching for the light within the mentors in this study, there were many days when I was unable to see any glimmer of light in myself. Getting this work from concept to page included a lot of restarts, perseverance, forgiveness, and uncomfortably slow movements toward barely visible progress. I had to fight each day against grief, doubt, distraction, loneliness, and self-inflicted overwhelm. However, while I am not yet healed enough to fully shine, I was able to develop this work into something I can be proud of and use as a beacon for all my future endeavors. In the significant revision of this work I faced personal disappointment, but gained a deeper connection to the work that will highlight the supportive work of these case mentors. I humbly add that this is not a journey I could have braved alone. During scary times like grief and dissertations, do as Mr. Rogers so brilliantly advised and "look for the helpers." I had the support of helpers throughout this experience who lifted me and walked by my side as I traversed every stumble.

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PREFACE

"If science were not tested in 5th grade, you wouldn't even be teaching it…"

I wish I could say that it was joy and satisfaction with my career that moved me to pursue a PhD in Science Education. Such a sentiment would only be partially true. While I enjoyed every moment of bringing inquiry-based learning experiences to my students, it was these infuriating and tone-deaf words from an administrator that highlighted a problem I wanted to solve through my work and propelled me into action.

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CHAPTER 1- INTRODUCTION

"When kids look up to great scientists the way they do musicians, actors [and sports figures], civilization will jump to the next level." -Brian Greene

Access to information has become unlimited as 97% of Americans have cell phones available in their pockets, with 85% of those cell phones considered smartphones (Pew Research Center, 2021a, 2021b), which garners the power to ask (and answer) questions at a rate that rivals the retrieval of rotely memorized facts introduced in the classrooms of the past. Through this open access to the internet, people can conveniently get information on important topics, like politics and science (Pew Research Center, 2019). Recent research finds that Americans tend to receive knowledge passively, accepting potentially biased or inaccurate sources, and those consuming it are not likely to seek out trustworthy research (Light et al., 2022). However, when the public receives knowledge passively, it can lead to a limited understanding of scientific processes and discourse. This passive reception can deepen the existing deficit of trust and confidence in science experts, as people may not fully grasp the methods and outcomes of scientific research (Bauer & Falade, 2021). Focusing solely on cognitive deficits and textbook knowledge may not address the broader issues of public engagement and trust in science.

As education levels and basic understanding of science have been shown to influence a person's beliefs about science (National Science Board [NSB]/National Science Foundation [NSF], 2020), a strong national science education is a viable way to start rebuilding faith and trust in science (Bybee, 2010; Pennycook et al., 2023). Students are typically exposed to science concepts through public school classrooms and science teachers (Bybee, 2010; National Academies of Sciences, Engineering, and Medicine [NASEM], 2015), but classroom practices that focus on the memorization of existing facts have not evolved with the availability of

information technology (Bertoline et al., 2013), resulting in an education system that is not built to support critical thinking about scientific facts or emerging ideas.

Reforms in Science Education

Historical educational reforms for science education started in the late 1800s, as government officials, scientists, school districts, and teachers grappled with the best way to meet the needs of learners, and society as a whole (Rudolph, 2019). With the power to access new information through quick digital means, science education needs have evolved from requiring students to recall information presented in teacher-centered lessons to needing student-centered lessons where students apply knowledge with critical thinking, creativity, and problem-solving skills (Kennedy & Sundberg, 2020; Salehjee & Watts, 2020). *Student-centered learning*, the facilitation of students exploring content through inquiry or open laboratory performance tasks (Schiro, 2013), allows students to learn science using methods similar to those of professional scientists to develop their explanations of science concepts (You, 2016). Student-centered experiences are critical for understanding scientific content, as well as developing critical thinking, problem-solving, and communication (Cunningham & Carlsen, 2014; Guzey et al., 2016; Kang et al., 2016). As the learners, science puts students in the center of the experience, placing them in collaborative engagement with the natural world, which enhances students' understanding of scientific concepts and skills (Ford, 2015; National Research Center [NRC], 2012; Pamuk et al., 2017) and has a positive effect on the overall student interest, participation, and achievement in science (Capobianco et al., 2015).

The importance of this shift to reform instruction is heralded by national initiatives to change standards, curriculum materials, and assessments for science education across the United States. Introduced over a decade ago, the Next Generation Science Standards (NGSS) (NGSS

Lead States, 2013) align with the National Research Council's (NRC, 2012) Framework for K-12 Science Education. The NGSS 3-Dimensional Learning Model integrates Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), and Disciplinary Core Ideas (DCIs) to promote deep, interconnected understanding of scientific concepts through engaging in *inquiry*, the processes of questioning and investigating (NGSS Lead States, 2013). The NGSS model reinforces the need for teachers to create these inquiry-based learning environments where students are immersed in the exploration of real-world phenomena through opportunities to use *SEPs*, skills such as asking questions, using models, conducting investigations, analyzing data, employing mathematics and computational thinking, explaining and designing solutions, arguing from evidence, and communicating information to others (Windschitl & Calabrese Barton, 2016). To meet the evolving science learning needs of students, teachers can become *reform-oriented* (Kennedy & Sundberg, 2020) by moving away from teacher-led instruction and adopting the appropriate student-centered approaches that emphasize the nature of science and integrate SEPs with regular science content instruction (Bybee, 2017; NRC, 2012), rather than relying on memorization competencies.

Teachers play a critical role in shaping their students' learning, thinking, and reasoning of science concepts, by making decisions about how to align their teaching methods with NGSS reform initiatives and utilize student-centered learning models in their classrooms (Tekkumru-Kisa et al., 2020). Several instructional approaches support science teachers' incorporation of SEPs into their teaching. These approaches include research-based science teaching methods, like problem-based learning (Hmelo-Silver, 2004; Yew & Schmidt, 2012) or Ambitious Science Teaching (Stroupe, 2017; Windschitl et al., 2018, 2020), as well as reform-oriented curricula, like OpenSciEd (Edelson et al., 2021), or Storylines (Reiser et al., 2021). Modeling Instruction

(MI) is a specific example of a reform-oriented science learning approach that addresses changes to both pedagogy and curriculum (Jackson et al., 2008), that build SEPs that align with NGSS initiatives (Cullen, 2015; Stammen et al., 2018). Specifically, MI emphasizes organizing student-led learning by *modeling*, implementing model development and deployment cycles to actively engage in experimentation, data analysis, and presentation of their findings (Jackson et al., 2008). Additionally, MI students are empowered to create conceptual models, apply them to real-world phenomena, and revise their models based on emergent data (Hestenes, 1987, 2010; Wells et al., 1995), fostering deep understanding, critical thinking, and collaborative learning that significantly improves student engagement and achievement in science (Jackson et al., 2008; Malone et al., 2019).

Despite strong evidence and theoretical support for integrating SEPs into science instruction, solely relying on materials-focused innovations like textbooks and science kits to reform teaching methods is insufficient to significantly improve student science achievement (Chueng et al., 2016). According to the NGSS, science teachers must have adequate experience, training, and support (Covitt et al., 2023), to ensure they have sufficient knowledge and understanding of SEPs to effectively implement changes in their teaching practices (Tahani, 2021). However, unequal availability, design, and financial support for professional development across schools and districts present significant barriers to fostering these pedagogical shifts (Limbere et al., 2022). For instance, school systems in rural areas of the United States are experiencing slower transitions to aligning their instruction with the NGSS, primarily due to limited access to targeted professional development opportunities that focus on reform-oriented skills and strategies or professional communities that might reduce their isolation (Zinger et al., 2020).

Supporting Science Teaching Reform

To have lasting results for changes in teaching practices, professional development should take place in long sessions that expand over multiple meetings or opportunities to reconvene to reflect on the application of learned materials (Darling-Hammond et al., 2009, 2017; Desimone, 2009; Kennedy, 2016; Knapp, 2003), and include support from administration or peers afterward (Furtak, 2017; Koballa & Bradbury, 2012; Renbarger & Davis, 2019). Professional support for teachers learning or transitioning to reform-oriented practices should include opportunities for the teacher to collaboratively plan, practice, and reflect (McNeill & Knight, 2013; van Driel & Berry, 2012) because reducing the cognitive load for teachers during the implementation of a new practice affects the effectiveness and fidelity of the changes they make (Clements et al., 2015; Larson et al., 2018). Supportive communities of practice (CoPs), or mentorship, increase teachers' chances of committing to reform-oriented practices (Barnett & Friedrichsen, 2015; Luft et al., 2022; Trabona et al., 2019; van Driel et al., 2001). Grounded in social constructivism, social learning, and applied learning (Hayes & Pridham, 2019), mentoring is a support that highlights the importance of social interaction, learning from others, practical application of knowledge, and developmental growth (Vygotsky, 1978), to create supportive, dynamic environments where mentees can actively engage with their mentors to gain valuable insights and experiences (Lave & Wenger, 1991). Professional development that includes mentoring support afterward affects the likelihood of teachers continuing to learn or use the new practices in the future (Nolan & Molla, 2017), therefore, it is important to increase quality and access to effective professional development and mentoring (Heller et al., 2012; Kleickmann et al., 2013).

Mentorship can take various forms and be structured in different ways, depending on the goals and preferences of the individuals involved (Dawson, 2014; Mullen, 2020; Orland-Barak & Wang, 2021). Mentoring can also be applied in varying contexts (Aspfors & Fransson, 2015; Becher & Orland-Barak, 2018), ranging from 1:1 coaching that focuses on the needs of one teacher to group CoPs that can be efficient for sharing knowledge and fostering a sense of community among mentees (Prenger et al., 2019; Stoll et al., 2006). Variations in mentorship approaches result in differing levels of effectiveness in methods (Hagler, 2018), suggesting that not all mentoring methods are the most appropriate fit for reform-oriented science teachers (Hobson et al., 2009). Traditionally, mentorship involves pairing a new teacher with a veteran teacher from the same school to support them through their first year(s) of teaching (Lave & Wenger, 1991). The mentor serves as a role model, providing examples of lessons, strategies, and approaches (Bradbury & Koballa, 2008; Pantić et al., 2021; Wang & Odell, 2002), but is also responsible for providing advice, guidance, and feedback to their mentees to achieve their goals (Bradbury, 2010). Historically, this mentorship style has placed a passive role on the mentee as they attempt to learn a new craft (Aspfors & Fransson, 2015). Because the top-down approach emphasizes the experiences of the mentor being shared, with little focus on the lived experiences of the mentee, the relationship may experience power imbalances that can disrupt the trust within the relationship (Bradbury & Koballa, 2008; Mena et al., 2017). With the mentor providing resources and strategies that they have been using in their own classrooms, traditional mentoring relationships may also reinforce outdated teaching practices that do not foster change to reform-oriented practices (Luft et al., 2011; Thompson et al., 2015). For example, research reports that traditional mentoring models can hinder innovation, collaboration, and reflective practice among pre-service and early-service teachers (Barnhart, 2020), when mentor beliefs and

the pressures to uphold standardized curriculum reforms dominate the process (Cherian, 2007). Relying solely on traditional mentorship approaches can restrict teachers' agency in their practice, create unequal power dynamics, and introduce communication challenges, all of which influence preservice teachers' professional identities and instructional methods (Yoon & Larkin, 2018) and may ultimately reinforce the status quo (Mullen et al., 2020). Mentoring that is more constructivist, focusing on the new teacher building their own individualized understanding of good teaching practices, empowers the new teacher and increases their self-efficacy (Richter et al., 2013).

Educative Mentoring

Mentoring models in science that move beyond a traditionally hierarchical model into more collaborative mentorship that focuses on specific context or pedagogy, contribute to a mentee's ability to incorporate reform-oriented science teaching practices into their classroom (Braaten, 2019; Chaliès et al., 2008). *Educative mentoring* (EM) is a collaborative approach to supporting overall teaching practice in a manner that addresses the need for teachers to focus on developing pedagogy (Feiman-Nemser, 2001; Haug & Mork, 2021; Stanulis, 2019). EM emphasizes a reciprocal relationship between the mentor and mentee (Stanulis et al., 2012) that allows the mentor to learn alongside the mentee, in science-specific contexts, an opportunity not explicitly found in traditional mentoring (Bradbury, 2010; Feiman-Nemser, 2001a, 2001b). This collaborative approach focuses on the students' learning while encouraging both parties to learn from each other and work together to improve their teaching practice, which can help reduce the risk of power imbalances that can occur in other forms of mentoring. Educative mentors facilitate support for mentees' design and implementation of student-led learning experiences by incorporating questioning and active listening practices, rather than providing solutions (Brand,

2020). Educative mentors encourage teachers to think critically about their practice and experiment with innovative approaches (Bradbury, 2010). Collaborative problem-solving between mentors and mentees is used to identify and address specific challenges related to teaching and learning (Trevethan & Sandretto, 2017). This can include solving immediate issues in the classroom, as well as long-term goals of changes to practice (Wexler, 2020). Data-driven instruction and reflection are also critical components of the EM process (Wexler, 2020). As a framework for mentoring science teachers, EM includes many of the tenets of good teaching practice in science, which is not always the case in traditional mentoring relationships. For example, both EM and reformed-oriented science teaching use investigations to define problems through data analysis, experiment with new methods and practices, and reflect on their effectiveness (Schulz, 2005; Trevethan & Sandretto, 2017). Due to the similarities between EM and reform-oriented teaching practices in science, it is believed that EM promotes a culture of continuous improvement and shared learning that can be an effective approach to support science teacher professional development (Feiman-Nemser, 2001; Bradbury, 2022).

Mentoring practices in science education have begun to navigate toward educative, or collaborative, mentoring relationships that focus more on learner outcomes (Bradbury, 2022; Ellis et al., 2020), but mentors are often selected by administrators subjectively based on factors such as tenure and availability, rather than classroom practices or pedagogy (Becher & Orland-Barak, 2018). Mentors are often chosen based on being considered high-quality teachers after being evaluated in their own classrooms, an attribute that may vary in meaning depending on the evaluator (Polikoff et al., 2015). However, research says that being identified as a highly-qualified teacher does not necessarily translate to being a successful mentor (Wang, 2001). Effective mentoring requires specific skills and knowledge that not everyone possesses naturally

(Aspfors & Fransson, 2015). Some of those skills apply to general mentoring, such as collaboration, relationship building, reflection, and support (Allen et al., 2005). In addition to those interpersonal skills, purposeful science education mentoring requires understanding how students learn science, identifying strengths and weaknesses in science content knowledge, and developing strategies to include SEPs (Becher & Orland-Barak, 2018). Not every person selected or nominated to become a mentor exhibits all necessary skills, but they may develop them over time (Schwille, 2008), or require training to acquire them. Even experienced or effective mentors benefit from explicit training in mentoring skills that support intentional reflection about mentors' knowledge and beliefs and provide clear expectations about their mentoring practices (Hudson, 2013). Professional training for science mentors need to reflect reformed science pedagogy, as well as include specific challenges and opportunities to learn content in science education (Melton et al., 2019), allowing mentors to learn more and benefit from the mentor-mentee relationships as much as the mentee teacher (Clinard & Ariav, 1998; Hudson, 2013).

Because there are many forms of mentoring (Dawson, 2014; Mullen & Klimaitis, 2021) and not all methods of mentoring foster the development of contextually specific teaching practices (Bradbury, 2022), it is essential to find a mentoring framework that is appropriate, successful, and trainable for reform-oriented teaching methods (Gul et al., 2019). While EM is hypothesized to be such a model, aligning well with constructs that support teachers who are learning and implementing reformed context-specific teaching practices because it is reflective of the same teaching practices expected of reform-oriented teachers, there is still a lot that is unknown about how this would work when implemented in practical situations. There are no current guidelines for explicitly training EM with any population, nor studies exploring how mentors implement educative practices with their in-service, secondary-level, science teacher

mentees who are learning new reformed teaching practices to incorporate SEPs or NGSS standards in their classrooms. This results in mentorship varying drastically from one mentor to another, across the educational environment, discipline, and experience levels of those selected as mentors (Biggers et al., 2019; Richmond et al., 2017; Wexler, 2020). In addition, current literature on science educator mentorship does not represent the complete landscape of teachers, as it tends to be focused on pre-service teachers (Drake, 2023) and is limited to primary teachers (Bradbury, 2022). There is room for research regarding how in-service and secondary-level science teachers can be supported through mentorship as they learn new pedagogical practices, especially for those who may be required to make shifts in their epistemological beliefs to do so.

Purpose of the Study

This multiple-case study explored the implementation of EM with mentors working with mentees learning to implement MI, a reform-oriented science teaching approach, through one academic year. The goal was to gain insights into how to better support mentors in implementing EM. To address the gaps in the literature related to the training of science education mentors, especially in EM, this study investigated three mentors who each supported two or three teachers who participated in the MI Summer Institute and would implement MI in their biology and/or chemistry classrooms. Each mentor in this study was introduced to the components of EM that compared traditional and educative methods, a follow-up workshop with their mentees to set goals and build relationships, and the facilitation of mentorship in regular CoP sessions throughout their first year of implementation. In the year following their training, each mentor used the EM components within CoP (Lave & Wenger, 1991), in a blended format primarily hosted virtually to accommodate the distance between the teachers' schools and flexibility in school county calendars.

This study examined how three mentor teachers decide how to implement educative practices while guiding their mentees in reforming their science teaching through MI. Their experiences would demonstrate how the theoretical ideas of EM can be conceptualized and implemented in practice as these mentors support in-service teachers, an area of research that has not been included in the literature. The research questions guiding this study are:

1. How did mentors implement EM components and practices over two semesters after participating in EM training?
2. Which components and practices of EM did mentors consistently implement, and where did they face difficulties?
3. What are the key characteristics of mentors' decision-making processes when implementing EM practices?

Significance of the Study

This study is essential for science educators and researchers because it aligns science education with the demands of the modern world, which require teaching approaches to reform to address contemporary challenges such as misinformation, scientific literacy, and critical thinking. This study addresses the challenges related to supporting the professional development of reform-oriented teaching, and emphasizes the importance of educative mentors in this process. Specifically, this study examines how three mentors implement EM components and practices over two semesters, shedding light on how EM can facilitate meaningful instructional change. By investigating which EM components and practices mentors consistently implement and where they face challenges, this research provides actionable insights into how to strengthen mentorship in science education. Moreover, by analyzing the decision-making processes mentors

use when implementing EM, this study contributes to understanding how mentors navigate the complexities of supporting teachers in shifting toward reform-based instruction.

This research addresses a critical gap in literature, as much of the foundational work on EM has been theoretical. By empirically examining how EM functions within a CoP among science teachers, this study offers practical insights into the implementation of reform-oriented mentorship. Findings from this study provide an in-depth look at how mentors integrate key EM features into their practice, including collaborative reflection and inquiry-based support, highlighting their successes and obstacles. Understanding these patterns can inform future mentor training programs by identifying best practices and common difficulties, enabling the design of targeted professional development strategies. Additionally, by exploring mentors' decision-making processes when engaging in EM, this research uncovers how mentors adapt to varying classroom contexts, mentee needs, and systemic challenges. These findings have the potential to strengthen mentorship frameworks, ensuring that professional development initiatives are both practical and sustainable, ultimately contributing to broader efforts to enhance science education nationwide.

Summary

This chapter explores the role of EM in supporting science teachers as they implement reform-oriented teaching practices, specifically MI. The chapter highlights the increasing need for student-centered science education in response to the evolving accessibility of information and the challenges of scientific literacy. It reviews historical and contemporary education reforms, emphasizing the NGSS and the shift toward inquiry-based learning. The study examines the role of mentorship in facilitating these changes, distinguishing EM from traditional mentoring approaches by its emphasis on collaboration, reflection, and pedagogical

development. The research aims to investigate how three mentors implement EM while guiding in-service teachers in adopting MI, addressing gaps in literature related to science teacher mentorship and professional development. By analyzing mentors' decision-making and the challenges they face, the study provides insights into improving science education mentorship and professional development support systems for reform-oriented teachers.

Chapter 2 will explore relevant literature on science education reform, professional development and support for in-service science educators, including mentorship models. The second chapter will also describe the conceptual framework for EM and the theoretical framework of social constructivism that guided the study. Chapter 3 will detail the multiple case study design for this research, describing the three mentors included in the study regarding their experience and training. The third chapter will also explain the data collection and analysis processes, including the inductive coding schemes for interviews with the mentors, including semi-structured and video-stimulated interviews and the a priori coding scheme of the Educative Mentoring Observation Rubric (EMOR) to identify EM practices in each mentor's recorded mentoring sessions across an entire school academic year. Chapter 4 will describe the implementation of EM practices that emerged for each mentor, including the frequency and consistency of inclusion for the five EM practices. Common patterns that emerged across all three cases regarding consistency, challenges, and influences on the mentors' implementation of EM will also be reported. The fourth chapter will also share key themes in the mentors' decisions about how they would apply their conceptual understanding of EM with their mentees. Chapter 5 will discuss the implications of this study as it relates to literature and initiatives that support future educative mentors for in-service science teachers and directions for future research toward reform-oriented science teaching.

CHAPTER 2- LITERATURE REVIEW

"The delicate balance of mentoring someone is not creating them in your own image, but giving them the opportunity to create themselves." -Steven Spielberg

Science education reform has been a focal point of educational policy and research, emphasizing transitioning from traditional, teacher-centered instruction to student-centered, inquiry-driven learning (Bybee, 2014; NRC, 2012). The Next Generation Science Standards (NGSS) and similar frameworks advocate for reform-oriented teaching approaches that integrate disciplinary content with scientific practices and crosscutting concepts. However, achieving these reforms requires significant support for in-service science educators, mainly through professional development and mentorship.

This literature review examines key areas relevant to this study, including Modeling Instruction (MI) as a reform-oriented science program (Jackson et al., 2008), professional development models (Darling-Hammond et al., 2017; Desimone, 2009) that support in-service science teachers, and various mentorship frameworks (Dawson, 2014; Mullen & Klimaitis, 2021) that facilitate the adoption of reform-based teaching. Special attention is given to educative mentoring (EM), emphasizing collaborative learning, reflective discourse, and inquiry-based professional growth (Bradbury, 2010, 2021).

This chapter introduces the study's conceptual framework for EM and the theoretical foundation of social constructivism (Lave & Wenger, 1991; Wenger, 1998), which underscores the role of social interaction and shared learning experiences in shaping teacher practice. By synthesizing research on these critical topics, this review provides the foundation for understanding how mentorship can effectively support secondary science teachers in adopting and sustaining reform-oriented instructional approaches, like MI.

Literature Review

Reform-Oriented Science Teaching

Science has been taught in various methods throughout history, from teacher-led to student-led approaches (Rudolph, 2019). Arguments have been made throughout time that having access to authentic learning experiences is an effective method for learning science (Brooks & Brooks, 1999). The Next-Generation Science Standards (NGSS) (NGSS Lead States, 2013) were developed using the National Research Council (NRC) (2012) report *Framework for K-12 Science Education*. They are a collection of science learning expectations that were collaboratively constructed by multiple states to align the teaching of science disciplinary content, science practices, and 21st-century skills (NRC, 2012). The researchers behind the NGSS call for reformation in the way science is taught in the United States (Bybee, 2014; NRC, 2012), in order to develop scientific communication, as students learn to articulate their ideas, explain their reasoning, and engage in scientific discourse with their peers. Reform-oriented teaching utilizes a social-constructivist model of teaching that allows for the facilitation of learning through collaboration to achieve a common learning goal (Bandura, 1977; Dewey, 1938; Lave & Wegner, 1991; Vygotsky, 1978), which in science is to prepare students to become scientifically literate and informed citizens. The NGSS proposes that science learning is the integration of three dimensions: disciplinary core ideas (DCIs) that are broadly important across specific K-12 science disciplines, crosscutting concepts (CCCs) that apply across all domains and contexts, and science and engineering practices (SEPs) that broaden the definition of inquiry as it applied to scientific exploration (NGSS Lead States, 2013). As part of this three-dimensional model, the incorporation of SEPs into core instruction reinforces the processes, skills, and habits of mind that scientists and engineers use to investigate the natural world and

design solutions to problems (Ford, 2015). SEPs align well with social-constructivist learning because they involve active and collaborative engagement with the natural world and with other learners, which can enhance students' understanding of scientific concepts and skills (Bertoline et al., 2013). The eight science and engineering practices include:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

These practices, coupled with DCIs and CCCs, are critical for understanding scientific phenomena, but are also foundational for developing skills that are valuable in many other areas of life, such as critical thinking, problem-solving, and communication (NGSS Lead States, 2013; NRC, 2012). Becoming reform-oriented fosters innovation in science teaching, as teachers design lessons where students apply their knowledge to novel situations (Inkinen et al., 2020), utilize problem-solving and metacognitive skills, and increase their use of model representations (Jackson et al., 2008), which encourages the overall improvement in conceptual performance among science students (Malone et al., 2019; Wells et al., 1995). According to a meta-analytic review based on 56 publications between 1988 and 2014, conducted by Savelsbergh et al. (2016), SEPs increased student science aptitude and interest in science concepts.

Teachers can shift to reform-oriented teaching incorporating SEPs through research-based curricula and learning programs. One specific example of a reform-oriented science learning program is MI, a research-based pedagogical approach developed by Arizona State University Modeling Program, founded by David Hestenes, Malcolm Wells, Gregg Swackhamer, and Larry Dukerich, that is highly constructivist and student-led (Jackson et al., 2008). Dukerich (2015) described three key differences between a high school chemistry course using MI and a traditional approach: how the content is structured, the role of laboratory work in developing concepts, and the nature of interactions between the instructor and students. MI integrates key SEPs (Cullen, 2015), such as developing and using models, analyzing and interpreting data, and engaging in arguments from evidence (Stammen et al., 2018). Students collaboratively design experiments, construct conceptual models, and apply these models to explain and predict physical phenomena. This hands-on, student-led approach emphasizes critical thinking and communication, encouraging students to refine their understanding through experimentation and peer discussion (Jackson et al., 2008; Wells et al., 1995). When implementing MI in the classroom, the teacher's role switches from a traditional mode of presenting information to students to a reformed mode of facilitating students in the construction of knowledge (Malone et al., 2019; Schwarz et al., 2009). MI in secondary science education positively impacts student learning in various science practices and skills (Jackson et al., 2008), such as enhancing expert-like problem-solving, metacognitive abilities, using multiple representations, and overall conceptual understanding. Jenkins and Howard (2019) found that high school chemistry students using MI were more adept at writing experimental procedures, creating data tables and graphs from collected data, and composing conclusions based on their findings. Additionally, while MI students perform similarly on district assessments, learning chemistry is a more positive and

meaningful experience (Dukerich, 2015). Teachers trained in MI feel better prepared and more likely to succeed in implementing these practices in their classrooms, but are hindered by a lack of teacher preparation, resources, and support (Haag & Megowan, 2015).

To be considered a reform-oriented educator, a science teacher who uses traditional teacher-led lecture-based instruction must intentionally shift their pedagogical approach to student-led approaches that emphasize the importance of active learning, inquiry-based activities, and collaboration among students (Bybee, 2017; Furtak et al., 2012; Kennedy & Sundberg, 2020; NRC, 2012). For example, teaching using the MI approach requires teachers to rethink the way they operate their classrooms to allow the students to create conceptual models that illustrate their various levels of understanding and the application of those models to concrete, physical, biological, and chemical phenomena to promote understanding of science and mathematical principles (Hestenes, 2010; Jackson et al., 2008).

A range of personal, cultural, and systemic factors can hinder the transition to reform-oriented science teaching (Fischer et al., 2018; Johnson, 2006). While some teachers excel in general pedagogy, they often struggle to implement inquiry-based strategies effectively (Capps & Crawford, 2013a). Integrating new instructional approaches into existing practices presents challenges, as deeply rooted beliefs about teaching and learning can create resistance to change (Preminger et al., 2024). In the context of MI, implementation fidelity is frequently compromised by misalignment between teachers' instructional goals and curriculum expectations, as well as cognitive dissonance that undermines commitment to reform-based methods (Barlow et al., 2014). Similarly, Limbere et al. (2022) identified a disconnect between teacher preparation programs and the expectations set by science education standards, contributing to reluctance in adopting innovative teaching models like MI.

A critical barrier to reform-oriented teaching is the specialized knowledge required for effective implementation. Gilbert and Justi (2016) emphasized that teaching science through models, one of the SEPs in reform-based instruction, requires a deep understanding of both models and the modeling process, including epistemic practices. Many teachers lack this comprehensive knowledge, limiting their ability to engage students in authentic scientific inquiry. Without targeted professional development, this knowledge gap can significantly hinder efforts to shift toward reform-oriented instruction.

Beyond individual and pedagogical challenges, systemic barriers further obstruct reform efforts. Fitzgerald et al. (2017) found that high school astronomy teachers in Australia faced significant obstacles in implementing reform-oriented practices, including time constraints, inadequate professional development, a lack of clear models and definitions, insufficient resources, and limited administrative support. These findings highlight the broader institutional and structural issues that must be addressed to create sustainable change in science education. Effective reform requires not only teacher buy-in (Hübner et al., 2021), but also systemic support through professional learning opportunities, aligned curricula, and institutional commitment to pedagogical transformation.

Support for Implementation of Reform-Oriented Teaching Practices

Professional Development Programs

While quality curriculum materials are essential, effective teaching remains the foundation of the science classroom. Kleickmann et al. (2016) demonstrated that student achievement levels are lower when teachers rely solely on educational curriculum materials than when those materials are paired with expert support and collaborative, active learning opportunities. Comprehensive support systems, including targeted professional development, a

clear understanding of curriculum innovations, and hands-on experience with new instructional approaches are critical for teacher growth (Cheung et al., 2017; Peers et al., 2003); therefore, the integration of professional development and learning with model curricula and classroom materials is vital for improving science education (Darling-Hammond et al., 2017). Capps and Crawford (2013a) reinforce the need for ongoing, rigorous professional development to help teachers understand inquiry-based instruction, the nature of science, and the practical application of reform-based methods in the classroom. Effective professional development programs should include five key components: (a) a focus on content; (b) active learning; (c) coherence with teachers' experiences and contexts; (d) sustained duration; and (e) collective participation (Desimone, 2009). When professional development incorporates these elements, it provides meaningful support for educators, fostering improved student achievement (Darling-Hammond et al., 2017). It has been found that "long-term professional development programs using strategies like learning in networks, peer coaching, collaborative action research, and case studies can achieve lasting changes in teachers' practical knowledge" (Dori & Herscovitz, 2005; van Driel et al., 2001). Further, Desimone and Garett (2015) found that professional development is most effective when explicitly linked to classroom instruction, reinforcing the need for practical, contextualized training that aligns with the daily experiences of science teachers (Preminger et al., 2024).

Effective professional development is supportive for teachers implementing reform-oriented practices and instructional strategies. It enhances teacher knowledge, shifts perceptions and beliefs, and leads to change in teaching practices that ultimately result in better student learning outcomes (Desimone, 2009). Strategic engagement with school leadership and the creation of a supportive learning environment can enhance teachers' self-efficacy and autonomy

in implementing new practices (Tsaliki et al., 2022). According to a study conducted by Pringle et al. (2020), a comprehensive professional development program can positively impact middle school science teachers' enactment of reform-based science teaching by improving their disciplinary content knowledge and instructional practices, further demonstrating that professional development emphasizing critical reflection (Capps & Crawford, 2013b) and collaborative discourse can transform teachers' instructional practices and support implementation of reform-oriented practices in science teaching (McPherson, 2022). Knapp (2003) observed that offering multiple opportunities for in-depth engagement over time has transformed teaching practices and improved student outcomes.

While professional development is generally beneficial, motivating and supporting teachers in implementing newly learned strategies remains complex (Desimone & Garrett, 2015). Teachers may respond differently to the same professional development experiences, and effectiveness results can vary widely. In a recent systematic review of literature regarding interventions aimed at preparing preservice science teachers to teach scientific models and modeling effectively, Chan et al. (2024) found that due to the variations in modeling contexts across studies, no clear pattern emerged regarding the effectiveness of these interventions. The findings suggest that a holistic approach that addresses both cognitive and affective motivational aspects while providing extended support is more effective in preparing preservice teachers for teaching scientific models and modeling. However, even with professional development support, teachers face technical, political, and cultural barriers that can hinder the adoption of new practices (Johnson, 2006). Without sustained and well-structured professional development, reform efforts may be inconsistently applied or abandoned altogether (Shaharabani & Tal, 2017). Moreover, indirect factors can prevent reformed practices from improving student performance.

For example, Fischer et al. (2018) examined Desimone's professional development framework (2009) in the context of Advanced Placement (AP) science curriculum reform. They found that professional development significantly influenced teachers' instructional practices, increasing the number of laboratory investigations and the enactment of AP science practices. However, while professional development led to changes in teaching, the impact of these changes on student AP assessment performance was weak, suggesting that while professional development can help align instruction with curriculum reforms, significantly improving student outcomes may require broader or alternative approaches. To create lasting changes that enhance science teaching and student learning (Peers et al., 2003; van Driel et al., 2001), professional development programs must offer ongoing engagement and adapt to the evolving demands of science education (Windschitl, 2009).

Mentoring

Professional development programs often integrate coaching and expert support, such as mentoring, to provide personalized guidance that addresses individual challenges (Desimone, 2009; Geeraerts et al., 2015). This tailored support increases the likelihood that teachers will implement new methods or practices in their classrooms more effectively than professional development alone (Kohler et al., 1997). In education, mentoring extends beyond skill development to encompass broader personal and professional growth (Desimone et al., 2014). However, there is no universally accepted theory or definition of mentoring, as the concept continues to evolve and adapt to different contexts and needs (Dawson, 2014; Pleschová & McAlpine, 2015). Mentoring has traditionally been structured as a hierarchical dyadic relationship in which the mentor, typically more experienced and knowledgeable, imparts wisdom and guidance to the mentee, who is often younger and less experienced (Fletcher &

Mullen, 2012; Franke & Dahlgren, 1996; Mullen, 2017). To contextualize mentoring, *The Oxford Research Encyclopedia of Education* (2019) defines mentoring in education as a positive, supportive facilitation of learning and development between a person with more experience, knowledge, or expertise, and a person less knowledgeable or new to that field (Hayes & Pridham, 2019). To further define mentoring, Mullen and Klimaitis (2021) conducted a systematic literature review on the complexities of mentorship, identifying nine distinct types. Many of these models offer alternatives to the traditionally hierarchical dyadic structure, fostering more complex and equitable learning support with social transformative value. These mentoring types include formal, informal, diverse, electronic, collaborative, group, peer, multilevel, and cultural mentorship. For clarity in this dissertation regarding variations in definition, mentoring is conceptualized as a relationship-based process in which an experienced and knowledgeable mentor provides guidance, support, and feedback to a mentee seeking to develop personally and/or professionally.

Mentoring is generally characterized by a supportive and guiding relationship that can take both formal and informal forms (Fountain & Newcomer, 2016), with applications across various fields and contexts (Stokes et al., 2020). As a result, mentoring practices vary significantly across different settings, such as education, workplaces, and community organizations, shaped by factors like organizational structure, cultural norms, and the specific needs of mentees (Orland-Barak & Hasin, 2010; Wang, 2001). Given the distinct demands of science teaching, science teachers require well-designed mentoring programs explicitly tailored to the specific practices and process of teaching science (Larsen et al., 2023; Orland-Barak & Wang, 2021). The use of science-specific mentoring is found to be effective in creating sustainable changes in teaching practices and developing leadership skills (Gul et al., 2019).

Studies from Australia (Koch & Appleton, 2007) and the United States (Richmond et al., 2017) emphasize the importance of mentoring models focused on constructivist teaching, science content understanding, and pedagogical content knowledge (PCK). These studies conclude that successful mentoring involves one-to-one interactions, modeling, and professional development workshops that address the specific needs and predispositions of teachers.

When combined with effective professional development, mentors, and other teacher leaders, are a valuable support mechanism for science teachers successfully transitioning to reform-oriented pedagogies by enhancing teachers' inquiry-based teaching abilities (Darling-Hammond et al., 2017; Heredia et al., 2024). Nam et al. (2013) explored a collaborative mentoring program for novice middle school science teachers in South Korea, finding that an inquiry-based approach improved instructional practices and deepened reflection. Similarly, Melville & Bartley (2010) found that inquiry-based mentoring within broader inquiry communities supported science teacher development and aligned with Canada's National Science Education Standards. Furthermore, mentoring plays a vital role in shaping professional identity and fostering reflective practice (Devos, 2010). Research by Koul (2023) suggests that collaborative mentoring, including joint lesson planning and establishing positive relationships, enhances primary teachers' self-efficacy in science instruction, reinforcing the need for supportive mentoring structures. Mentoring has also been shown to significantly enhance science teachers' PCK—the knowledge required to teach a specific subject effectively (Barnett & Friedrichsen, 2015; Can-Kucuk et al., 2022). A large-scale study of novice urban secondary teachers in Malaysia (See, 2014) found a strong correlation between mentoring and high levels of PCK across subject areas. Effective mentoring relationships facilitate joint planning and teaching, which are crucial for PCK development (Appleton, 2008). Moreover, mentors help

teachers reflect on their practice, align instruction with their beliefs, and develop targeted instructional strategies (Aydin et al., 2013). Beyond instructional support, mentoring also affects teachers' well-being. Burger (2023) examined different mentoring styles and their influence on novice teachers' emotional exhaustion, well-being, and satisfaction of basic needs such as competence and autonomy. The study underscores the role of mentoring in fostering well-being and meeting teachers' essential professional needs.

While mentoring is considered a strong support for the growth of teachers, Orland-Barak and Wang (2021) note that there are persistent hurdles in aligning mentoring with teacher education reforms and ensuring that mentors are adequately prepared remain significant hurdles. The effectiveness of mentoring can vary due to the method and approach utilized by the mentor (Spooner-Lane, 2017). For example, a directive mentoring style may restrict mentees' ability to independently explore and implement new teaching strategies, while a shift towards a more non-directive style can empower teachers to take ownership of their teaching practices (Michailidi et al., 2021). Mena et al. (2017) found that mentors in their study dominated conversations, inhibiting pre-service teachers' ability to learn effectively.

Mentoring experiences also differ across cultural and structural contexts. Chaaban et al. (2021) compared pre-service teachers' mentoring experiences in Lebanon and China, finding that Lebanon's unstructured approach often misaligned with mentees' expectations, while China's structured apprenticeship model was more supportive. Similarly, studies in Ethiopia (Tarekegn et al., 2020) and Jordan (Abed & Abd-El-Khalick, 2015) reported ineffective mentoring experiences due to a lack of constructive feedback, guidance on curriculum and policy, and modeling of effective science teaching. The studies demonstrate how the different approaches to

mentoring impact the mentees' success and emphasize the need for science-specific mentoring to enhance the professional development of preservice teachers.

While mentoring is essential for professional growth, the skills required to be an effective mentor are rarely explicitly taught (Langdon & Ward, 2015; Leeder et al., 2022; Richmond et al., 2017), compromising effectiveness. Studies from Turkey (Hudson et al., 2009) and Australia (Hudson, 2005) indicate that mentors frequently fail to address key areas such as system requirements, pedagogical knowledge, and modeling. This gap suggests a need for targeted professional development programs to equip mentors with the skills required for effective science mentoring. A recent meta-analysis by Maxwell et al. (2024) found that while few structured mentor training programs exist, those that do improve mentors' understanding of their roles, increase confidence, and enhance self-efficacy through critical reflection.

Educative Mentoring for Science Teachers

Traditionally, mentors assist new teachers with non-specific teaching responsibilities, such as classroom management, unit planning, and adjusting to the school culture (Searby, 2014; Stanulis & Bell, 2017) through a hierarchical relationship (Fletcher & Mullen, 2012; Mullen, 2017). However, the reforms to teaching and learning in science education have influenced a trend toward collaborative methods of mentorship (Bradbury, 2022), where a mentor serves as a role model, providing examples of effective behaviors, strategies, and approaches (Bradbury, 2010; Clarke et al., 2014). The mentor may also provides advice, guidance, and feedback to help the mentee to identify and achieve their goals, and to develop the skills, knowledge, and attitudes needed to succeed in their chosen field (Wang & Fulton, 2012), enabling educators to make meaningful changes in their teaching methods and encourages retention (Maready et al., 2021; Shanks et al., 2020). As illustrated in Figure 2.1, EM emphasizes a more reciprocal relationship

between the mentor and mentee that focuses on developing the mentee's teaching practice and the mentor's skills (Bradbury, 2010; Schwille, 2008).

Table 2.1

Traditional vs. Educative Mentoring (Bradbury, 2010)

Traditional Mentoring	Educative Mentoring
Providing support necessary to retain novice teachers in the profession	Fostering a disposition of sustained inquiry into teaching practice
Meeting immediate needs	Meeting immediate needs while developing a long-term orientation toward reform-based science teaching
Sharing practical solutions to day-to-day problems	Thinking about teaching as a complex process where there is rarely one “right” answer
Providing copies of lesson plans, notes, and science activities	Using background knowledge of students and their work samples to plan lessons that support learning about a particular topic
Sharing of advice from mentor to novice	Valuing the contributions and ideas of both the mentor and novice

Using a collaborative, or EM approach encourages both parties to learn from each other and to work together to improve their teaching practice, which can help reduce the risk of power imbalances (Bradbury, 2022; Stanulis et al., 2012). This approach can create a positive and supportive relationship between the mentor and mentee as they each share reflections on their personal and professional experiences (Bessette & Bennett, 2021) resulting in mutual learning opportunities (Maor & McConney, 2015; Ndamba & Chabaya, 2011). EM emphasizes mentoring as inquiry-based learning and encourages teachers to think critically about their practice and experiment with innovative approaches (Bradbury, 2010) that focus on improving student learning outcomes (Stanulis et al., 2019), which promotes a culture of continuous improvement and shared learning that can be a practical approach to supporting teacher professional

development. Specifically, research indicates that discipline-specific EM fosters the development of pedagogical content knowledge (PCK) in preservice teachers by helping them integrate PCK components into their teaching and reflections (Barnett et al., 2015; Cebesoy, 2017; Can-Kucuk et al., 2022).

At the foundation of EM conceptualization, Feinman-Neister (2001) believes mentors have clear ideas of what they want novices to learn and what teaching entails. They should also acknowledge their role is a teaching role. They are expected to understand that the learning process should be purposeful, which means it takes time and should not be left to chance. Mentors should use a combination of showing and telling, as well as asking and listening, to help novice teachers learn to teach. This process should include both teachers in co-planning and co-teaching, as they share resources and shift responsibilities depending on the novice's readiness and capability (Feiman-Neister, 2001).

Bradbury (2010) built on Feiman-Neister's work and emphasized that quality educative mentors are led by inquiry into their practice as much as in the development of the mentee. Mentors question and investigate what is working and not working in a given teaching situation. In a meeting with a mentee, this can be done in a think-aloud for problem-solving. This type of inquiry is common in science classrooms and would be natural for a mentor-mentee relationship to encompass. As part of this process, mentors and mentees will participate in goal setting and rationale development to experiment with reform-based approaches because, "mentees need opportunities to try out reform-based ideals" (Bradbury, 2010). Unfortunately, while mentors see this as necessary, many institutions do not function or support learning in this manner (Bradbury, 2010). One defining aspect of EM is that problem-solving happens collaboratively (Bradbury, 2010), rather than the insight being limited to that of the mentor.

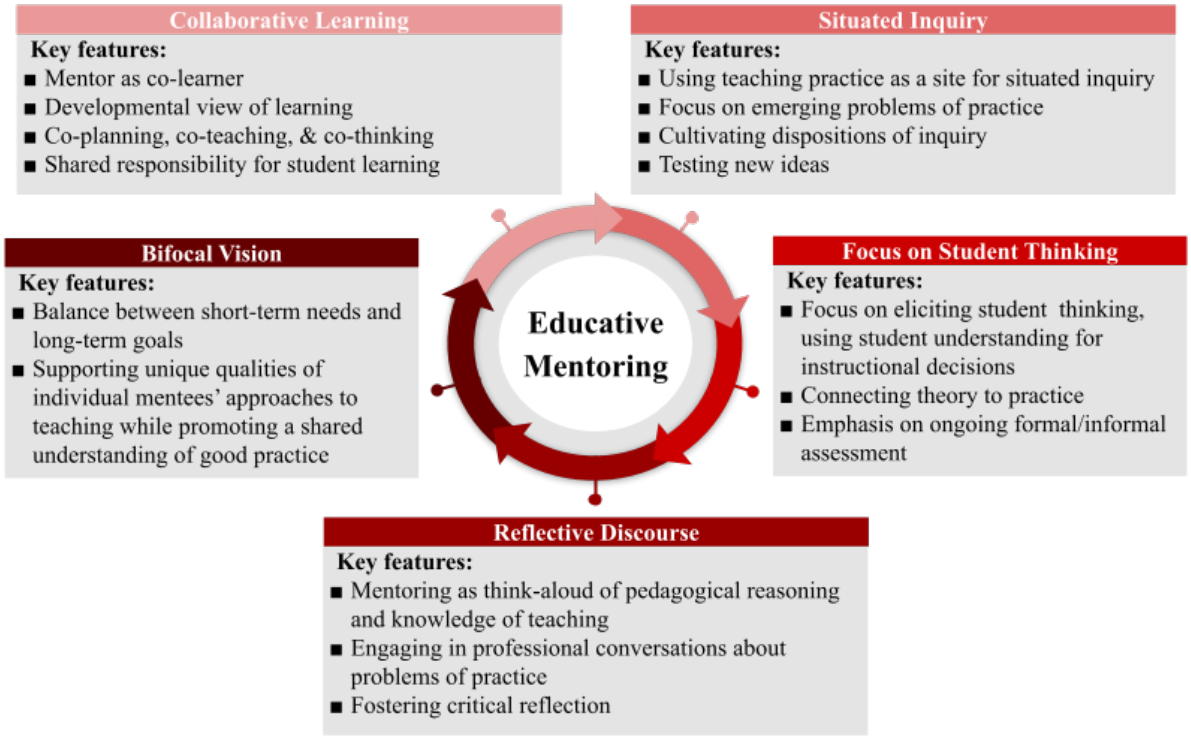
In her work exploring the impact of mentor teachers who engage in educative practices, Wexler (2020) continued to build a conceptual definition of educative mentors and their role in growing and retaining highly effective science teachers. She explained that educative mentors should be transparent with their mentees about the influences on decisions they make in planning lessons. These planning and debriefing discussions should include samples of student work and examples of engagement practices. A strong educative mentor will share reflections on their practice in meetings with their mentee, with focused conversations and questions about student learning in both classrooms (Wexler, 2020).

Based on the foundational literature, EM consists of five core concepts: Collaborative Learning, Situated Inquiry, Student Thinking, Reflective Discourse, and Bifocal Vision (Bradbury, 2010; Feiman-Nemster, 1998; Wexler, 2020). Collaborative learning involves working together to plan, teach, and assess. Collaborative learning is an essential practice, where mentees and mentors collaborate to identify lesson content and structure (Stanuilis et al., 2019). Situated inquiry is a process that should include various elements such as using student thinking and work as the basis of inquiry into appropriate practice (Stanulis et al., 2019), drawing on the expertise of both partners to generate new ideas, linking ideas to theory and practice, providing opportunities for mentees to experiment with new ideas, and creating a safe space for evaluating their effectiveness (Bradbury, 2010). Student Thinking means that classroom practices should develop student ideas and promote constructivist student thinking (Stanulis et al., 2019). The primary focus is on student thinking and understanding (Wexler, 2020). Reflective discourse allows the mentor and mentee to engage in disciplined and honest discussions about their pedagogical practice to navigate individual problems and challenges (Feiman-Nemser, 2001). A bifocal vision emphasizes the importance of addressing both short-term needs and long-term

developmental goals (Wexler, 2020). Each of these core concepts, illustrated in Figure 2.1, has key features of experiences and expectations of practice that describe that component, which function together within a circular and overlapping process between the mentors and mentees.

Figure 2.1

Educative Mentoring Framework: Core Components and Key Features



As illustrated in this conceptual visualization, no single component is a clear beginning or end to being educative. This intentional decision was made to demonstrate that mentors and mentees can, and will, work within one or more of these components at a time and revisit them repeatedly throughout their relationship. These five core components are an appropriate guide for developing EM programs in schools, especially for classrooms that use an MI curriculum, and guide professional development.

Situated Inquiry

The framing of learning through inquiry is not a new strategy for most science educators. Mentors can cultivate teaching reformation that includes inquiry showing/modeling, explaining, asking questions, and listening (Feiman-Nemser, 1998). They can also work to frame problems in ways that focus on those most crucial to developing reform-based teaching ideals, helping mentees see that teaching does not have a "one size fits all" approach (Bradbury, 2010). An EM relationship benefits both parties as the mentee becomes a more integral part of the CoP (Lave & Wenger, 1991; Trevethan & Sandretto, 2017). Mentors model inquiry through an analyzing mindset, which includes inquiring into their teaching practices with a natural curiosity about what does and does not work in their lessons. This inquiry can be done by thinking aloud with the mentee about occurrences in lessons. Thinking aloud should include a description of the observable action or decision, as well as the rationale for an action or decision (Bradbury, 2010). This process should include the use of student thinking and work as the root of the inquiry (Stanulis et al., 2019), such as the use of the expertise of both partners to develop new ideas, connect ideas to theory and practice, support novice teachers by including opportunities for the mentees to try out new ideas, and offer a safe space for evaluating the effectiveness of new ideas (Bradbury, 2010).

Collaborative Learning

EM is a series of collaborative learning opportunities for the mentor and the mentee. EM highlights the value a novice teacher brings to the learning, planning, and teaching processes. Bradbury (2010) believes that an effective mentor can see the needs of the mentee as they are the novice in this context, but does not control that dynamic. Instead, mentors and mentees work together to grow and improve each other's practice. Collaboration in mentor/mentee

relationships is defined as mentors operating as co-learners in the classroom (Trevethan & Sandretto, 2017); both teachers co-plan, co-teach, and co-think (Stanulis et al., 2018), sharing the responsibility for improving student learning (Norman & Feiman-Nemser, 2005; van Driel et al., 2002). The collaborative nature of this relationship would also help both the mentor and mentee by building a relationship founded on respect for both mentor and mentee (Schwille, 2008; Trevethan & Sandretto, 2017); exploring content and context for improving practice; focusing on a mentee's prior experience, readiness, and capability; and creating collaborative learning opportunities to support the development of dispositions, knowledge, and skills of continuous improvement through specific feedback.

As mentors and mentees work collaboratively, there is a focus on using student problems and difficulties to plan instruction (Barnett & Freidrichsen, 2015). Working collaboratively can, and should, include co-planning, co-teaching, and co-assessing. Co-planning involves teacher candidates and mentors working together to identify lesson content and structure (Stanulis et al., 2019). Co-teaching is more expansive and predicated upon shared instructional responsibilities of the teacher candidate and mentor (Friend et al., 2010). Co-assessing involves teaming up to look at student work and determine the next steps for instruction (Stanulis et al., 2018).

Bifocal Vision

Traditional mentoring focuses on the immediate needs of the mentee, whereas EM allows mentoring partners to acknowledge those short-term needs while connecting them to their long-term goals (Wexler, 2020). In EM, the mentor is attentive to a mentee's short-term needs while also maintaining a focus on long-term goals that will ensure the success of the mentee in the future (Bradbury, 2010; Feiman-Nemser, 2005; Wexler, 2020). The mentor may find it helpful to develop a strategy or method of gauging the understanding and experience of each mentee

because each will come to the relationship with different strengths, weaknesses, and experiences (Aydin et al., 2013), and an awareness of the stage of development may point to the short-term needs that the mentee has. Mentors should also examine novices' beliefs about teaching, help them solve problems using their own methods, and promote student-centered and reform-based ideas (Aydin et al., 2013).

Mentors' support should guide mentees' goal-setting in ways that will keep their focus on the bigger picture through the lens of the more minor hurdles and challenges. It may seem that "mentors are supposed to intervene in the decision-making process when the ideas of novices are not reform-based" (Aydin et al., 2013). A mentor may need to intervene by addressing immediate issues while encouraging the mentee to think about broader topics (Bradbury, 2010). This dual approach involves valuing the mentee's ideas, but also recognizing that not all ideas are equally valid. The mentor should identify ideas that may not align with reform-based teaching or meet student needs, model standards-based teaching rather than just discussing it, and support the mentee in developing their vision of reform-based teaching. Throughout this process, the mentor can ask questions and foster discussions to help the mentee progress (Bradbury, 2010).

Reflective Discourse

Unlike traditional mentoring, which focuses on the observation and growth of a novice teacher, often through the mentor's feedback, EM is rooted in a desire to grow and learn through intentional reflection (Bradbury, 2010). This mentoring model shifts the focus from seeking one-sided feedback from the mentor to shared reflection between the co-teachers. This reflective discourse is encouraged to be a place where both the mentor and mentee address problems of practice by open-ended discussion, rather than sessions led by the mentor (Feiman-Nemser,

2001). The mentor and mentee will develop EM skills by engaging in conversation about problems of practice (Richmond et al., 2017), guided by probing questions that allow for deeper thinking (Kim & Silver, 2016). This form of reflection operates as a think-aloud for processing pedagogical content knowledge (PCK), fosters critical reflection of the practices of each co-teacher (Walker & Ardell, 2020), engages both teachers in professional conversation about problems in their implementation or practice (Trevethan & Sandretto, 2017), and cultivates a safe space to reflect on experiences to improve. Reflective discourse is observable as both partners self-reflecting on past practice to determine goals, observing each other throughout a given period, and offering constructive feedback.

Focus on Student Thinking

Rather than focusing on the behaviors and actions of the mentee, as in traditional mentoring, the focus in EM is on how reform-oriented teaching practices can develop student ideas and encourage constructivist student thinking (Stanulis et al., 2019), where the clear focus is on student thinking and understanding (Wexler, 2020). Shifting the focus of mentoring sessions toward student learning will strengthen the teachers' skills while challenging them to move toward more reform-based ideals (Stanulis et al., 2019). Further, it is expected that there will be an increase in student-led discovery and construction of knowledge when students are engaged and participating, students' academic, social, and emotional needs are met, and teachers plan the proper formative assessments to gauge student learning (Wexler, 2020); mentors help their mentees check for these aspects in student work and through their observations, making it a focal point of their discussions.

Using student data and artifacts to assess thinking facilitates learning and collaboration between mentors and mentees (Stanulis et al., 2019). To support mentees as they incorporate

student thinking into their lessons, mentors should find ways to incorporate their observation data of students and student work into mentoring meetings. They should also use the "think aloud" method to encourage novice teachers to discuss their instructional choices and reflect on whether lessons meet the unique needs of all learners (Wexler, 2020; Stanulis et al., 2019).

Studies on Educative Mentoring

Recent research on EM has explored its application across diverse educational settings, emphasizing its role in fostering inquiry-based reflection, collaborative learning, and student-centered teaching. Studies highlight key mentoring practices, including Situated Inquiry, Reflective Discourse, Bifocal Vision, and Student Thinking within their individual contexts. For example, Langdon and Ward (2015) examined a pilot program in New Zealand designed to inform national induction and mentoring policies. Their findings indicated that evidence-based reflection, goal setting, and focused observations helped mentors transition from hierarchical expert-novice dynamics to collaborative partnerships. Additionally, some mentors extended their roles to school-wide induction and appraisal programs. However, the shift to a facilitative approach remained challenging, underscoring the need for sustained professional development. Similarly, Palombo and Daly (2022) demonstrated the effectiveness of EM in geography education by using the classroom as a site of inquiry. In this setting, mentors and mentees collaboratively analyzed student learning evidence to guide instructional decisions through structured observations, co-planning sessions, and reflective discussions. This process not only encouraged critical questioning but also supported continuous professional growth.

Expanding on content-specific applications, Abramo and Campbell (2019) studied music teacher mentoring, emphasizing narrative-based reflection and the strategic use of natural teaching moments rather than prescriptive guidance. While this approach fostered deeper

pedagogical discussions, balancing autonomy with structured mentoring posed challenges, particularly in addressing sociocultural teaching contexts. Similarly, Kasen et al. (2024) examined EM in secondary mathematics mentoring, identifying purposeful questioning, co-planning, and reflective debriefing as effective strategies for promoting mentee independence. However, they noted that mentors often struggled with relinquishing control and refining questioning techniques, reinforcing the need for ongoing support.

Further illustrating the adaptability of EM, Palmeri and Peter (2019) investigated its use among university mentors working with early childhood and elementary teacher candidates. Their structured yet flexible mentoring framework shifted the focus from evaluation to reflection, prompting mentees to analyze instructional strategies and connect theory to practice. Despite initial resistance from mentors, sustained professional development helped them adopt a more reflective approach.

Richmond et al. (2017) found that EM fostered a collaborative learning environment in STEM education. Structured mentoring sessions and informal communication networks supported professional growth and contributed to high teacher retention rates in high-need schools. Meanwhile, Barnett and Friedrichsen (2015) provided insights into EM's role in secondary biology education. They demonstrated how mentoring helped pre-service teachers develop pedagogical content knowledge through critical reflection on student misconceptions and instructional alignment.

Across these studies, several EM practices emerge as particularly effective. Inquiry-based mentoring encourages mentees to use classroom evidence to inform teaching, while structured reflective dialogue facilitates critical instructional analysis. Collaborative planning enhances decision-making transparency, and the gradual release of responsibility fosters mentee

autonomy. Additionally, establishing professional learning communities and providing ongoing mentor development is crucial, as many mentors initially struggle with shifting from an evaluative to an inquiry-driven approach.

While core EM principles remain consistent, their application varies by context. For example, in STEM fields, EM often emphasizes formative assessment and student misconception analysis (Barnett & Friedrichsen, 2015; Kasen et al., 2024), whereas, in humanities, narrative-based reflection and classroom inquiry are more prevalent (Abramo & Campbell, 2019; Palombo & Daly, 2022). Further exploration is needed to understand how science-specific contexts shape EM practices and their effectiveness in facilitating instructional change (Bradbury, 2010, 2022). Moreover, existing studies explore EM as a support for pre-service teachers across various institutional programs, which limits the scope of context to the needs and experiences of early and pre-career educators. Limited research exists on EM's role in supporting in-service science teachers as they reform their instructional practices (Barnett & Freidrichsen, 2015). This dissertation addresses this gap by examining EM's implementation in mentoring secondary biology and chemistry teachers using MI. It aims to provide empirical insights into how mentors conceptualize and apply EM principles to support science teaching reform.

Theoretical Framework

In structuring the plan for bringing EM to science educators to explore its practices, this study is guided by the principles of social constructivism, informed CoPs. Learning is a social process shaped by interaction, collaboration, and cultural context rather than an isolated individual experience (Lave & Wenger, 1991), enriched through discussion, collaboration, and shared experiences emphasizing that learning activities allow students to negotiate and navigate ideas through communication (Wertsch, 1991). As situated in a community of like-minded

educators learning and utilizing similar teaching methods, EM is a framework for understanding and implementing a social-constructivist approach to supporting other science teachers to reform their teaching to include more social-constructivist pedological approaches (see Figure 2.2), acknowledging the importance of observation, collaboration, and authentic contexts in the learning process (Bradbury, 2010).

Figure 2.2

Relationship of Theories Informing Educative Mentoring

Social constructivism emphasizes learning as an active, social process where interaction builds knowledge (Vygotsky, 1978). It posits that learning is a social process, highlighting the importance of collaboration, social interaction, and language. Learners engage with peers, educators, and experts, encountering diverse viewpoints to refine understanding. The core tenet is that learning involves developing new ways of understanding through active engagement with others and the environment, where meaning is constructed through experiences and interactions, transcending the mere acquisition of information. It emphasizes the significance of authentic, situated learning within CoPs, where learners engage in meaningful activities and contribute to the community's social fabric (Dufour, 2014; DuFour et al., 2006; Lave & Wenger, 1991; Trabona et al., 2019). This theory underscores that the construction of knowledge learning is

inherently tied to a social and cultural context, occurring through active participation in a CoP, where real-world activities and collaborative problem-solving occur. Knowledge is constructed through these interactions, highlighting the importance of social engagement and the acquisition of skills, knowledge, and understanding as learners participate in real-world activities within their social communities (Wenger, 1998), offering an insightful way to understand how learning and knowledge exchange happen within groups.

At the heart of this theory are three key ideas: community, practice, and domain. Community refers to people who come together around shared interests and activities, fostering a sense of belonging and mutual support, which could include collaborating with colleagues in their school or district or connecting with other educators through online networks. This community aspect is crucial because it provides a space for teachers to share experiences, offer advice, and build professional relationships. Practice is all about the shared activities and methods that define how the work is done. In the context of science teaching, this includes everything from developing lesson plans and conducting experiments to using new educational technologies. Science teachers can exchange ideas, refine their techniques, and stay up-to-date with the latest educational strategies by engaging in these practices. This shared practice helps teachers improve their effectiveness and adapt their teaching to better meet students' needs. The specific area of interest that brings the community together is the domain, where the teachers connect through their domain of MI, specifically their shared exchange of knowledge, experiences, and best practices. Members collaborate to solve problems of practice and collectively enhance their reform-oriented skills and understanding within this domain. Active engagement and collaboration are the cornerstones of CoPs, enabling the mentors and mentees to share insights, experiences, and ideas, often working together on projects or challenges. CoPs

frequently develop shared resources, such as documents and tools for MI, which aid in the learning and development of the community. Furthermore, CoPs contribute to the personal and professional growth of members, helping them establish a sense of belonging and identity within the MI community and their specific science content. Over time, CoPs adapt to evolving needs, changes in the domain, and emerging developments, welcoming new members and seeing others depart, thus shaping the community's dynamics (Michailidi & Stavrou, 2021).

Summary

Chapter 2 reviewed the literature on science education reform, professional development, and mentoring to support in-service science teachers. Reform-oriented teaching, guided by the NGSS, emphasizes inquiry-based learning and SEPs to enhance student understanding. MI was highlighted as an effective, student-centered pedagogical approach that aligns with these reform efforts. Professional development and mentoring are critical in facilitating the transition to reform-based teaching. This review examined EM, a model that fosters Collaborative Learning, Situated Inquiry, Reflective Discourse, Student Thinking, and a Bifocal Vision that balances immediate and long-term professional growth. Research indicates that EM can enhance teachers' instructional practices, yet there is a gap in empirical studies on its application for in-service science teachers. Framing this study within the conceptual framework of EM and the theoretical framework of social constructivism, this chapter establishes the importance of socially collaborative mentorship in supporting science teachers' adoption of reform-oriented practices. The findings from this review provide a foundation for investigating how mentors can effectively construct and implement science-specific EM practices to sustain instructional change in science education.

CHAPTER 3- METHODOLOGY

"To acquire knowledge, one must study; but to acquire wisdom, one must observe."

-Marilyn vos Savant

Science education reform efforts emphasize a shift from traditional, lecture-based instruction to student-centered, inquiry-driven learning environments (Bybee, 2014; NRC, 2012). Professional development and mentorship help in-service science teachers adopt and sustain reform-based instructional approaches to support this transition. This study examines how mentors implement educative mentoring (EM) to support teachers integrating Modeling Instruction (MI) into their classrooms. Grounded in social constructivism (Lave & Wenger, 1991; Vygotsky, 1978), this research's methodological approach explores how EM relationships facilitate collaborative learning, reflective discourse, and shared professional growth within a community of practice (CoP).

By aligning research design, data collection, and analysis with the study's guiding research questions, this chapter establishes a systematic approach to understanding how mentors enact EM within professional development contexts. A qualitative multiple-case study design (Yin, 2018) investigates how three mentors interpret and apply EM in their work with mentees over an academic year. Data collection methods provide insight into how mentors engage in EM practices through recorded mentoring sessions, reflective interviews, activity logs, and feedback on mentee teaching videos. Data analysis methods identify inductive and deductive patterns in mentoring strategies and decision-making, through a cross-case analysis in examining commonalities and variations among the mentors' experiences that address the research questions of this study and contribute to the broader discourse on effective mentorship models for supporting science teachers in the implementation of reform-oriented instructional practices.

Research Context

Supporting the Implementation of Modeling Instruction in Rural Settings (SIMIRS)

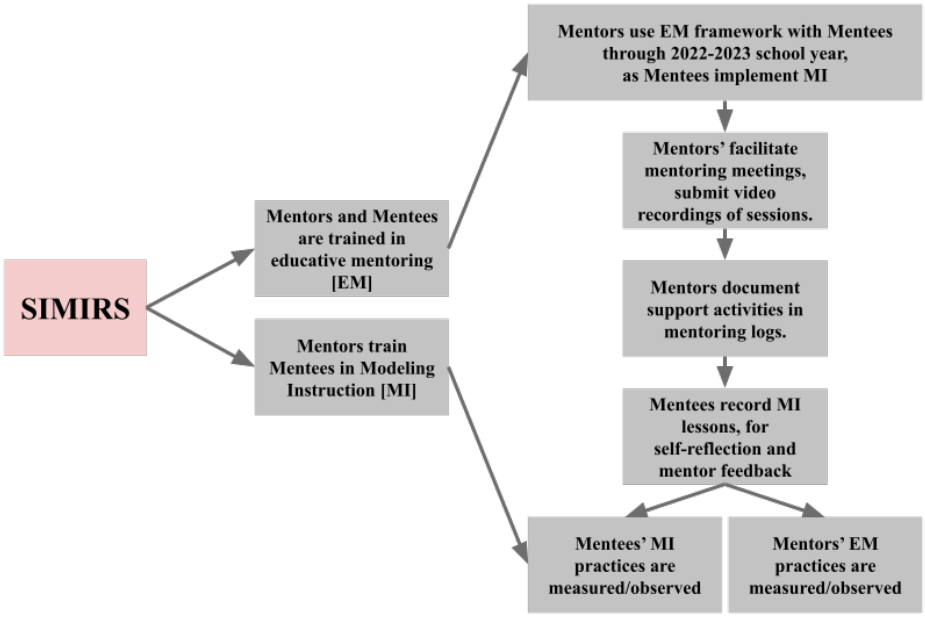
This study was conducted in the context of an NSF DRK-12 grant, Supporting the Implementation of Modeling Instruction in Rural Schools (SIMIRS), led by a project team from the College of Education and The Science House North Carolina State University (NCSU). The project aims to improve science education in rural high schools, specifically biology and chemistry. This improvement centers around enhancing the pedagogical content knowledge (PCK) (Shulman, 1986, 1987) of science teachers required for the implementation of MI aligned with Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) through substantial professional development that includes extended academic year support and mentoring. SIMIRS provides participating science teachers with 114 hours of professional development during the MI Summer Institute and quarterly follow-up sessions. This training equips them with the necessary knowledge and skills to effectively introduce MI in their classrooms. To offer ongoing support and address the professional isolation often experienced in rural areas, SIMIRS incorporates a virtual mentoring model. By tracking the PCK development of the participating teachers over several years, the project aims to identify key factors that contribute to effective teaching, including virtual mentoring (Ragan & Park, 2020).

Recruitment efforts for the SIMIRS in-service teacher participants were specifically targeted to biology and chemistry teachers in the rural western regions of North Carolina with the guidance of The Science House Mountain Satellite Office and STEM West. The grant ran for four years, with three cohorts of participants in the Summer Institutes. This study exclusively includes the first cohort of eight biology and eight chemistry teachers. To ensure that each of the sixteen participants had access to an experienced MI teacher to serve as their mentor, they were

split among nine mentors. These mentors were science classroom teachers with experience teaching MI, five with experience teaching MI biology and four with experience teaching MI chemistry. All nine mentors were provided professional development in the five EM components before the Summer Institute to ensure they were prepared before meeting their mentees. During the final week of Summer Institute, each mentor was matched with one to two mentees who taught the same subject, with careful attention to the unique teaching needs of each participant. This structure allowed the mentors and mentees to have a shared curriculum and understanding of the disciplinary content language. This reduction in the cognitive load allowed the learning communities to access new information about MI more quickly (Larson et al., 2018; Sweller, 2020). SIMIRS primarily focuses on developing the teachers being trained in MI, with the mentors playing an integral role in supporting that effort (see Figure 3.1).

Figure 3.1

Multi-phase Progression of Educative Mentoring and MI during the SIMIRS project



In the progression of the project, the mentors facilitated digital CoPs with their mentees that would allow them to construct their knowledge of MI in a community of other science teachers (Wenger, 1998) that would collaboratively identify problems of practice, discuss student learning, and use reflective practices to improve their application of MI to their individualized science classrooms. These meetings were planned and executed at the discretion of the mentor, leaving them the choice to include all mentees or plan sessions with individual mentees. The nine initial mentors were expected to provide bi-weekly mentoring sessions to their mentees, maintain a log of all mentoring-related activities, view and contribute constructive feedback to each mentee, and participate in interviews through one academic year. While the mentors were expected to incorporate EM in their mentoring sessions with their CoPs, they were encouraged to interpret the components and practices and decide on their implementation of those practices.

Educative Mentoring Professional Development

The mentors were trained in EM, a collaborative mentorship model that is theoretically similar to reform-oriented teaching practices in science teaching. The training and preparation for implementing EM were conducted in three phases to ensure that the professional development occurred for appropriate duration and included opportunities for collaboration and active learning (Darling-Hammond et al., 2009, 2017; Desimone, 2009; Kennedy, 2016). Each phase had a different focus and audience, but the common goal was to develop the construction of knowledge about EM necessary to implement this collaborative mentoring model. The planned EM professional development phases included: (1) a mentor-specific session, (2) a mentee-specific session, and (3) mini-sessions at a workshop for mentors and mentees to work together in-person with their new CoPs. Because professional development in adopting new methods should be built on the understanding that teachers are learners (Näykki et al., 2021) and

should be led in ways that will encourage the construction of new understanding, all of the phases were designed using research-based and reformed practices, such as leading with inquiry methods, utilizing collaboration, and facilitating reflection (Aspfors & Fransson, 2015). It is important to note that while the mentees also received some EM training on the components and purposes of EM to function collaboratively throughout mentoring experiences, this study focused on the experiences of the mentors.

Phase 1- Introducing Mentors to the Components of EM

The first phase of EM training was designed to develop mentors' understanding of EM through model development, mirroring the methods MI teachers use to facilitate science learning. During a 90-minute session, SIMIRS EM trainers guided mentors in transitioning from traditional mentoring models to EM. The session began with mentors reflecting on their personal mentoring beliefs and illustrating their perspectives using metaphors developed during interviews. Afterward, the research team presented EM definitions (Bradbury, 2010) and the EM Framework (Figure 2.1), prompting an open discussion comparing traditional mentoring and EM, particularly concerning power dynamics and MI teaching practices. Mentors then engaged in active learning by scripting and role-playing authentic mentoring scenarios incorporating EM principles. Observers, including other mentors and trainers, analyzed these scenarios for evidence of EM practices, leading to a group discussion on their function and impact. Finally, mentors revised their metaphor illustrations to integrate the new EM framework, marking the initial step in aligning their prior experiences with EM principles.

Phase 2- Familiarizing Mentees with the EM Components

The second phase of the training did not involve the mentors; the mentees were introduced to the components of EM. This professional development phase allowed the mentees

to become aware of the components, the emphasis on collaboration, and the facilitative role their mentors would play throughout the academic year.

Phase 3- Relationship Building with Mentors and Mentees

To deploy their new mentoring models, the mentors extended their initial training session through their engagement with mentees during the Summer Institute, where they could begin experimenting with their constructed understanding of EM implementation in a scaffolded environment. Embedded in the three-week Summer Institute training for the teacher-participants to learn MI, mentors and mentees had two hours of mini-session workshop sessions dedicated to reviewing EM with each other. Each mini-session included activity-based learning focused on a component of EM to provide practice in using the strategies and to collaboratively determine how the components of EM will be employed in their contexts. As part of these mini-sessions, the mentors and mentees engaged in relationship-building activities and facilitated an initial discussion to construct the goals and intentions of their continuing work together using EM.

Research Design

This dissertation study employed a qualitative multiple-case study design to examine the EM practices of biology and chemistry teachers who would be mentoring new MI teachers. Case studies are a systematic yet flexible research approach that follows a linear but iterative process, involving stages such as planning, designing, preparing, collecting, analyzing, and sharing data, with continuous refinement of previous decisions (Yin, 2018). This methodology allows for variation in the number of cases and the analytical context to align with research questions, goals, and the broader purpose of the study (Creswell & Poth; Yin, 2018). Multiple-case study research examines more than one case in depth to explore complex phenomena within real-life contexts, aiming to answer *how* and *why* questions where researcher control is limited and the

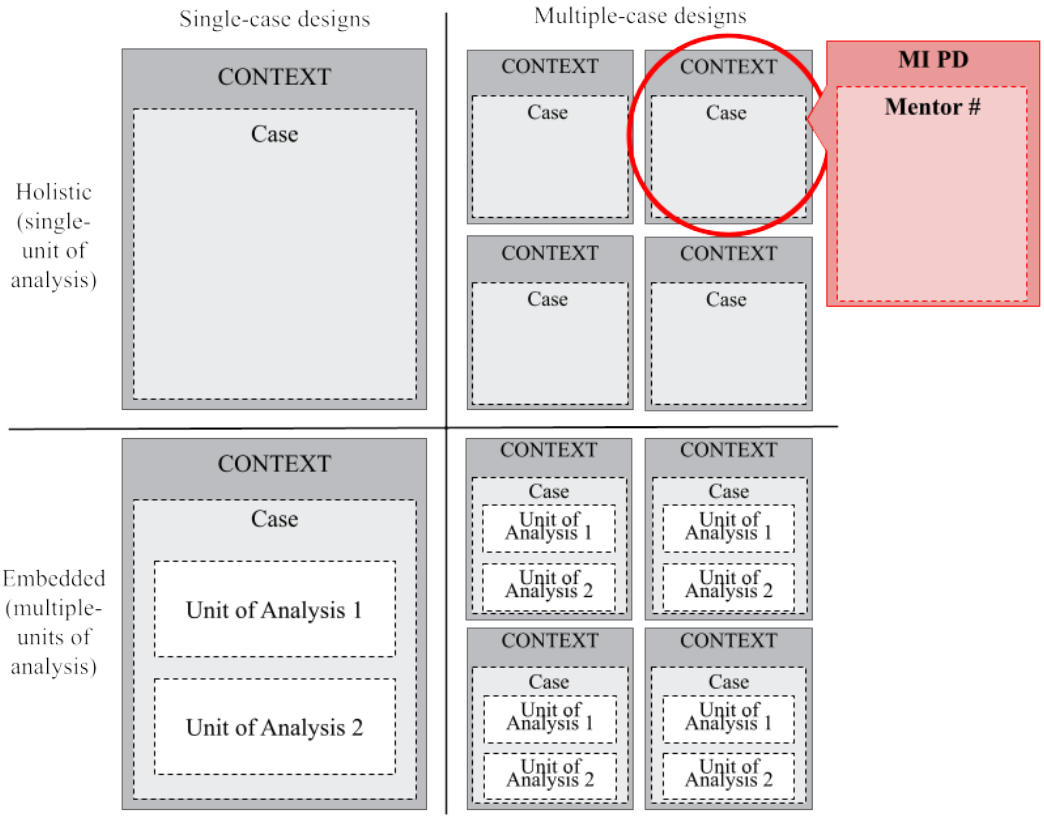
boundaries between the phenomenon and its context are unclear (Yin, 2018). This approach is valuable for studying dynamic social processes, individual behaviors, interactions, and routines, providing rich insights into real-world complexities (Lavarda & Bellucci, 2022).

A case is defined as a tangible person, team, intervention, or event within the boundaries of a specific real-world context (Yin, 2018). In this study, the case is defined as an individual mentor and their mentoring interactions with two mentees within a CoP because the study aims to explore the mentors' decision-making processes, mentoring strategies, and reflections on their practices by analyzing data from interviews, observations, and documents to find patterns and themes in the experiences of participants (Creswell & Poth, 2018; Stake, 1995). While a single case study can focus on extreme cases, multiple-case studies focus on two or more cases believed to be replications that can be assessed as examples of what may be generally expected (Yin, 2018). Multiple cases were included in this study to offer both within-case and cross-case analysis (Given, 2008).

As shown in Figure 3.2, there are different methods to design a case-study based on the number of cases and the approach to analysis (Yin, 2018). This study employs a *holistic* multiple-case study design, where each mentor represents a distinct case to be compared and contrasted to identify patterns and draw broader conclusions from multiple instances of the phenomenon (Yin, 2018). A holistic multiple-case study provides a comprehensive and comparative analysis of multiple mentors, offering valuable insights into their practices and decision-making processes while implementing EM. This method enhances the depth and breadth of the study, contributing to a more nuanced understanding of the mentoring approach's impact and effectiveness.

Figure 3.2

Comparing Case Study Designs (Yin, 2018)



This study examines multiple distinct mentoring cases, allowing for a rich, comparative analysis of how different mentors implement EM within their CoPs, how their practices align or diverge across cases, and common themes in the decisions that influence the mentoring practices (Yin, 2018; Stake, 2006). This analysis creates a complex picture of mentorship that is more compelling and robust than if a single case were chosen as the focus (Miles et al., 2014).

Case Mentor Selection

The participants for this study were selected from mentors who were already committed to the SIMIRS project. The initial project included 10 mentors who teach in high school settings, four White females and one Black female who primarily teach biology, one White female and four White males who primarily teach chemistry. The participants have an average of seven

years of experience mentoring pre-service teachers, beginning teachers, and new MI teachers. They had all undergone MI professional development and were actively implementing it in their science classrooms. Some mentors also served as instructors for MI Summer Institute professional development programs. One mentor withdrew early from the project due to changes in his teaching responsibilities.

Among the nine mentors, two biology and one chemistry mentors were selected who met the selection criteria: (1) having more than five years of implementing MI, (2) active commitment to mentoring requirements such as biweekly mentoring sessions and feedback on mentees' MI instruction videos, and (3) agreeing to participate in the study. Table 3.1 shares each case mentor's teaching, education, and MI experience.

Table 3.1

Case Study Participants' Demographic Data

Mentor	Gender	Race[a]	Education/Degree	Teaching Licensure	MI Subject (yr trained)	Teach Exp. [as of 2022]	Mentor Exp. [as of 2022]
Samantha	F	B	BA Biology- Comprehensive Science High School Add-on	Subject with Ed Add-on	Biology (2009)	12-15 years	0-5 years
Fiona	F	W	BS Science Education, Secondary Biology	Traditional	Biology (2012)	12-15 years	6-10 years
Xavier	M	W	PhD Soil Science, MS Forestry, BS Forestry	Lateral Entry	Chemistry (2008)	12-15 years	0-5 years

Note. [a]Racial categories from U.S. Census Bureau standards (Office of Management and Budget [OMB], 1997). Abbreviations W=White (non-Hispanic), B=Black (non-Hispanic).

The participants in this study include Samantha, an AP Biology teacher and Summer Institute instructor who mentors teachers implementing MI in biology; Fiona, a former biology teacher and current guidance counselor, supports one teacher integrating MI in biology and another adapting Earth science and chemistry after their teaching assignments change; and Xavier, a

former chemistry teacher and Summer Institute instructor, mentors two chemistry teachers adapting MI.

Research Design Alignment

To ensure that each research question (RQ) guiding this study was explored and answered, explicit planning connected each RQ with the data items that would be collected and the appropriate analysis that would best answer the RQ. Table 3.2 represents a research design matrix as a blueprint for this study, demonstrating how the RQs guide data collection and analysis (Choguill, 2005; Yin, 2018).

Table 3.2

Research Question and Design Matrix

RQ	Data Collection	Data Analysis
How did mentors implement EM components and practices over two semesters after participating in EM training?	➔ Video-recorded Mentoring Sessions ➔ Mentor Feedback on Participant Recorded Lessons ➔ Mentoring Logs	➔ **Descriptive Case Study** ➔ Educative Mentoring Observation Rubric (EMOR) ➔ **Deductive** analysis ➔ **Inductive** analysis ➔ **Cross-study Synthesis**
Which components and practices of EM did mentors consistently implement, and where did they face difficulties?	➔ Video-recorded Mentoring Sessions ➔ Mentor Feedback on Participant Recorded Lessons ➔ Mentoring Logs	➔ **Descriptive Case Study** ➔ Educative Mentoring Observation Rubric (EMOR) **Deductive** analysis ➔ **Cross-study Synthesis**
What are the key characteristics of mentors' decision-making processes when engaging in mentoring practices?	➔ Video-recorded Mentoring Sessions (clips for VSI) ➔ Mentoring Interviews (IP I-IV) ➔ Video-Stimulated Interviews (VSI)	➔ **Inductive** analysis ➔ **Cross-study Synthesis**

The study is guided by the following RQs: (1) How did mentors implement EM components and practices over two semesters after participating in EM training?; (2) How did mentors implement EM components and practices over two semesters after participating in EM training?; and (3)

What are the key characteristics of mentors' decision-making processes when implementing EM practices?

Since this study explored how mentors construct their understanding of EM through interactions within their CoPs, a social constructivist approach guides data collection and analysis. Social constructivism emphasizes that knowledge is developed through social interactions (Lave & Wenger, 1991; Vygotsky, 1978; Wertsch, 1991), making it essential to examine mentoring sessions and reflective interviews as sites where mentors negotiate and refine their EM practices. By analyzing recorded mentoring sessions, this study captures how mentors implement EM in real-world social contexts (RQ1) and identifies consistent practices and challenges they encounter (RQ2). Reflective interviews further reveal the decision-making processes behind their mentoring choices (RQ3). Using constant comparative analysis, this study examines patterns across all interactions over time, ensuring that findings emerge directly from mentors' social experiences rather than being interpreted in isolation.

Data Collection

Each mentor case was supported by a portfolio of data collected across the academic year of the study to construct descriptions of each case (Creswell & Poth, 2018), as described in Table 3.3. All three cases included video- and audio-recorded mentoring sessions, reflective (IP I-IVb) and video-stimulated interviews (VSI), mentoring activity logs, and feedback on the MI instruction videos mentees recorded for review by the CoP. Multiple data sources were used for triangulation to establish the credibility of the study. Triangulation uses evidence from two or more sources that converge on the same finding (Creswell, 2013; Creswell & Poth, 2018). For example, the activities included in the documentation of mentoring activities corroborate the purpose and duration of the recorded sessions being used for observation. Similarly, the recorded

mentoring sessions included discussions about the mentor's feedback on the mentees' lessons, validating that the feedback was provided.

Table 3.3

Case Study Participants' Data Collected

Mentor	#Virtual Sessions	#In-Person Sessions	Activity Log (# entries)	#Videos Feedback	IP (#/5)	VSI[a] (hh:mm)
Samantha	13	2	39	8/8	5	01:48hr
Fiona	13	2	33	3/4	5	01:28hr
Xavier	13	2	22	8/8	5	01:47hr

Note. [a]The VSI was conducted after the 2022-2023 school year concluded, hh:mm format indicates duration of interview, time recorded by Otter.ti in transcription.

Timeline of Research Activities and Data Collection

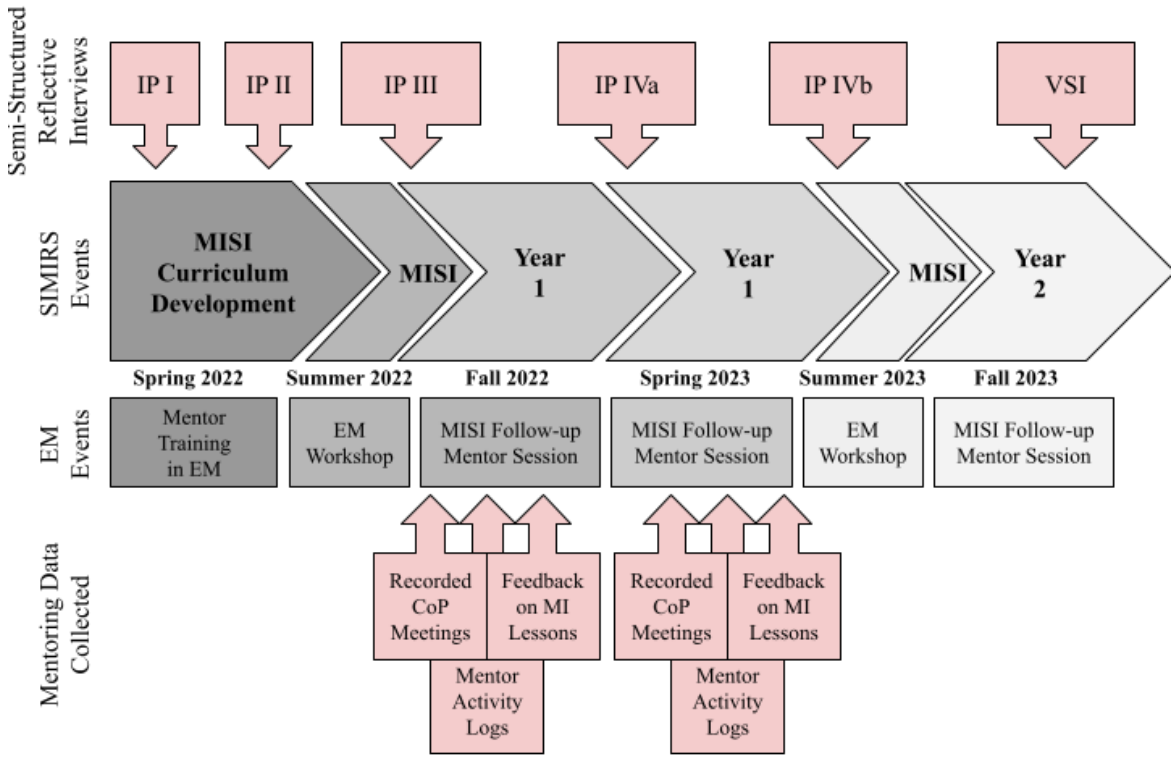
This study employs a longitudinal case study design to examine how mentors implement EM over one academic year (two semesters). Longitudinal research enables the repeated collection of data from the same participants (Creswell & Creswell, 2018; Van Ness et al., 2011), allowing for the observation of changes in behaviors, attitudes, and practices over time (Menard, 2002). By analyzing mentoring sessions and conducting reflective interviews before, during, and after implementation, this study captures the mentors' knowledge, decision-making, and mentoring strategies within their CoPs over time (Saldaña, 2013). This approach provides rich, contextualized insights into how mentors refine EM practices, navigate challenges, and respond to professional development, offering a nuanced understanding of mentoring dynamics with implications for future EM training and professional development (White & Azri, 2005).

The data collection followed the timeline in Figure 3.3, with items collected multiple times during the research period. A collection of reflective interview data about the mentors' experiences and perceptions of mentoring (IP I-IVb) began ahead of the first training sessions (IP

I), and continued through the first academic year of mentoring the first cohort of MI teacher-participants, the 2022-2023 school year. An interview was conducted after the EM training (IP II) and after the mentors met and trained with their mentees (IP III).

Figure 3.3

Research Activity and Data Collection Timeline for Each Mentor



Two additional reflective interviews were conducted at the culmination of each semester, IP IVa following the fall semester and IP IVb following the spring semester. During the academic year, recorded mentoring meetings, mentoring logs, and recordings of the mentee's classroom teaching were collected. At the start of the year following their experience mentoring, video-stimulated interviews (VSI) exploring the video-recorded mentoring sessions were conducted in the semester following the implementation year to increase the recall from the mentors regarding their mentoring decisions and influences.

Video-Recorded Mentoring Sessions

The mentors were expected to facilitate a minimum of eight mentoring sessions per semester, through an entire academic school year, as long as that was sustainable for the participants. Due to technical difficulties with recording, each mentor submitted 15 recorded mentoring sessions, consisting of 13 video-recorded virtual sessions and two audio-recorded sessions conducted as part of an in-person follow-up professional development for SIMIRS Summer Institute participant teachers. The sessions were recorded using the mentors' choice of video conferencing or screen casting program and were then submitted to the SIMIRS project team. Each video was de-identified and tagged with coded identifiers before being run through Otter.ai, an artificial intelligence (AI) application that converted the video files submitted by the mentors into a text transcript. The transcripts were cleaned up for accuracy by a research assistant unfamiliar with individual participants, which ensured there were no implicit biases or other errors in transcription (Groves et al., 2009). The transcripts were held in secure cloud storage for the research team to access before being analyzed.

Semi-Structured Reflective Interviews (IP I-IVb)

Each mentor participated in five semi-structured reflective interviews, strategically spaced to capture their initial beliefs, experiences following EM training, and reflections after each semester of mentoring. Each interview followed a semi-structured interview protocol (Appendix A), providing a set of guiding questions while allowing flexibility for clarifications and follow-up questions as needed (Yin, 2008). This approach helps maintain a natural flow of conversation while ensuring key topics are covered using a funneled approach, beginning with broad background questions before progressing to more specific inquiries about mentoring practices and experiences (Creswell, 2013; Creswell & Poth, 2018). The final section of each

interview provided an open-ended opportunity for mentors to share additional thoughts on mentoring or MI. Additionally, the protocols were organized by categories to increase the comprehension of the questions and reduce the estimation and recall response errors when asking interview questions (Groves et al., 2009).

To ensure clarity and effectiveness, the interview protocols underwent pilot testing with cognitive interview techniques (Groves et al., 2009). Participants were asked to reflect on the meaning and difficulty of each question, allowing refinement to improve alignment with study objectives. Adjustments included clarifying wording and adding follow-up questions to extend responses more naturally. Table 3.4 breaks down the purpose and structure for each interview. The Pre-EM Training Interview (IP I) was conducted before mentors received EM professional development to establish baseline data on their mentoring experiences, beliefs, and perceptions of science education mentoring. The Post-EM Training Interview (IP II) followed the EM professional development for mentors to reflect on EM training content, MI connections, and anticipated mentoring approaches changes. The Post-Summer Institute Interview (IP III) was scheduled after initial face-to-face meetings with their CoPs during Summer Institute, where mentors discussed early mentoring experiences and their planned EM strategies for the upcoming virtual mentoring sessions. The Post-Semester 1 Interview (IP IVa) was conducted at the end of the first semester. This interview focused on mentors' reflections on their experiences, challenges, and successes in implementing EM during the fall semester. The Post-Semester 2 Interview (IP IVb) was the final interview. It built on the previous reflection, incorporating additional questions on mentors' evolving perceptions of EM throughout the school year. The data collected from these questions helped to determine the possible EM components that

already existed within the MI curriculum and provided some insight into what that understanding looked like at different points in their first year of applying EM components in their CoPs.

Table 3.4

Semi-Structured Reflective Interview Protocol (IP I-IVb) Descriptions

Protocol	Time	Purpose	Structure	Qs
Protocol I (IP I)	Pre EM Training	The primary focus of this protocol is gaining initial demographic information and exploring the perceptions and beliefs that the mentors hold about what mentoring in science education has been and what it should be.	Four categories: ● Mentor Background Information ● Mentoring Beliefs/Conceptions ○ Beliefs about Mentoring ○ Beliefs about Mentors ○ Beliefs about Mentees. ● Perceptions of Mentoring Practices ● Perceptions of Supporting Modeling Instruction	23
Protocol II (IP II)	Post EM Training	Reflected on the content covered in the EM training and shared connections with their MI teaching practices and comparisons to previous mentorship practices.	Three categories: ● Post Educative Mentoring Professional Development/Training Reflection ● Changes in Mentoring Perceptions and Practices ● Goals and Changes	11
Protocol III (IP III)	Post the Summer Institute Workshop	Reflect on mentoring experience during initial face-to-face meetings with their CoP, including sharing their plans for implementing EM during their subsequent Zoom mentoring sessions.	Two categories: ● Intended Goals & Planned Mentoring Strategies ● Modeling Instruction	9
Protocol IVa (IP IVa)	Post Semester 1	Reflect on the past semester of mentoring, sharing experiences, and identifying the use of EM and goal-setting areas to improve implementation.	Three categories: ● General Reflection of Mentoring Experience ● Utilizing Educative Mentoring ● Supporting Mentee MI Implementation	8
Protocol IVb (IP IVb)	Post Semester 2	This version of the protocol begins with the same question and purpose as the previous protocol, however, additional questions were added about changes in their perceptions of mentoring following the entire academic school year.	Four categories: ● General Reflection of Mentoring Experience ● Utilizing Educative Mentoring ● Supporting Mentee MI Implementation ● Mentoring Beliefs and Perceptions (for comparison with IP I)	12

Note. See Appendix A for complete interview protocols.

All interviews were conducted via Zoom, which enabled recording, transcription, and de-identification for analysis. This plan ensured accuracy and provided a verifiable data source for cross-referencing with field notes (Yin, 2008). Interviews lasted approximately one hour, with additional time allocated for clarifying and probing questions as needed. The recorded interviews were de-identified and transcribed before analysis, using a process similar to the video-recorded mentoring sessions.

Video-Stimulated Interviews (VSI)

Each mentor participated in a video-stimulated interview (VSI) after an initial analysis of their recorded mentoring sessions. Video clips highlighting exemplary EM practices or key mentoring decisions were selected and shown to mentors, who were asked to revisit video-recorded mentoring sessions and reflect on their actions and choices during these sessions (Groves et al., 2009). Having mentors revisit video recordings of their past interactions allowed them to articulate their knowledge, reveal implicit aspects of their mentoring practices, and provide insight into how they developed their understanding of EM (Calderhead, 1981).

Table 3.5 outlines goals of the interview protocol for the VSI and samples of questions that could be used, as needed, to gain further insights into mentors' decisions during their mentoring sessions. The VSI followed a semi-structured interview protocol (Yin, 2018) consisting of 11 scripted questions applicable to any video presented (See Appendix B), along with a bank of optional probing questions for deeper exploration (Henry & Fetters, 2012). This approach allowed for a more detailed examination of the factors influencing mentors' decision-making, including their thoughts, beliefs, and emotions during the session, impressions of others participating in the session, and/or impressions of self (Henry & Fetters, 2012). Before viewing each video clip, the mentor was provided with background information, including the session date and participating mentees. First, they were asked to recall any context about the session before we watched the video together via Zoom screen sharing. The video was paused throughout the viewing to ask context-specific questions from the interview protocol, either at pre-determined clips or when mentors wished to stop the video or share insights. Any spontaneous remarks were further probed for additional context. Questions were intentionally phrased to maintain neutrality, avoiding assumptions or leading responses (Groves et al., 2009).

Table 3.5

Video Elicitation Interview Questions (adapted from Henry & Fetters, 2012)

Question Goal	Sample Question
Thoughts, beliefs, and emotions	What were you doing/trying to do in the session? What were you noticing/hearing at this point? Were there any other thoughts going through your mind? What did you feel at this point? Can you recall more details about your feelings? What makes this moment stand out to you? How did you want the other person to perceive you? Why did you make that statement/ask that question?
Impressions of others	What did you think the [mentee] was thinking about you at this moment? What were your impressions of the [mentee's] actions at this point? Why do you think the [mentee] made that statement at this moment?
Impressions of self	What do you notice about your actions at this point? What about your behavior at this point surprises you?
Decision-making processes	What let you know that this was the right decision to make at this point? What information did you use in making this decision? What other courses of action were you considering or were available to you? What made you decide this was the right decision at this point in time? How much time pressure did you feel in making this decision? If the [mentee] had said X, instead of Y, how would that have influenced your decision and/or assessment of the situation?

These prompts encouraged mentors to recall session events, explain their reasoning behind specific actions, and reflect on their decisions in the moment. Open-ended wording allowed flexibility and responsiveness, adapting to the mentor's answers. To prevent redundancy, prompts were alternated, and if a mentor's response preemptively addressed a later question, that question was skipped.

Mentoring Activity Logs

The mentors were expected to formally meet with the mentees every two weeks and engage with them informally as needed. In order to keep track of all their mentoring activities,

the mentors self-tracked their mentoring activities in a research-provided digital mentoring activity log (see Appendix C). In these logs, mentors documented each instance of communicating with their mentees, including a summary of the discussion, mode of communication, and attendance. The document specifically explained the expectations for completion of the document, but allowed for the individualized use and organization that was most appropriate for individual cases. This data helped develop a more complete picture of mentorship in each case, allowing researchers to connect all the data and create a holistic picture of mentorship. The mentoring activity logs were considered confidential, as the mentors may have documented specific situations for their mentees; therefore, they were hosted on a protected cloud storage account that restricted access to the research team and mentors.

Feedback Comments on Teacher-Recorded Lessons

Due to the geographical distance between mentors and mentees, opportunities for the mentors to observe the mentees practicing their MI skills were not allowable. To address this, teacher participants recorded their MI lessons and uploaded them to GoReact, a platform that allows video sharing with detailed time-stamped feedback (Ardley & Hallare, 2020; Ardley & Repaskey, 2019). Mentors used this feedback function to ask questions, offer suggestions, and encourage co-reflection and inquiry, offering mentors opportunities for professional learning through practice-based discussions (Stanulis et al., 2019), similar to their verbal feedback in mentoring sessions. Feedback supported the data collected in the mentoring log and the observations in the mentoring sessions. While the initial plan was to analyze written feedback alongside mentoring discussions, it was found that the feedback from the recorded lessons was also reviewed during dedicated mentoring sessions. To avoid redundancy and prevent misleading conclusions from repeated data (Saldaña, 2016), the purpose of the written feedback data was

reconsidered to validate experiences discussed in mentoring sessions and provide additional context for co-reflective conversations (Creswell, 2013; Creswell & Poth, 2018).

Data Analysis

Descriptive Case Study

All collected evidence was analyzed and bound to individual cases (Stake, 2005). This collection included multiple sources relevant to the research questions, incorporating rival explanations and interpretations. Data interpretation focused on synthesizing findings to address key research questions, guided by established literature and expert experience (Yin, 2018). A descriptive case study approach provided in-depth, context-rich insights into how mentors facilitated CoPs, revealing unique patterns and mentoring practices that may not emerge in broader quantitative analyses (Stake, 1995).

Mentor responses from semi-structured reflective interviews (IP I-IVb) provided findings regarding the underlying experience and beliefs that define the mentors as practitioners and the type of CoP they have developed with their mentees. A complete case profile was developed with the findings from the individual deductive and inductive analyses from each recorded mentoring session. If additional context or clarification of information from the dialogue in the transcript was needed, the video recordings for each mentoring session were available to watch. The mentoring activity log provided context and notes from the mentor about the individual sessions. If the case required more data to find patterns of how the mentors interacted with their mentees, the feedback provided by mentors to their mentees on their video-recorded lessons was also available for further review.

Deductive Analysis: Educative Mentoring Observation Rubric (EMOR)

Examining the implementation of EM practices required analyzing the cases for the inclusion and application of practices specific to EM for each case. The Educative Mentoring Observation Rubric (EMOR) was used as a deductive coding framework. This evaluative tool was designed by SIMIRS researchers, to link observational data to five components of the EM Framework (Figure 2.1): Situated Inquiry, Collaborative Learning, Bifocal Vision, Reflective Discourse, and Student Thinking. Rather than assessing EMOR as a training tool, this study utilized it to identify key EM within the EM Framework (Rogers, 2000; Yin, 2009). The rubric's defined indicators facilitated a structured comparison of mentoring practices across cases (see Appendix D). This study focused on utilizing the specific indicators for each component and key feature of EM on the EMOR to understand how to identify EM practices in mentoring relationships, rather than as an assessment or training rubric.

Inductive Analysis: Constant Comparative Method

To support descriptive case analyses, inductive coding followed the constant comparative method (Glaser, 1992; Glaser & Strauss, 1967, 1999; White & Cooper, 2022), allowing codes and themes to develop from the data. Memos were recorded throughout the process to track emerging connections and ensure analysis consistency. Multiple reviews of video-recorded sessions and related data sources enabled targeted analysis, capturing contextual summaries, mentor-mentee interactions, and emerging themes (Saldaña, 2016). As additional support for findings, analytic memoing included contextual summaries, observations on interactions and relationships among CoP members, and identifying emerging themes relevant to the research questions (Saldaña, 2016).

The coding process occurred in two stages (Saldaña, 2013). The first cycle involved open coding of raw transcripts from mentoring sessions and interviews. This process involved open coding of the recorded mentoring session and the IP transcripts data. Through an inductive method, codes emerged through descriptive and in vivo coding. Some codes were summarized statements that could be applied more generally, while other codes were created from the specific language used by the mentor to demonstrate their thinking and beliefs (Creswell, 2013). Codes were continuously refined until saturation was reached, confirming the presence of EM practices across cases (Glaser & Strauss, 1967, 1999; White & Cooper, 2022).

The second cycle of the coding process integrated properties of the initial code results from the first cycle and organized them into themes or categories that could answer the specific research questions (Yin, 2018). This stage involved comparing and grouping many codes by common properties, allowing the emergence of conceptual themes that provided more profound insight into mentoring practices (Glaser & Strauss, 1967, 1999; White & Cooper, 2022).

Cross-case Analysis

Following individual case analysis, a cross-case comparison identified patterns in EM implementation. The themes presented from each mentor case were compared, revealing broader EM implementation patterns that emerged across the different cases that could support teachers in this type of mentoring. Cross-case analysis enhances the development of theoretical frameworks and contributes to future research (Creswell & Poth, 2018; Stake, 1995). The primary objective was to identify conceptual similarities in the experiences of all three mentors and to discover patterns in the mentorship, patterns in EM practice implementation, and decision-making processes related to EM (Creswell, 2013).

Answering RQ1

RQ1 asks how mentors implement EM principles and practices over two semesters after participating in EM training. To address this question, mentoring session transcripts were analyzed using a combination of deductive and inductive approaches. The EMOR was applied as a deductive coding framework to identify specific EM components within the recorded mentoring sessions. This structured analysis provided a systematic way to determine how mentors incorporated EM practices in their interactions. An inductive approach using the constant comparative method was applied to the same mentoring session transcripts and related artifacts to contextualize these findings further. This process allowed emerging themes and patterns in mentoring practices to be identified beyond the predefined EMOR categories. Analytic memoing documented interactions, relationships, and evolving mentoring strategies, ensuring a comprehensive understanding of how EM was enacted (Creswell & Creswell, 2018). By integrating results from EMOR deductive analysis with inductive, RQ1 is answered by revealing both the explicit application of EM principles and the nuanced ways mentors adapted and implemented these practices over time. This dual-layered approach provides a detailed picture of how EM principles were operationalized in real mentoring contexts, highlighting variations in mentor engagement and effectiveness across cases.

Answering RQ2

RQ2 asks which components and practices of EM mentors consistently implemented and where they faced difficulties. To address this question, mentoring session transcripts were deductively coded using the EMOR to identify the presence and frequency of EM components in practice. This deductive analysis highlighted patterns in which EM components mentors consistently applied and which aspects presented challenges. This process allowed for the

identification of recurring themes in mentoring practices, highlighting areas where mentors demonstrated confidence and consistency and challenges they encountered in implementing specific EM principles. It answers RQ2 by revealing trends in EM implementation and identifying common strengths and difficulties mentors experienced in applying EM practices. Examining mentoring behaviors and feedback patterns will provide insight into the areas where mentors may require additional training or support. This will contribute to a deeper understanding of the practical challenges of implementing EM and inform future mentor development efforts.

Answering RQ3

RQ3 asks about the key characteristics of mentors' decision-making processes when implementing EM practices. The VSI transcripts were analyzed inductively using the constant comparative method to explore how mentors made decisions regarding EM implementation. These interviews allowed mentors to reflect on their mentoring approaches, providing insights into their reasoning behind when and how they applied EM practices, or why they chose not to in certain instances. By systematically coding and comparing responses, themes emerged regarding the cognitive processes guiding their mentoring decisions. A cross-case analysis was conducted to refine these insights and identify mentor response patterns. This comparison across cases revealed key characteristics of mentors' decision-making processes, key influences on mentoring choices, and variations in how mentors operationalize EM in their CoPs. This answers RQ3 by highlighting common beliefs and decision-making patterns that shape mentors' understanding and application of EM practices. The findings will inform key considerations for selecting and preparing mentors, ensuring they have the necessary support and training to effectively implement EM in diverse mentoring contexts.

Positionality Statement

It is important to recognize that the research is not free from the biases and subjective interpretation of the observer (Mertens, 2020; Roberts et al., 2020). I am a white, cis-gendered female with both undergraduate and graduate degrees in education. I recognize that while I was a classroom teacher for over ten years, many of which were spent teaching science in the rural western region of North Carolina, I have never been a biology or chemistry teacher at the secondary level. I have experience with constructivist teaching models, including inquiry-based learning, but I have never used MI nor been formally trained to do so. I acknowledge that my positionality limits my understanding of the background concepts and language used in this research project and may affect how data is analyzed and interpreted. Developing relationships assisted me in becoming more aware of the experiences of biology and chemistry teachers, the methodology and curriculum of MI, and the epistemological beliefs of the participants and the Summer Institute instructors. It is imperative to contextualize professional development effectively to meet the specific needs of the mentors (Aspfors & Fransson, 2015; Bradbury, 2010; Feiman-Nemser, 2001). I have not benefited economically from this study, so there are no known conflicts of interest to report (Given, 2008).

Credibility and Trustworthiness

As the cases were explored in real-world environments susceptible to external events that may have disrupted the planned events, decisions were made to address how those events would be considered. This included the timing and scheduling of interviews, the amount of time between meetings, the number of participants in attendance, the mode of the meeting (i.e., phone, Zoom, or email). For these reasons, it was important to develop field procedures to help mitigate being unprepared for unexpected situations. Participants were provided with a schedule of data

collection activities. Additionally, the mentors were asked to track all meetings and communication with their mentees, which allowed researchers to determine if any changes were relevant to the data analysis (Yin, 2018, p. 98). Including multiple data sources, research expectations, and protocols that could be replicated across multiple cases increase the strength of the conclusions. This collection of multiple data sources within the same context supported the credibility of all claims and analyses, including any rival explanations that could be acknowledged and rejected, thus increasing the strength of the results. Because multiple data sources are being used, a database of data was created, and there is a chain of evidence to ensure security and privacy (Yin, 2018, p. 113).

Member checking is a validity process that allows study participants to confirm the credibility of the data and interpretations (Creswell & Miller, 2000) before the final publication or presentation. The various data artifacts and information collected reflect the truth in the descriptions of people and events and reach an acceptable level of validity.

Ethics and Considerations

In constructivist research, the rights of each participant must be considered and protected. This study was approved by the NCSU Institutional Review Board (IRB) [IRB Protocol 24316], an administrative body affiliated with the institution, tasked with safeguarding the welfare, rights, and privacy of human research participants. It reviews and has authority over all research involving human subjects, including approval, exemption, disapproval, monitoring, and requesting modifications, in accordance with federal regulations and institutional policy. In the proposal for approval by the IRB, considerations were made to the respect, privacy, benefits, and justice of participants.

The SIMIRS project carefully considered the benefits and risks for the participants. The research team has confirmed the absence of conflicts of interest among all researchers involved in the project, ensuring research integrity. The study has numerous benefits, including professional development for teachers, networking opportunities among mentors, and enhanced teaching practices that will ultimately benefit approximately 25,000 rural students. It will also inform future teacher preparation retention efforts in underserved regions. Risks concerning privacy, data security, and biases were carefully considered. Privacy risks have been mitigated by using pseudonyms and secure data storage, while transparent study design, peer review, and ethical oversight collectively worked to manage potential biases. Participants retained the right to withdraw without penalty, aside from losing any compensation earned for their contributions, reinforcing the voluntary nature of their involvement.

By intentional design, the project ensured equal opportunity by extending an open invitation to biology and chemistry teachers from all rural North Carolina school districts, aiming to create a representative sample open to all eligible individuals. For mentors, clear inclusion criteria were established, primarily focusing on previous training and curriculum use qualifications. Inclusion criteria did not exclude participants based on demographic characteristics, such as, but not limited to, race or gender. The study excluded vulnerable populations such as minors, prisoners, pregnant women, and those with mental health challenges. All biology and chemistry teachers, including the mentors, provided informed consent without coercion, which ensured their voluntary, informed decisions to participate. The informed consent document outlines explicit compensation provisions and minimal risk descriptions. For participants' privacy protection, all data was de-identified through assigned ID numbers and all

identifying information was redacted and replaced with pseudonyms. All collected data was digitally stored and encrypted with limited access.

Summary

Chapter 3 outlined the methodological design used to examine how mentors implement EM to support in-service science teachers integrating MI. Framed within a social constructivist perspective, this qualitative multiple-case study explored how three mentors and their mentees engaged in collaborative learning, reflective discourse, goal setting, and student-focused decision-making situated in inquiry over an academic year. Data were collected from multiple sources to analyze mentoring practices in depth, including video-recorded mentoring sessions, semi-structured reflective interviews (IP I-IVb), video-stimulated interviews (VSIs), mentoring activity logs, and written feedback on mentees' teaching videos. These sources were triangulated to ensure credibility and capture the nuances of mentoring across cases. Data analysis followed a structured approach that combined deductive and inductive methods. The Educative Mentoring Observation Rubric (EMOR) was used deductively to identify the frequency and consistency of EM components in mentoring sessions. An inductive constant comparative analysis identified emerging patterns in mentoring strategies and challenges, shaped by mentors' individual experiences and interpretations of EM. A cross-case analysis compared mentoring practices across cases, highlighting commonalities and variations in how EM components were enacted within CoPs. By outlining the research context, study design, data collection methods, and analytical approach, this chapter establishes the foundation for analyzing how EM supports professional development for reform-oriented science teaching. The following chapter presents the findings, highlighting key themes and patterns that emerged from the analysis of mentoring practices.

CHAPTER 4- RESULTS AND FINDINGS

"Science is beautiful when it makes simple explanations of phenomena or connections between different observations." -Stephen Hawking

This multiple-case study explored three mentors' experiences and practices in educative mentoring (EM) as they supported teachers implementing Modeling Instruction (MI) in science classrooms across different communities of practice (CoPs). This chapter addresses how the mentors navigated the implementation of EM components, which components and practices they consistently implemented, and where they faced difficulties. Patterns in the mentors' decisions and practices are analyzed to highlight their conceptualization and operationalization of EM, providing insights into their understanding of the theoretical principles of EM. These findings reveal strengths and areas for improvement, offering valuable insights to inform future mentor training programs and strategies for supporting mentors in effectively fostering EM practices.

Case Mentors and Their Educative Mentoring Practices

This section provides an in-depth analysis of the three cases at the core of this study, focusing on how each mentor develops and applies EM practices through social interactions and shared experiences with their two mentees. Each case begins with a detailed description of the structure of their meetings, accompanied by key data such as attendance, meeting duration, topics discussed, and the distribution of speaking time. Emerging themes regarding the methods, consistency, and challenges mentors face in implementing the five components of EM are identified: Situated Inquiry, Collaborative Learning, Bifocal Vision, Reflective Discourse, and Student Thinking. The analysis also explored the mentors' perceptions of mentoring and their relationships with their mentees, highlighting how these beliefs shape their decisions and practices. For confidentiality, all participant names have been replaced with pseudonyms.

Case One- Samantha

At the time of this study, Samantha was a high school biology teacher at a STEM-focused magnet school in the urban district of a medium-sized city in North Carolina, where she had dedicated fourteen years of her career. She has been a high school science teacher for sixteen years, mainly teaching biology, but also taught physics earlier in her tenure. Her course schedule includes standard and Advanced Placement (AP) biology classes. Her school administration supported her in using MI in her teaching throughout her career. Under her leadership as the department chair at her school for twelve years, her entire department transitioned to using MI and has seen significant improvements in student learning and test scores as a result. As a personal goal, Samantha has considered using her strengths in teaching MI Biology to build a portfolio for becoming a National Board Certified Teacher (NBCT). Prior to the start of the Supporting the Implementation of Modeling Instruction in Rural Schools (SIMIRS) project, Samantha had been teaching using MI for fourteen years. She was first trained in physical science MI in 2008 through the NC Science House and later trained in biology. As one of the first teachers trained in MI Biology, in 2009, Samantha was invited to help develop the MI curriculum that the NC Science House would offer biology and chemistry teachers throughout the state to incorporate into their classrooms. Samantha had been an established leader and MI instructor with NC Science House for twelve years, leading biology workshops during the Summer Institute and supporting the participants afterward, which she continued as part of the SIMIRS research project. As an instructor at the Summer Institute, Samantha mentored participants as they returned to their schools and implemented the new pedagogy. She did not receive any official training in specific mentoring methods for this role. However, she had previously completed multi-day intensive training from her alma mater as part of a grant-

supported teacher preparation support program that matched her with mentee teachers from different professions. This training was not explicitly related to MI, but she did support her mentees in learning MI through her example and encouraged them to pursue further training.

Samantha's Perceptions of Mentoring

Samantha's early experiences with mentorship, which included both positive and negative elements, played a pivotal role in shaping her mentoring philosophy. She integrates insights from the strengths and challenges of her mentorship experiences, focusing on the value of relationship-building while consciously avoiding the "one-sided sharing of experience and knowledge" that she found less compelling in her own development. Her perspective is captured in her description of the mentor-mentee relationship as being akin to "siblings [rather than parent and child]," where, "You have to see each other as equals. There is some give and take. Parents are high up, and you don't open up as much!" (IP-I, Spring 2022). This analogy highlights her emphasis on equality and open communication, underscoring the importance of creating a safe, collaborative space for mentees to express themselves honestly. Framing mentorship as a partnership of equals striving toward a shared goal, Samantha values a dynamic that encourages mutual respect and dialogue, reinforcing her belief that relational dynamics influence effective mentorship. Her emphasis on fostering trust and collaboration aligns with principles of mentorship that prioritize the co-construction of knowledge and shared responsibility.

Samantha's Community of Practice

Samantha mentored within a CoP, as described in Table 4.1, that consisted of herself and two other science teacher mentees. This CoP was developed after the mentees participated in the Summer Institute workshops for MI Biology to build their practice as biology high school teachers, including adapting the MI pedagogy for use in honors and AP classrooms. One of the

mentees, Safira, taught biology for over 5 years at a rural high school. She had previously trained in MI, but had returned to more traditional teaching practices during (and post) Covid-19 in her rural public high school. She decided to join SIMIRS to support sharpening her MI skills and returning to more reform-oriented teaching.

Table 4.1

Demographic Information for CoP Members (including Mentor and Mentees)-Samantha

Member	Gender[a]	Race[b]	Degree/ Prep	Teaching Range [as of 2022]	Subject (Grade) [2022-2023]	School Type
Samantha	F	B	BS- Bio MAT- Secondary Science/ Traditional	12-15	Biology (including AP) (HS) [Other experience includes: Physics (HS), Earth/Enviro (HS)]	Academic and Technology Magnet High School- Urban
Safira	F	W	BS- Secondary Ed-Bio/ Traditional NBCT- Bio	4-7	Biology (including AP)	Public High School- Rural
Sora	F	W	MS- Bio/ Lateral Entry	16-19	Biology	Public High School- Rural

Note. [a]Race and Gender as self-identified; Racial categories from U.S. Census Bureau standards (Office of Management and Budget [OMB], 1997). Abbreviations W=White (non-Hispanic), B=Black (non-Hispanic)
[b]School Type population: Urban > 50,000 residents; Suburban connected to urban < 50,000 residents; Rural < 2,500 residents

The other mentee, Sora, had taught for more than 15 years with a different rural public school. She decided to join the Summer Institute and learn how modeling can be used in advanced biology classrooms after Samantha's invitation to meet her at a professional development for AP biology teachers. Both mentees were familiar with teaching biology, including AP courses, which was a connection that Samantha shared. Across all their individual experiences, Samantha and her mentees benefited from that connection, as they each had peer support and understanding when discussing biology, AP, or MI-specific topics and concerns. Planned to occur every two weeks, the CoP met on Saturdays, outside the teaching environment and schedule. This allowed them to meet outside their teaching responsibilities and focus on the mentor sessions. To provide

her mentees with open access to support from the group, informal mentoring was available through group chat, text message, or email on a continuous and indiscriminate basis.

Of their total eighteen meeting sessions described in Table 4.2, fifteen were recorded and submitted for review, including 16 virtual (V) and two in-person (I) sessions from the academic year. Three sessions that did not include a recording, but were included in the mentoring activity logs (indicated with brackets [ ]), could not be verified. The shortest meeting recorded was held for 10 minutes, and the longest lasted 35 minutes, showing a variance in meeting duration that averaged 22 minutes. Sessions with a planned focus on the reflection of the mentees' recorded lessons or beginning of the semester goal-setting were longer than those that followed the short-term needs of the CoP more flexibly. Overall, the CoP met together for approximately 5.5 hours over the fifteen sessions.

Table 4.2

Description of Sessions- Samantha

#	Type[a]	Notable Topics[b]	Science Focus (%)	Mentee Attendance	Duration (min)	Mentor Talk[c] (%)
1	V	[MI Units] [Class Management]	68% Science	Both	22	50%
2	V	MI Lessons	80% Science	Both	22	57%
3	[V]	[MI Lessons] [Class Management]	-	[Both]	[60]	-
4	[V]	[MI] [Goal progress]	-	[Both]	[60]	-
5	I	MI Lessons	86% Science	Both	10	56%
6	V	MI Lessons	55% Science	Both	26	55%
7	V	MI Lessons	72% Science	Both	19	39%
8	[V]	[MI] [General Teaching]	-	[Sora]	[30]	-
9a	V	*Video Review*	95% Science	Sora	35	43%
9b	V	*Video Review*	70% Science	Safira	30	59%
10	V	MI Lessons	75% Science	Sora	23	41%

Table 4.2

Description of Sessions- Samantha

#	Type[a]	Notable Topics[b]	Science Focus (%)	Mentee Attendance	Duration (min)	Mentor Talk[c] (%)
11	I	MI Lessons	55% Science	Both	28	44%
12	V	MI Lessons	80% Science	Both	11	62%
13	V	MI Lessons	65% Science	Both	23	48%
14	V	School Event-Prom	65% General	Both	18	47%
15	V	Scheduling	90% General	Both	10	53%
16a	V	*Video Review*	59% Science	Sora	28	46%
16b	V	*Video Review*	65% Science	Safira	30	67%

Note. Information in brackets ([]) indicate answers provided on the mentoring log that cannot be fact-checked. Dashes (-) indicate information that could not be determined from the source available.
[a]Type of session is defined as virtual (V) or in-person (I).
[b]Primary topics of discussion met the criteria of being the topic discussed for the longest duration or percentage of the entire meeting.
[c]Mentor Talk time percentages were calculated by Otter.ti during the transcription process.

Data analysis revealed several notable features of Samantha's mentoring sessions. One significant finding in Samantha's mentoring sessions was that the flow and content varied based on the expressed concerns of mentees or Samantha on that given day. Rather than institute a predetermined focus or schedule, Samantha wanted the group to determine the flow of their meetings through open-ended check-in questions that she asked at the beginning of most sessions. She followed her open inquiry by shifting the focus to gauge where everyone was in their pacing, which was directly connected to the mentees' goal of teaching every MI unit. The questions would vary, but they were usually open-ended, as well. She would ask questions, such as "Where are y'all at [in MI Units]?" (Session 6) or "Have you finished unit one?" (Session 2) that still allowed the trajectory of the session to be determined by the mentees. She would assess their needs and direction for the remainder of the meeting based on their responses, leading to various topics throughout the academic year. For example, in response to the open-ended

question in Session 6, she learned that Sora and Safira were both just finishing a unit, enabling Samantha to posit questions specific to their experiences, like, “What are your reflections on [the unit]... How do you think your kids [did], especially with lesson four, cell respiration and photosynthesis?” (Session 6). The mentees' experiences guided Samantha’s questions, allowing targeted conversations and reflection. Some sessions casually explored personal experiences, while others focused more on structured planning and reflection on science teaching. For example, in the same session, the CoP discussed prom (Session 14) and spent a small amount of time reviewing the goals for pacing. Aside from the first meeting and two sessions at the end of the year, over 50% of each session was spent discussing MI or other science-specific teaching issues (Table 4.2). For example, the MI curriculum pacing was often the focus, with Samantha and both mentees sharing their experiences or ideas for planning labs targeted to the specific pacing and content needs of each person, rather than generalized school or classroom operations.

Also unique to Samantha’s CoP was the full attendance and participation from all members as a supportive group of peers. The formal sessions were planned to take place approximately every two weeks, but were flexible enough to accommodate the schedules of all CoP members because it was important to Samantha to have as many opportunities as possible for her to meet with both mentees in one session. The recorded sessions were planned to be attended by both mentees, except Sessions 9 and 16, which were separate to focus feedback on the individual goals and observations of each mentee. Samantha reflected:

> We did [the review sessions] separately, intentionally that time. I know they gave each other feedback, but I wanted to hone in on them individually that semester… so that they can genuinely lay it all out… truly hone in on their individual goals, reflective moments for themselves. I didn't want the other person jumping in (VSI, Fall 2023).

This deliberate separation ensured the mentees would be comfortable making and accepting honest observations of their teaching. There were two group meetings in the middle of the school year that Safira could not attend, but Sora was present in all full mentoring sessions. Overall, Samantha had the most meetings attended by both mentees, demonstrating a commitment from the mentees to their own learning. Having CoP meetings with both mentees allowed for as much of a focus on peer-to-peer conversations as those of mentor-mentee, which reduced the dependency on Samantha to lead discussions.

Another important theme in Samantha's mentoring sessions was the balance in the mentor's speaking time compared to the mentees. The share of talk time between Samantha and the mentees showed some slight variance in Table 4.2, with the overall balance showing that Samantha was the primary talker (over 50% of the talk time) in only four sessions. The rest of the time the mentees dominated the conversations as they reflected on their practice, shared experiences, or asked questions. Samantha attributed this more equal distribution of talking to stronger relationships, science-focused conversations, and targeting goals, which was continued by both mentees actively in the group chat, seeking advice and sharing experiences even when she was unavailable (VSI, Fall 2023).

Samantha's Implementation of Educative Mentoring

In the mentoring sessions with her mentees, Samantha showed evidence of using each of the five main components of EM, including Situated Inquiry, Collaborative Learning, Reflective Discourse, Bifocal Vision, and Student Thinking, at least once during her 15 meetings with her CoP. Table 4.3 illustrates that she practiced most components at a similar rate across all the sessions, except for the Student Thinking, which had the fewest examples in practice and was only found in five of the 15 sessions.

Table 4.3

Frequency of Educative Mentoring Practice Indicators- Samantha

EM Component	Fall 2022 Sessions							Spring 2023 Sessions								Total
	1	2	5	6	7	9a	9b	10	11	12	13	14	15	16a	16b	
Situated Inquiry	3	5	2	2	1	2	9	6	6	3	3	0	1	2	4	49
Collaborative Learning	8	2	0	5	3	4	3	3	2	2	1	2	0	3	2	40
Bifocal Vision	4	5	2	1	2	5	5	6	2	1	1	2	1	3	3	43
Reflective Discourse	2	1	1	2	1	11	5	2	2	3	1	1	1	8	9	50
Focus on Student Thinking	0	0	2	3	0	4	4	0	0	0	0	0	0	0	3	16
Total Codes per Session	17	13	7	13	7	26	26	17	12	9	6	5	3	16	21	

Note. Session numbers represent the sessions recorded and submitted for analysis by the mentor. Those with the same number, but a differing letter denoted those sessions planned to be separate but served the same focus/function.
For a detailed breakdown of the frequency of the key feature descriptors for each component, see Appendix E.1

Samantha's mentorship reflected key principles of EM and social learning theory, emphasizing collaboration, context-specific support, and reflection. While her approach varied across sessions, with some practices consistently embedded in her mentoring, others were limited or influenced by the session focus and timing. Four themes emerged from her mentoring: (1) the frequent use of Situated Inquiry, (2) consistent implementation of collaborative practices, (3) limited emphasis on student thinking, and (4) the dependency of EM practices on session topics.

Frequent Reflection through Situated Inquiry.

Samantha incorporated Reflective Discourse (50 times) and Situated Inquiry (49 times), representing a slightly higher rate than the other components of EM. Samantha's approach to mentorship exemplified the facilitation of mentees' reflection through her Situated Inquiry, emphasizing learning as a social process embedded within authentic contexts. By tailoring her questions and discussions to specific challenges faced by her mentees, Samantha created a dynamic learning environment where teaching practices were rooted in real classroom scenarios. For example, she prompted reflection through questions like, "How have the activities been for

cells this time?" (Session 13) and "What do you want me to look for [in your recording]?" (Session 12). These inquiries encouraged mentees to critically assess their teaching methods and adapt MI to their unique classroom contexts. She also routinely encouraged her mentees to assess their experiences with MI. For example, Samantha reviewed the recorded lesson with Sora and prompted her with reflective questions like, "How do you think the students responded?" or "What adjustments might help next time?" (Session 9a). These questions encouraged mentees to think critically about their teaching and make iterative improvements to their approach to teaching science with modeling. In this case, Sora reported that she "was able to complete all units and saw improved student retention and growth compared to previous years" (Session 9a), reflectively connecting back to the goal established at the beginning of the semester and discussing changes or revisions to those goals.

Samantha also modeled reflective thinking by sharing her personal teaching experiences, which helped them build confidence and develop their strategies. During one session, Safira asked, "What is your biggest piece of advice for standard students?" (Session 9b). In this quotation, Safira explicitly asked for advice, and Samantha responded by sharing an idea and talked through her reasoning and reflection as it applied to her own classroom. When Safira expressed that she was excited to try that with her students, Samantha encouraged her to try and invited future discussions about her adaptations, encouraging her to share her experience after she tried it. This response demonstrates how practical experience can guide mentees in making instructional decisions; however, this example also indicates that Samantha occasionally leaned more toward offering solutions than fostering deeper collaborative problem-solving. To enhance the social learning experience, incorporating more opportunities for mentees to co-construct

knowledge through inquiry-based discussions could deepen their understanding of MI practices as part of a participatory and interactive CoP.

Consistent Collaborative Learning in Bifocal Vision.

Samantha consistently focused on Collaborative Learning and Bifocal Vision as part of her mentoring approach. Table 4.3 shows practices for both being found in every mentoring session of the academic year, demonstrating reciprocal learning within a CoP. By positioning herself as a co-learner, Samantha fostered an environment where mentees felt empowered to share their experiences and solutions. For example, Samantha reflected on a lesson she had taught in previous years, mentioning that she had discontinued a particular activity due to frustration with the logistics of the lab. When Sora shared how she planned to change it slightly to reduce some problems, Samantha responded with curiosity, saying, “Let me know how your kids like it” (Session 6) as she considered those changes for herself. This mutual exchange exemplifies shared expertise, where participants learn through collective problem-solving and mutual feedback. At the beginning of each semester, Samantha invited mentees to share their goals and challenges. She revisited these goals in subsequent sessions through reflective check-ins about their pacing and progress.

Samantha’s bifocal vision also reflected a commitment to addressing both immediate concerns and long-term professional growth as part of this collaborative approach. During this academic year, each mentee had different schedules and administrative restrictions influencing their implementation of MI; however, they each set the same longer-term goal for applying MI to all lessons. This allowed Samantha to address immediate needs, such as helping both mentees adjust the "Thirsty Birds" lab for evolution and natural selection, to accommodate a condensed schedule (Session 2), while also guiding them toward achieving their long-term goals, like

completing all MI units within a semester. Despite her focus on pacing and curriculum alignment, Samantha could further integrate long-term goals into immediate problem-solving. For instance, shifting conversations from commiseration about standardized testing constraints to actionable planning, such as asking, “How should we structure the lab activity to get the concepts in before the test?” (Session 15), could better connect short-term adjustments to overarching objectives, reinforcing the interconnected nature of immediate and long-term objectives within the CoP framework.

Limited Focus on Student Thinking.

While Reflective Discourse was a central feature of her mentoring, formal discussions about student thinking or assessments to inform instructional planning were less frequent, as demonstrated in Table 4.3. Typically, when asking questions about students or their understanding, Samantha would ask how the mentees felt the students were doing with MI structures, but rarely used structured sessions to develop assessments or lessons. During one discussion, she asked, “How are your kids doing data-wise? Seems like they're okay. They're grasping it?” (Session 5). This question prompted the mentees to reflect on the effectiveness of MI as viewed through assessment results, but did not demonstrate deeper discussion into analyzing the data or student artifacts to gauge learning.

Informally, mentees shared student whiteboards that showed examples of the students' successful models through a group chat, highlighting how they evaluated student progress independently (VSI, Fall 2023). While these informal exchanges demonstrated Samantha’s influence, they were not systematically incorporated into mentoring sessions. The absence of structured opportunities to incorporate these artifacts into mentoring sessions limited collaborative reflection on how student learning could inform instructional adjustments. By

including student artifacts in formal discussions, Samantha could model how to connect teaching practices with evidence of student learning, strengthening her mentees' reflective and adaptive capacities. Samantha recognized the value of student artifacts and expressed an interest in integrating the whiteboard examples shared in their group chat into mentoring sessions. She specifically reflected, "It would have been helpful for them to bring something back. I will have to think… when that comes up, ask them if they can bring it to the session" (VSI, Fall 2023). Formalizing this practice in future mentoring sessions would allow mentees to connect reflective teaching practices with student outcomes, aligning more closely with the components of EM.

Implementation of EM Dependent on Context.

In Samantha's mentoring sessions with her CoP, it was evident that the implementation of EM components varied significantly depending on the focus of each session, underscoring that learning is context-dependent and shaped by the social environment. The end of each semester saw increased implementation of all EM practices, specifically in Reflective Discourse practices. A few sessions also included examples of all EM components in one meeting. These sessions were dedicated to the review of each mentee's recorded lessons (Safira 9a and 16a, Sora 9b and 16b). For example, when reviewing Sora's lessons from the spring semester, Samantha explained:

> Samantha: This is our last official meeting. We can discuss your two lessons from the spring and compare them to the fall—any changes you made for specific reasons because of what happened in the fall, or anything you changed up based upon the classes you had versus last semester. Anything you want to discuss—challenges, etc. Okay?
>
> Sora: All right.

> Samantha: So you did the same two lessons like last semester, the opening to the energy model with the stations for all different forms of energy. And then the second lesson, picking right up after that with a storyline of how it applies to energy and ecosystems. So let's discuss the first lesson… I put little notes there… So [my first note is] I like how you actually recap the storyline. I do the same thing with my kids. I go way back and keep bringing up that bubble. So I like that you still incorporate that in. Do you feel like it's helpful to your kids? (Session 16b)

In this exchange, Samantha invited Sora to decide how they would proceed with the review before she began reviewing her notes. After sharing her observation, she transitioned to asking questions, allowing Sora to navigate her reflection. Like in this session, the lesson review sessions included some observational feedback provided by Samantha, but were paired with inquiry that probed the mentees to share how and why they made certain decisions, consider what effect it had on the students, and reflect on changes they consider necessary for future lessons. While the individualized approach to these review sessions utilized EM practices that fostered vulnerability and self-reflection, as previously mentioned, it limited opportunities for group collaboration within the CoP. Though not included in the analysis results, there was evidence of collaborative reflection outside the formal lessons review. The mentees exchanged comments on each other's video recording (GoReact Comment Tags) before meeting with Samantha to co-reflect on the lesson. Incorporating group reviews of teaching videos into a conversation might have encouraged more significant collaborative learning, allowing mentees to benefit from the collective expertise and shared reflections of other professionals.

Another heightened representation of EM occurred at the beginning of each semester when Samantha focused the sessions on goal setting and establishing MI pacing and planning for

that semester. As illustrated in Table 4.2, Sessions 1 and 10 emphasized Collaborative Learning as the CoP talked through the MI units and how they applied to each person, including Samantha. As a member of the CoP, Samantha embodied EM through her participation as an equal member of the CoP, contributing to the establishment of goals by sharing:

> Samantha: And I kept pushing [getting NBCT] off. So, I'm thinking now, and I'm going to finally start doing it.
>
> Sora: I have decided I'm not going to [do NBCT] this year because I'm doing the modeling thing for [my school]. I know Safira and I talked about that this summer, but I don't want to overwhelm myself.
>
> Samantha: Safira, did you do the old one or the new one?
>
> Safira: I did the new one… I did it in one year, but by the time that I decided that I was going to start it was [soon] in November… so it was really just a semester. It was tough, but I think it was good just to get it all done. I was just focusing on one class for all three of the writing components and then just studying for the test component in my free time.
>
> Samantha: Okay. Yeah, I may try it. I don't know if I'll be able to get it done in a year… maybe two years. What order do you recommend doing? (Session 1)

In this collaborative exchange, Samantha shared her own reflection and hesitation about her goal and sought insight from her mentees. This same approach was used with each mentee during this same session, as Samantha inquired about their plans and expectations. Through Situated Inquiry, Samantha facilitated the development of the CoP's shared purpose for learning as the mentees were invited to self-identify areas of personal and professional areas of potential problems while formulating their goals, both immediate for that semester, and across long-term growth and implementation of MI (Table 4.3, Sessions 1 and 10).

Overall, the sessions with the relatively high notable EM use (Table 4.3), were the discussions focused on MI and science topics for more than 50% of the duration (Table 4.2, Notable Topics). For example, at the very beginning of a session that primarily focused on talking through an upcoming unit, Samantha framed the conversation and then asked questions about how and why the mentees were planning to approach and facilitated the upcoming unit, after presenting it with challenges to their pacing goals. She asked Safira, "Are you planning on doing all the [lab] the way it is, or do you think you're gonna revise [it]?" and opened the conversation to science-specific topics (Session 2). This conversation flowed naturally through many examples of Collaborative Learning as they talked about their science-specific lesson plan ideas, but also included reflection on lessons previously taught by Samantha, questions about intention and reasoning, connection to the long-term pacing goals, and eventually the sharing of resources (Table 4.3; Table 4.2, Notable Topics). During content-focused discussions like this, Samantha used EM to foster active engagement in exploring reform-oriented practices, subject-specific content, and MI strategies. In contrast, sessions with less direct connection to teaching, like Sessions 14 and 15, which focused on school events and testing schedules (Table 4.2, Notable Topics), showed fewer opportunities for reflective or collaborative engagement. Without authentic, task-relevant contexts in these sessions, discussions were less connected to the mentees' day-to-day challenges and diminished the opportunities for meaningful participation and co-construction of knowledge.

Case Two- Fiona

Fiona, a teacher with extensive experience teaching biology, recently completed a Master of Education (M.Ed.) degree in school counseling and guidance. Immediately preceding the academic year of this case study, she had accepted a guidance position in the elementary building

of a public K-8 school in a small rural town in North Carolina. Until that change, she had been a high school biology teacher in the same small rural district. She had taught for fourteen years, most recently instructing standard and AP biology. About ten years ago, Fionas's county adopted MI as an initiative to reform science instruction, so she was trained in MI Biology at NC Science House. At that time, her principal supported the program and encouraged MI in the school due to its inquiry-based, hands-on approach that taught science content by applying science and engineering practices (SEPs). After a few years of using MI, when the number of Summer Institute instructors started to decline, Fiona was invited to become an instructor for the Summer Institute workshops. Since becoming an MI Biology instructor for the Summer Institute, Fiona concurrently mentored the MI teachers who participated in those summer workshops. This mentoring role was embedded in her role as an MI instructor, but she received no formal training; however, before joining the SIMIRS project, she mentored within the county's beginning teacher support program for about eight years. For this role, she underwent specific training through a county program that involved video-based learning and assessments. During this experience she mentored various teachers, mainly beginning science teachers in biology, physical science, and chemistry, but also supported an English teacher.

Fiona's Perceptions of Mentoring

Despite having over six years of mentoring experience (see Table 3.1), Fiona mentioned in interviews that she did not view herself as a mentor. Instead, she described her role as "a teacher that is available and willing to help support other teachers," emphasizing responsiveness and adaptability. Her analogy of mentorship as "a good pair of tennis shoes, supportive. The cushion is in the right place at the right time" (IP-I, Spring 2022) reflects her belief that effective mentorship is rooted in understanding and meeting the immediate needs of mentees. This

perspective highlights her focus on being available and providing tailored support, aligning with the idea that mentorship must adapt to the unique circumstances of each mentee.

Fiona believes mentoring should be comprehensive, encompassing academic guidance and emotional and professional support. This holistic view of the mentor's role is evident in her emphasis on the importance of self-awareness in mentoring. She advocates for periodic evaluation of one's practices to ensure effectiveness, noting that mentors must be able to recognize "when they need some learning themselves because sometimes [they] get burnt out and need to go back for more training" (IP-I, Spring 2022) This statement underscores Fiona's commitment to continuous improvement, a crucial element in maintaining the quality of mentorship over time.

While Fiona did not initially consider her previous experiences with guiding Summer Institute teachers as mentorship, she acknowledged that these experiences, combined with her ability to empathize with new teachers and reflect on her own challenges, informed her practices within the SIMIRS project. This determination suggests that her conceptualization of mentorship is rooted in practical experience and a strong sense of empathy, which are valuable assets for building trust and rapport with mentees.

Fiona's Community of Practice

Fiona's CoP, as detailed in Table 4.4, includes Fiona and her two mentees that participated in the MI Biology Summer Institute workshops. Fiona's experience in teaching biology and Earth/environmental science, MI pedagogy, and mentoring prepared her to lead CoP sessions focused on the mentees' implementation of MI in their different high school science classes. Both mentees worked at the same science-focused high school in a moderately rural region of North Carolina. Due to the size of the school and student population, the mentees did

not teach the same subject and only shared some of the same students. They had worked together at that school before deciding to participate in the Summer Institute professional development workshops at the same time. One mentee, Farah, was the Earth and environmental science teacher at the school, but also taught chemistry. She advocated for student-led teaching and actively sought opportunities for professional development to improve her classroom experiences, which led to her decision to dive into MI. During the first semester of this case study, she also completed her Master's degree. After earning this degree, she was offered a new position at the school, teaching college-level biology courses.

Table 4.4

Demographic Information for CoP Members (including Mentor and Mentees)-Fiona

Member	Gender[a]	Race[b]	Degree/ Prep	Teaching Range [as of 2022]	Subject (Grade) [2022-2023]	School Type
Fiona	F	W	BA- Secondary Science Ed-Bio MEd- School Counseling/ Traditional	12-15	Guidance (ES) [Other experience includes: Biology (including AP) (HS), Physical Science (HS) Chemistry (HS) Earth/Enviro (HS)]	Public High School- Rural
Farah	F	W	BS- Secondary Science-Bio/ Traditional	8-11	Earth/Enviro (HS) Chemistry (HS)	Applied Science Public High School-Rural
Finn	M	W	MS- Bio/ Non-traditional	16-19	Biology (including AP) (HS)	Applied Science Public High School-Rural

Note. [a]Race and Gender as self-identified; Racial categories from U.S. Census Bureau standards (Office of Management and Budget [OMB], 1997). Abbreviations W=White (non-Hispanic), B=Black (non-Hispanic)
[b]School Type population: Urban > 50,000 residents; Suburban connected to urban < 50,000 residents; Rural < 2,500 residents

The other mentee, Finn, was an NBCT biology teacher who had previously been trained in MI Physics but still taught with a traditional view of teaching science. During the year of our study, he had a full plate of school responsibilities, including coaching baseball and sponsoring the Beta

Club. His heavy load of extracurricular responsibilities contributed to his difficulty attending mentoring sessions. When deciding when the CoP would meet, they agreed each meeting would take place after school hours to accommodate each person, as there was no overlap in their three different planning periods.

Fiona and her CoP met a total of 16 times (see Table 4.5), of which 13 virtual sessions (V) and two in-person (I) sessions were recorded and submitted to the SIMIRS research team, leaving only one session unable to be verified ([ ]). With her meetings totaling approximately four hours, Fiona had the shortest average meeting time of all three mentors. The average duration for a recorded mentoring session was 17 minutes, with a sizable variation between the shortest meeting of five minutes and the longest of thirty minutes. The two longest sessions were in-person, demonstrating Fiona's preference for connecting with other teachers face-to-face rather than through a digital platform.

Table 4.5

Description of Sessions- Fiona

#	Type[a]	Notable Topics[b]	Science Focus (%)	Mentee Attendance	Duration (min)	Mentor Talk[c] (%)
1	[V]	[Check-in] [MI]	-	[Farah]	[30]	-
2	V	Setting Goals	30% Science	Both	16	34%
3	V	MI Lessons	65% Science	Farah	18	45%
4	V	MI Lessons	65% Science	Farah	15	35%
5	I	MI; Lesson Plans (joined by visiting mentees)	40% Science	Farah	26	18%
6	V	Holiday	65% Science	Farah	7	54%
7	V	*Video Review*	55% Science	Farah	12	46%
8	V	MI Lessons	65% Science	Finn (Farah sick)	18	36%
9	V	MI Lessons	45% Science	Farah	21	27%
10	V	MI Lessons	65% Science	Both	7	48%

Table 4.5

Description of Sessions- Fiona

#	Type[a]	Notable Topics[b]	Science Focus (%)	Mentee Attendance	Duration (min)	Mentor Talk[c] (%)
11	V	MI Lessons	65% Science	Both	16	19%
12	I	MI Lessons	60% Science	Farah	30	28%
13	V	MI Lessons	62% Science	Farah	21	25%
14	V	Holidays	15% Science	Farah	5	38%
15	V	*Video Review*	60% Science	Both	22	35%
16	V	EOY and Summer	27% Science	Farah	12	54%

Note. Information in brackets ([]) indicate answers provided on the mentoring log that cannot be fact-checked. Dashes (-) indicate information that could not be determined from the source available.
[a]Type of session is defined as virtual (V) or in-person (I).
[b]Primary topics of discussion met the criteria of being the topic discussed for the longest duration or percentage of the entire meeting.
[c]Mentor Talk time percentages were calculated by Otter.ti during the transcription process.

Fiona's CoP highlights three prominent themes that shaped its dynamics and outcomes. A primary theme in the mentoring sessions was that attendance and commitment were foundational to Fiona's CoP, with the level of participation of each mentee influencing their experience and outcomes with implementing MI in their classrooms. Farah attended nearly all the sessions, including the in-person follow-up workshop sessions each semester (Sessions 5 and Session 12), consistently engaging in the CoP. This level of commitment allowed Fiona many opportunities to build a strongly connected relationship with her and provide targeted support, like when she met with the mentees to discuss specific MI lessons they had taught. She read through her observations from Farah's recorded lesson from the fall semester, highlighting positive examples, such as:

> I watched the second video, and I put comments… it was cool where you talked about [Polymerase chain reaction]. I'm guessing you did that the day before… on muscular dystrophy, which was really cool because they're [going to] learn about that when they

> get to genetic disorder [lessons]. So you're tying it all in… What I really loved was when after they did get their gels running, they made a flowchart from start to finish. And I thought maybe they can even do the flowchart before [the lab] and then add to it after… like my kids (Session 7).

This conversation shows that targeted feedback can help Farah identify her strengths and areas for improvement in her teaching practice. Fiona made sure to bring the positive elements of Farah's lessons up for collaborative reflections, as she learned that Farah was already self-reflective, but would often be overly critical and miss what she is doing well (VSI, Fall 2023). Leaning into her connections with Farah, Fiona could tailor her approach to guide and support her growth.

In contrast, Fiona was not able to build as strong a relationship with Finn, which can be attributed to his minimal attendance and infrequent communication (Mentoring Log). Despite multiple attempts by Fiona and Farah to communicate and connect with him, Finn only attended five of 16, or just 31%, of scheduled meetings (see Table 4.5), and never submitted a recorded lesson to review with Fiona. In one of those rare sessions, Fiona guided the mentees in determining their goals for the school year. When Finn mentions not fully implementing MI, preferring to include only a few lessons from the curriculum, she is understanding and flexible, acknowledging that "bits and pieces will work until you feel more comfortable" (Session 2). As demonstrated in this discussion, Finn was hesitant about reforming his teaching completely; therefore, Fiona adapted her mentoring to his circumstances by validating his blended approach to MI, but restricting collaboration in planning MI lessons for his students. Finn's delayed modeling implementation and limited reflective discussions with Fiona curtailed opportunities for more transformative professional growth. Farah and Finn's varying levels of participation and

engagement further underscore how individual commitment influenced Fiona's ability to provide consistent and meaningful support, revealing the critical role of sustained engagement in a CoP.

Another defining theme of Fiona's CoP was the prevalence of informal collegial discussions that varied between personal and professional. The sessions typically devoted time to personal exchanges throughout the academic year, which fostered a sense of psychological safety and mutual respect within the CoP. Informal topics explored in this CoP allowed Fiona to gain information about her mentees' hobbies, life events outside the classroom, school events, and holiday plans (Table 4.5). This background knowledge contributed to relationships, as she showed genuine interest in their lives and utilized that knowledge to connect with her mentees in future sessions. For example, during the summer Fiona learned that Farah was completing an advanced degree. From this personal information, she checked in on her progress and congratulated her when she graduated (Session 4). Additionally, Fiona frequently shared her own challenges, such as a particularly stressful day managing student behaviors and new job responsibilities that came with her new position at the school. She shared,

> Fiona: I was getting pulled in so many different directions this week. Last week was pretty calm. Hopefully this week will be calm, but in this job, you just never know when fires are [going to] break out... I'm glad you are my mentee; you got it going on.
>
> Farah: Oh, I don't know, I was really stressed for a few days because I also started doing a long-term project with my freshman, soilless versus soil, hydroponic aeroponic. And things didn't go so well (Session 3).

Fiona's willingness to share personal anecdotes modeled vulnerability and openness; in this case, it encouraged Farah to disclose her personal struggles during the same session. This shared experience established a community that allowed future sessions to be a safe space for sharing.

As an example, the only session where Finn and Fiona met without Farah included multiple conversations with Finn about his busy schedule, including discussions about holiday plans, balancing extracurricular responsibilities, and hosting a student teacher, were met with understanding and encouragement. After Finn shared his reasons for being able to implement MI, Fiona refocused on the overall goal, “Well, it sounds like you're doing good. Got it? Well, on the way. Did you do any modeling? I think that our long-term goal was to try to do some this semester.” (Session 8). In this exchange, Fiona demonstrated empathy for his workload, reinforcing his participation even when he struggled to meet all professional expectations, and helping to sustain his involvement in the CoP despite competing demands. By prioritizing relational and emotional elements, she created an empathetic environment that normalized the ups and downs of professional and personal life. However, they occasionally detracted from the depth of professional discussions by leaving less time for rigorous analysis of teaching practices or student outcomes.

A theme that emerged, unique to Fiona’s CoP, was Fiona mentoring from the sidelines. Fiona positioned herself as a peer teacher throughout her mentorship, limiting her evaluative or instructive roles. During mentoring sessions, Fiona typically spent less than 50% of the time talking (Table 4.5, Talk Time), letting the mentees lead the discussions and do the bulk of the sharing. The informal open-ended format of the CoP allowed space for any member, mentor, or mentee to facilitate navigating shared challenges as equals. Farah sometimes took the lead and checked in with Fiona, asking her “Have you had a good week? Good weekend?” (Session 6). In that same session, Farah excitedly suggested a new technology tool she learned about at a workshop that she thought would fit Fiona’s needs at school. These instances demonstrate the mutual respect and consideration of peer teachers supporting each other. All three participants,

including Fiona, shared their work-related struggles, and in those discussions, Fiona did not present herself as having all the answers or being above these challenges, which helped maintain a sense of equality. For example, at the end of the year, Fiona met with both Farah and Finn and led a discussion about a recently taught lesson on DNA:

> Fiona: Some things that jumped out at me were pre-thoughts. They were very good. Like, they knew a lot about DNA.
>
> Farah: … I was surprised at how much they already knew.
>
> Fiona: So, Finn, do you use pre-thoughts? Kind of getting engaging where they are? Even if it's not as a whole class? Like, sometimes we do it from a bell ringer. I will be like, 'Tell me what you know about this.' So, if I didn't have a chance to do it as a whole class, they at least did it individually. Do you use that a little?
>
> Finn: Well, yeah, to answer your question, I always have a list of things we're going to do on this screen whenever they come in (Session 15).

In this review, Fiona highlighted aspects of Farah's lesson that went well. She also used questions to connect with Finn, who had not submitted his own video for observation and collaborative reflection. While this guidance included probing questions, this would have been more collaborative if, as a peer teacher, she inquired into the mentees' reasoning for their decisions in planning, which may have encouraged Finn to look deeper into his motivation for teaching science. Instead, her focus on identifying the positive examples from the lesson, or suggesting short-term solutions, often overshadowed possible discussions of systemic challenges or research-based strategies. This illustrates that while Fiona's peer approach emphasized community and mutual respect, it sometimes constrained her ability to challenge mentees to engage in more profound reflective practices or explore long-term professional goals.

Fiona's Implementation of Educative Mentoring

Fiona had lower frequency in all component categories than the other mentor cases, as seen in Table 4.6. However, Fiona attempted to include each component at least once during the academic year. Fiona's mentoring emphasizes Situated Inquiry and Collaborative Learning, though her overall approach to mentoring lacks consistency or focus on the components of Bifocal Vision, Reflective Discourse, and Student Thinking. There was notable variation in her inclusion of the components of EM during the academic year. This unequal distribution of practices suggests that she had some opportunities to include EM that were not fully explored or realized. Fiona reflected that this may have been because of her own feelings of overwhelm within her new role as a school counselor (VSI, Fall 2023).

Table 4.6

Frequency of Educative Mentoring Practice Indicators- Fiona

EM Component	Fall 2022							Spring 2023								Total
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Situated Inquiry	4	5	2	1	0	2	0	2	0	2	4	4	0	1	0	27
Collaborative Learning	0	5	6	4	0	2	0	1	0	1	4	0	0	4	0	27
Bifocal Vision	3	2	0	0	1	0	5	1	0	2	0	1	0	2	0	17
Reflective Discourse	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	5
Focus on Student Thinking	0	1	1	1	0	0	0	2	1	1	1	0	0	3	1	12
Total Codes per Session	7	13	9	10	1	4	5	6	1	6	10	5	0	10	1	

Note. Session numbers represent the sessions recorded and submitted for analysis by the mentor. Those with the same number, but a differing letter denoted those sessions planned to be separate but served the same focus/function.
For a detailed breakdown of the frequency of the key feature descriptors for each component, see Appendix E.2

As observed in this study, Fiona's mentoring practices reveal an uneven implementation of EM components with her two mentees. Four themes emerged from Fiona's mentoring sessions, including: (1) Fiona's emphasis on inquiry and collaboration, (2) her limited use of Reflective

Discourse, (3) inconsistencies in her mentoring approach, and (4) the impact of session duration on her ability to integrate EM components effectively.

Frequently Collaborative Through Inquiry.

Fiona's most consistently demonstrated EM components were Situated Inquiry and Collaborative Learning, as detailed in Table 4.6. Her use of questioning strategies and active listening allowed her to guide mentees to new ideas and find solutions. For instance, in a session addressing challenges with teaching stoichiometry, Fiona shared her experience of using a chocolate chip cookie recipe in MI, but when Farah mentioned that she didn't have access to an oven, she proposed a possible change to a no-bake cookie activity. Excited by this idea, she exclaimed, "That's good! I like that!" (Session 13), encouraging Farah to adapt the activity to make it more accessible and relevant for her students. This practical advice grounded in Situated Inquiry empowered Farah to implement MI contextually appropriately. However, Fiona did not follow up to assess the outcomes of this adaptation or encourage deeper reflection, which limited Farah's opportunity to analyze and refine her practice critically.

In contrast, Fiona's interactions with Finn were less inquiry-driven and more supportive. His inconsistent attendance and reluctance to adopt MI often shifted discussions toward managing frustrations rather than addressing MI strategies. For example, Fiona used active listening while Finn expressed concerns about disengaged students:

Finn: I have a fourth period, 18 seniors that have one foot or leg out the door.

Fiona: Senioritis?

Finn: Very much so… I'm trying to maintain order by keeping them busy.

Fiona: There you go!

Finn: I think that's the best classroom management strategy, as always keep on learning.

Fiona: Yeah, that's good. Fiona. How's yours going? (Session 10).

She affirmed and validated his frustrations but transitioned the conversation back to Farah without co-reflecting on the antecedents preventing him from using modeling strategies with his students. This pattern suggests that Fiona adapted her mentoring style to each mentee's immediate needs but missed opportunities to leverage inquiry to advance their understanding of MI principles.

Fiona also included Collaborative Learning in many of her sessions during the year. Fiona emphasized Collaborative Learning with Farah, treating their mentoring sessions as a partnership in which both mentees contribute ideas and problem-solve together. For example, Farah shared that she was planning her upcoming lessons on DNA, protein synthesis, and mutations, but was looking for hands-on activities to teach about mutations to help keep her students engaged. Instead of prescribing a solution, Fiona shared her own experiences to reason through some possibilities for Farah. She mentions that she primarily uses readings because a previously useful interactive website no longer works, but added "We can research that because they're asking more and more on the [End-of-Course Exam] about mutations, that they're not all bad and they're not all good" (Session 4). They decided that Farah could use technology resources like Amoeba Sisters videos and EdPuzzle to activate prior knowledge and engagement. This collaboration allowed Farah to feel ownership over the process and encouraged her to think creatively about scaffolding MI in her class. However, with Finn, collaborative efforts were hindered by his limited commitment to MI. When Finn shared challenges with students engaging with each other in the whiteboard meeting portion of his planned MI lessons, Fiona responded, "It's such a good formative assessment, like fast, you know, move on." (Session 11). This validated his attempt at implementing the new practice and reinforced its value as a formative

assessment, demonstrating Fiona's effort to maintain collaboration despite Finn's resistance and difficulty in aligning his practices with MI's inquiry-driven framework.

Missing Reflection Discourse.

Reflective discourse was the least prominent EM component in Fiona's mentoring, appearing in only two sessions throughout the year. One of those examples, during the SIMIRS fall follow-up, Fiona facilitated reflective discussions by asking, "How do you think your kids compare now in the semester versus in the past?" (Session 5). This prompted mentees to analyze the impact of their teaching practices on student learning. However, such instances were rare, particularly in one-on-one sessions. For example, after reviewing a lesson video with Farah, Fiona commented, "I finished your second video. And there was not a lot to say. It was very good. I'm sure you saw those comments on there. Did they learn a lot with that?" (Session 16). While validating, this approach lacked the depth to encourage Farah to evaluate and refine her MI practices critically. Reflective discourse was nearly absent with Finn, as their conversations focused on immediate frustrations rather than a deeper analysis of teaching practices. To strengthen Reflective Discourse, Fiona could ask Farah questions such as, "What aspects of the modeling activity helped students connect with the concept, and what might you change next time?" Reflective prompts could encourage Finn to consider how MI strategies might address his classroom challenges, fostering a deeper understanding of inquiry-based teaching. Addressing these gaps through intentional reflection and long-term goal alignment could enhance Fiona's ability to guide her mentees in developing inquiry-centered teaching practices.

Consistently Inconsistent.

Fiona's mentoring demonstrated notable inconsistencies in implementing EM components across sessions. While Situated Inquiry was evident in 67% of her mentoring

interactions (Table 4.6), other critical EM components, such as Reflective Discourse and student thinking, were applied sporadically. In some instances, key EM components were absent (See Appendix E.2). For example, Session 14, the shortest of all recorded sessions, lacked any identifiable EM components, centering instead on personal updates rather than professional development. Fiona showed potential to integrate EM principles in earlier sessions, as illustrated by her interaction with Farah in Session 3. During this meeting, Fiona revisited Farah's short-term goal, asking, "We talked about our short-term goals, and yours was timing. How's that going?" This question prompted a discussion about strategies for improving time management and student engagement, but did not connect these strategies to broader goals for fostering a MI classroom culture. Furthermore, Farah's short-term goal of improving timing was not explicitly revisited until Session 7, when Farah independently reflected, "Yeah, timing-wise I'm fine now. I feel fine" (Session 7). This pattern demonstrates Fiona's reliance on opportunities for educative discussions to arise naturally, rather than deliberately fostering them. While moments of meaningful dialogue occurred, her inconsistent application of EM components hindered the depth and sustainability of her mentoring practices.

Time Influences EM Practices.

The duration of mentoring sessions significantly influenced Fiona's ability to integrate EM components. Longer sessions, such as the in-person SIMIRS follow-up (Session 5), allowed for richer discussions by including multiple EM components. In this session, Fiona and Farah collaborated with other participants to analyze data and share strategies, demonstrating substantial inquiry and collaborative learning practices. In contrast, shorter sessions often lacked depth and educative focus as indicated by the lower numbers of indicators across EM components. For example, Session 14 contained only informal exchanges, with no time available

or commitment to addressing goals or science teaching. This reflects the challenges of fostering meaningful mentoring interactions within limited timeframes. To address this, Fiona could prioritize key EM components in shorter sessions and use structured frameworks to guide discussions, ensuring consistent support for mentees.

Case Three- Xavier

During the year of this study, Xavier worked in a student academic support role aiding students with various college science courses at an application-based magnet college preparation school embedded in a technical community college of a large urban county in North Carolina. He had recently transitioned into this support role from teaching honors-level Earth science and chemistry courses using MI, as he anticipates his retirement from teaching. In the past, he also taught classes on research methods. Prior to becoming a teacher, he earned advanced degrees in Earth/environmental Science (M.S.) and Forestry (Ph.D.) and had a self-proclaimed successful career as an environmental consultant in Forestry. Later in his career, he decided to enter the teaching profession through lateral entry and non-traditional licensure. Xavier first encountered MI while taking a physical science professional development workshop in 2008, shortly after beginning his teaching career. Although he never taught physical science, he adapted the principles he learned in that workshop to teaching Earth science. The following year, he took an MI workshop for chemistry with NC Science House and began implementing it in his classes, continuing this teaching approach until moving to his current academic support role in 2019. Similar to Samantha in biology, Xavier was invited to join the early development of the MI Chemistry curriculum and has been leading the Summer Institute training workshops since 2009. Outside of working with NC Science House, he has been involved in developing and leading modeling workshops across the country in chemistry and astronomy, both in-person and online.

Though he was never formally trained to be a mentor until he participated in the SIMIRS project, Xavier has supported new MI teachers after they participate in his various modeling workshops, both in-person and through long-distance communication, including the Summer Institute.

Xavier's Perceptions of Mentoring

Xavier's perceptions of mentoring reflect his personal teaching experiences and interactions with mentors during critical career transitions. Despite lacking formal mentorship training, Xavier draws upon his experiences as a mentee to shape his understanding of effective mentorship. His perspective suggests that he values mentorship to support mentees' autonomy rather than prescribe methods or curricula. This view aligns with his non-traditional preparation for teaching.

Xavier expressed that mentors should act as the "guide on the side, [rather than] sage on the stage" (IP-I, Spring 2022) revealing his belief in a facilitative rather than directive approach to mentoring. This metaphor underscores his conviction that quality mentoring involves fostering reflective thinking rather than dictating solutions. Xavier's emphasis on the mentor's role in prompting mentees to "do the thinking" suggests that mentoring is a collaborative and inquiry-driven process. He believes that effective mentors leverage their expertise subtly, guiding mentees to critically analyze their teaching practices without diminishing their individuality.

This perspective reflects a deep respect for the diversity of teaching styles and a recognition of the mentees' need to own their professional growth. Xavier implicitly critiques more authoritarian or prescriptive mentoring styles by advocating for a mentoring approach rooted in active listening and thoughtful questioning. His view positions mentorship as a process that balances expertise with the mentee's agency, highlighting the importance of creating a reflective space for professional development.

Xavier's Community of Practice

This case includes the entire CoP facilitated by Xavier. Two teachers who participated in the Summer Institute Workshops for MI Chemistry (see Table 4.7) were matched with Xavier for this mentorship to benefit from his experience in teaching chemistry using MI, his previous experience in environmental science, and his vast knowledge of MI pedagogy.

Table 4.7

Demographic Information for CoP Members (including Mentor and Mentees)-Xavier

Member	Gender[a]	Race[b]	Degree/ Prep	Teaching Range [as of 2022]	Subject (Grade) [2022-2023]	School Type
Xavier	M	W	PhD-Soil Science, MS-Forestry, BS-Forestry/ Non-traditional	12-15	Academic Support-Chemistry [Other experience includes: Chemistry (HS) Earth/Enviro (HS)]	Early College Magnet High School- Urban
Xin	M	B	BS- Bio [Chem Minor] PSM- Forensic Science MAT-Secondary Science/ Traditional	0-3 (first year teacher)	Chemistry (HS), Earth Science (HS)	Early College Public High School-Suburban
Xanthe	F	W	BS- Bio/ Non-traditional	4-7	Chemistry (HS) Earth Science (HS)	Public High School-Suburban

Note. [a]Race and Gender as self-identified; Racial categories from U.S. Census Bureau standards (Office of Management and Budget [OMB], 1997). Abbreviations W=White (non-Hispanic), B=Black (non-Hispanic)
[b]School Type population: Urban > 50,000 residents; Suburban connected to urban < 50,000 residents; Rural < 2,500 residents

One of the mentees, Xanthe, was a chemistry teacher at a small suburban public high school. She sought to learn MI as a change from her traditional lecture-based science teaching dependent on teacher-led lab activities. During the year of our study, Xanthe was pregnant during the Summer Institute and went on maternity leave at the end of her first semester implementing this method. This caused her to lean toward more traditional teaching methods to

ensure a long-term substitute without MI training would be able to continue in her planned absence. She implemented more MI practices with her classes during the spring semester.

The other mentee, Xin, was a first-year teacher with many years of practical science experience. His decision to become a teacher came after several career changes that built up his experiences in chemistry. Already holding an advanced science degree, he returned to further his education and became a teacher through an MAT program that included traditional licensure preparation. During an administration transition, he worked for a small college preparation-focused public school in a remote rural county that was moving the school in a more ambitious and reform-oriented direction. He and his new administrators were interested in finding a way to teach that would offer students deeper science learning; therefore, during his first year of teaching, Xin ambitiously decided to implement MI. By the end of this specific school year, he was redesigning the entire science program and taught multiple science subjects.

Xavier facilitated 18 sessions with his CoP, recording and submitting 13 virtual sessions (V) and two in-person (I) sessions for analysis. Three sessions recorded in the mentoring activity log could not be confirmed ([ ]). Totaling about seven hours, Xavier's mentoring sessions were the most extended duration of the three mentor cases, as shown in Table 4.8. It was not uncommon for the sessions to exceed the scheduled 30 minutes as the CoP meetings flowed with the natural course of conversation rather than a prescribed routine or schedule. During more than one recorded session, Xavier mentioned that he needed to tie up the meeting because they were approaching the Zoom time limit of 40 minutes, indicating that he may have continued if there was no imposed limit. The sessions averaged about 30 minutes, with some slight variation from the shortest of 25 minutes to the longest of 40 minutes.

Table 4.8

Description of Sessions- Xavier

#	Type[a]	Notable Topics[b]	Science Focus (%)	Mentee Attendance	Duration (min)	Mentor Talk[c] (%)
1	V	MI Lessons	65% Science	Both	34	55%
2	[V]	[Progress Check] [Students]	-	[Both]	[30]	-
3	[V]	-	-	[Both]	[30]	-
4a	V	*Video Review*	55% Science	Xanthe	30	63%
4b	V	*Video Review*	60% Science	Xin	25	53%
5	I	(joined by visiting mentee)	40% Science	Xin	35	28%
6	V	MI Lessons	65% Science	Xin	35	33%
7	V	MI Lessons	65% Science	Xin	22	32%
8	[V]	[MI Activity/Lab]	-	[Xanthe]	[20]	-
9a	V	MI Lessons	70% Science	Xanthe	10	68%
9b	V	MI Lessons	70% Science	Xin	27	48%
10	I	MI Lessons	60% Science	Xin	29	34%
11a	V	MI Lessons	55% Science	Xanthe	28	65%
11b	V	MI Lessons	60% Science	Xin	36	38%
12a	V	MI Lessons	60% Science	Xanthe	34	70%
12b	V	MI Lessons	60% Science	Xin	29	29%
13a	V	*Video Review*	55% Science	Xanthe	32	69%
13b	V	*Video Review*	45% Science	Xin	29	54%

Note. Information in brackets ([]) indicate answers provided on the mentoring log that cannot be fact-checked. Dashes (-) indicate information that could not be determined from the source available.
[a]Type of session is defined as virtual (V) or in-person (I).
[b]Primary topics of discussion met the criteria of being the topic discussed for the longest duration or percentage of the entire meeting.
[c]Mentor Talk time percentages were calculated by Otter.ti during the transcription process.

He and his mentees worked together to try and find a time to schedule their regular CoP sessions, attempting to meet everyone's needs and availability during planning periods. Unfortunately, Xin found that his job responsibilities and schedule did not allow him to meet easily during school hours, so the meetings were changed to accommodate his needs more. Later

in the year, the CoP changed to meeting with each mentee separately due to changes in schedules and needs, indicated in Table 4.8 with sessions ‘a’ being for Xanthe only and ‘b’ representing sessions with only Xin. This change shifted Xavier from his original goal of building collaborative relationships and planning opportunities within the CoP, but he could still build those individual relationships. In addition to the virtual sessions, the mentees requested informal mentoring support between sessions; therefore, Xavier communicated with both mentees through text messages and emails, as needed.

Xavier’s mentoring sessions with his CoP revealed several distinguishing features. One important feature is that the connections Xavier established with Xanthe and Xin shaped the mentorship they experienced, reflecting his adaptability to their unique circumstances. Xavier’s connection with Xin, a first-year teacher with a wealth of practical chemistry experience, emphasized empowerment and reflection. Xin’s background as a career-changer and his position in a reform-oriented rural school required Xavier to guide him toward integrating MI into a demanding and evolving context. During the spring follow-up workshops, Xavier responded enthusiastically to Xin’s explanation of how he planned to use the Kelvin scale in his teaching. Xavier noted, “I’d never have thought to go back and say, well, think about Celsius,” (Session 10), highlighting how Xin’s approach offered a fresh perspective. This acknowledgment reinforced Xin’s expertise and demonstrated that Xavier valued and learned from Xin’s contributions, fostering a mutually respectful dynamic that allowed Xin and Xavier to connect their practical experiences. For Xanthe, a suburban high school teacher transitioning from lecture-based teaching, Xavier built a supportive relationship that combined empathy with practical guidance. Xanthe’s pregnancy and upcoming maternity leave significantly influenced her teaching adjustments. Xavier provided reassurance and manageable solutions, often focusing

on strategies that accommodated her shifting priorities. For instance, as she was preparing for maternity leave, they both understood that her lesson would not employ as much MI, so Xavier suggested that she begin by incorporating MI in manageable steps that could later be expanded when she returned (Session 4a). This connection enabled Xanthe to balance her professional goals with her personal responsibilities, allowing her to return in the spring semester with a renewed focus on MI practices.

As seen in Table 4.8, during meetings with only Xin, Xavier talked for less than 50% of the meeting. When in sessions with Xin, he asked more questions with curiosity and probing for reflection by the mentee about his intentions when making decisions about planning. Xavier did not have to ask as many probing questions due to Xin's responses typically being longer and more detailed. This contrasts starkly with the meetings with Xanthe, where he was verbally active for over 60% of each session. When working with Xanthe, the mentor had less direct connections. These sessions were directed at her specific implementation of the MI curriculum and using MI tools through statements with direct suggestions, ideas, and feedback that identified areas for change and improvement. Due to the limiting nature of Xanthe's short expedient responses to his queries, Xander had to frequently ask additional probing questions to get more details about emerging problems of practice and clarification about context. In the two recorded sessions where both mentees were present, Xin talked more than Xanthe. The connection between these two mentees and the mentor resulted in a different focus and approach for each of those mentorships. Xavier found a strong connection with Xin due to similarities in their career and teaching, allowing him to have longer conversations that included curiosity about his pedagogical reasoning for ideas shared about how science concepts could be introduced or taught using the general modeling pedagogy. He also verbally expressed pride and

excitement about Xin's progress and general work. The similarities between Xavier and Xin's transition into second-career teaching were instrumental in building a strong relationship.

Another important feature of Xavier's mentorship was the intentional use of sessions with one mentee. Initially, Xavier facilitated joint sessions with both mentees, fostering a collaborative CoP. In these group meetings, Xanthe and Xin shared experiences and discussed common challenges, such as implementing MI. For example, in a joint session, Xanthe shared she was planning to record the mass/volume lab for observation. He supported her idea, sharing, "That's a good one... I think the challenging part is where [students] look at volume and mass… You can use [Vernier probes] to make graphs. Did I share all the instructions that we have for graphing with [Vernier probes]?" (Session 1). Xavier guided them through using Vernier probes and answered their questions about the benefits of this tool. These rare collaborative sessions created a sense of camaraderie and collective learning that strengthened the community. However, as their individual needs became more apparent, Xavier transitioned to separate meetings to provide personalized support. This shift allowed him to address the particular content area needs and teaching goals of each mentee. Specifically, Xavier supported Xanthe in using the models learned during the Summer Institute workshops. At the same time, he leaned into his background knowledge of Earth and environmental science to support Xin in applying the concepts of MI in his new course. By tailoring his mentorship to the unique contexts of Xanthe and Xin, he built relationships that addressed both their immediate challenges and long-term professional goals.

A cornerstone feature of Xavier's mentorship was his emphasis on sharing anecdotes to support his mentees' professional growth. By making his reflective thinking and pedagogical reasoning visible through anecdotes, he created opportunities for his mentees to learn from his

past experiences while building rapport and providing practical guidance. His stories not only illustrated effective strategies but also humanized the challenges of teaching, helping mentees feel supported and connected. While sympathizing with Xin's struggles with being a first-year teacher later in life, Xavier shared, "I'm glad I didn't do it at 23. I wouldn't be teaching still," before telling a story reflecting on how secure he felt having his science career and the teachers at his school, which he does not think would have been the case if he had gone straight to teaching. By sharing his own vulnerability and growth, Xavier helped his mentees see their struggles as part of a more extensive developmental process, fostering confidence and perseverance. In addition to offering emotional support, Xavier used stories to illustrate the application of MI and clarify Xavier's suggestions. Rather than presenting abstract recommendations, Xavier grounded his guidance in real-world examples from his own teaching. This approach helped his mentees visualize how MI strategies could be adapted to their contexts. Xavier's storytelling exemplified the ability to connect past experiences with mentees' current challenges. His reflective narratives helped to inspire his mentees, clarify complex ideas, and demonstrate how teaching practices evolve through experience. By making his thinking visible and relatable, Xavier empowered his mentees to approach their classrooms with confidence and adaptability.

Xavier's Implementation of Educative Mentoring

With the most extended mentoring sessions of all the mentors, Xavier had the most opportunity to practice mentorship that could be identified as EM, yielding the highest frequency of using EM indicators throughout the academic year, as evidenced in Table 4.9. He also consistently used all five components across all the sessions, with seven sessions including all five components.

Table 4.9

Frequency of Educative Mentoring Practice Indicators- Xavier

EM Component	Fall 2022						Spring 2023									Total
	2	3	4a	4b	5	7	9a	9b	10	11a	11b	12a	12b	13a	13b	
Situated Inquiry	0	3	7	5	9	2	5	5	4	5	5	7	6	8	7	78
Collaborative Learning	5	1	6	1	2	0	0	7	10	4	12	3	4	5	4	64
Bifocal Vision	5	4	1	5	2	2	4	5	2	2	1	7	2	3	0	45
Reflective Discourse	4	0	5	8	4	2	4	4	2	7	5	5	4	6	2	62
Focus on Student Thinking	0	0	2	4	0	1	1	0	4	2	2	3	0	1	0	20
Total Codes per Session	14	8	21	23	17	7	14	21	22	20	25	25	16	23	13	

Note. Session numbers represent the sessions recorded and submitted for analysis by the mentor. Those with the same number, but a differing letter denoted those sessions planned to be separate but served the same focus/function.
For a detailed breakdown of the frequency of the key feature descriptors for each component, see Appendix E.3

The level of implementation was relatively even for each component of EM, showcasing his strengths in Situated Inquiry, Collaborative Learning, Bifocal Vision, and Reflective Discourse. Like Samantha and Fiona, Student Thinking was lower than other components; however, Xavier included this component in nine of his sessions (60%) at least once. This limited emphasis on student thinking suggests an area for development in his mentoring practices. Themes that emerged when analyzing Xavier's sessions with Xin and Xanthe included: (1) a frequently collaborative approach to reflective problem-solving, (2) a consistent application of all EM components, (3) missed opportunities for a deeper focus on mentees' self-reflection, and (4) a traditional approach to feedback.

Frequently Collaboratively Reflective.

Xavier's most frequently implemented EM components, Situated Inquiry (78 times), Collaborative Learning (64 times), and Reflective Discourse (62 times), often occurred in tandem (Table 4.9). These components were employed effectively to address the individual needs of his mentees, using questioning as a tool for collaborative reflection. By doing so, Xavier encouraged Xanthe and Xin to critically assess their instructional practices and align them with

MI principles. For example, in a spring semester session, Xavier and Xanthe collaborated to reimagine her exam format, transitioning from traditional multiple-choice questions to a student-driven investigation. Their discussion highlights the interplay of EM components:

> Xanthe: I guess the only other thing that's in the back of my mind is I'm gonna have to make an exam.
>
> Xavier: And what are you thinking about in terms of that?
>
> Xanthe: I thought about doing it two different ways. I thought about having them describe the models by unit. The only other thing I thought was to pull questions from the test that we've done in the past.
>
> Xavier: I think it'd be interesting to combine both things that you're saying because I've always thought exams–what makes exams harder sometimes for students is that the questions are all over the place… Either that or sometimes I'll give [my students] the answer to a question and say, 'Now work it out. Show me how you got there.'
>
> Xanthe: That's a good idea, too. Because I have a lot of students… who look at a word problem and just give up. They don't even try; I've had some who literally just put question marks.
>
> Xavier: Yeah, but if you give them the answer. [Those who] never tried doing it… go through each and every thought (Session 11a)

This exchange exemplifies how Xavier used Situated Inquiry to identify Xanthe's challenges, engaged in Collaborative Learning to brainstorm solutions, and modeled reflective reasoning by sharing strategies from his own experiences. Xavier's collaborative and reflective problem-solving discourse fostered a culture of self-assessment and adaptability in his mentees, encouraging them to analyze and improve their MI practices critically.

Leader in Consistency.

Xavier's mentoring demonstrated considerable consistency in the application of EM components. As illustrated in Table 4.9, he implemented all five EM components in 47% of his sessions, surpassing Samantha's 27% (Table 4.3) and Fiona's 0% (Table 4.6). Additionally, his overall EM implementation rate exceeded 60%, demonstrating frequent use of these practices and consistent application across multiple sessions. For most of the EM components, those that were his most frequent as mentioned previously were also those he implemented the most consistently. His consistent approach to implementing EM practices ensured his mentees had opportunities to grow through structured, yet flexible, mentoring sessions.

Xavier frequently incorporated Bifocal Vision practices, addressing long-term goals in 93% of his sessions despite their lower overall frequency (45 instances). This suggests that while checking in on their goals might not have been a significant focus of individual sessions, resulting in fewer questions or statements regarding revisions to long-term goals, it was important to revisit consistently in most sessions through the academic year. This balance between addressing immediate instructional needs and revisiting broader developmental goals encouraged Xanthe and Xin to think beyond short-term challenges and gradually embed MI into their teaching.

Opportunities to Focus on Student Thinking.

While Xavier demonstrated strong practices in most EM components, his Student Thinking was infrequent (20) and often limited in scope and depth. He encouraged mentees to analyze and reflect on student learning, but the conversations did not allow investigation that would inform actionable changes. For example, in a session with Xin, their discussion about students' challenges with mathematical concepts remained surface-level:

Xavier: What do you think their struggles are due to?

Xin: Oh, well, unfortunately, I think I probably got a half dozen that I'm really worried about… I mean no F's, but it is not excelling.

Xavier: But is it that they walk in the door with limitations–with missing information?

Xin: Yeah, absolutely. Limitations on some of them… there's a lot of that going on.

Xavier: I saw the same thing as you when they came in as freshmen. There were things that they were missing (Session 6).

Xavier acknowledged systemic challenges, such as pandemic-related disruptions, but did not delve into specific student misconceptions or thought processes. Encouraging Xin to analyze artifacts like student work could have provided richer insights and actionable strategies. Xavier's overall reflective approach allowed both Xanthe and Xin to deepen their understanding of their teaching choices. However, additional Student Thinking might have prompted them to consider how MI could more actively engage students in constructing knowledge.

Balancing Provider and Facilitator Roles.

Xavier's mentoring often blended traditional and educative approaches. While he frequently used questioning to guide mentees, Xavier sometimes prioritized providing solutions over fostering mentee self-reflection, leaving missed opportunities for the mentees to find their own problems of practice and develop their own solutions. This was most evident during feedback sessions, where he frequently shared his observations and suggestions without first eliciting self-reflection from his mentees regarding their teaching. For example, after observing Xanthe's fall lab activity, Xavier noted:

[The students] just walked in and got to work. From a procedural point of view, obviously, they understand the procedures or the way they do it. Let's see, your

> movement was great. [You were] moving all around the room, getting to meet with the students. Um, I just think there are lots of little things that when you do it again you can do a little bit differently" (Session 4a).

Rather than asking Xanthe to reflect on the impact of her choices on student engagement, Xavier provided direct feedback, missing an opportunity to foster deeper self-assessment. Similarly, in a discussion with Xin about managing student participation, Xavier proposed strategies like assigning roles during group discussions, but did not encourage Xin to reflect deeply on why these challenges might have occurred. Encouraging mentees to review their teaching practices independently before receiving feedback could enhance their autonomy and critical thinking.

Cross-case Analysis

These findings address the research questions by presenting themes identified across all mentor cases. First, key features of each EM component were examined, revealing patterns in how mentors implemented educative practices with their mentees. Next, an analysis of EM implementation across all cases highlights consistent practices and challenges encountered throughout the academic year of the study. Finally, mentor interviews are analyzed to identify themes related to the factors that influenced and motivated the mentors as they defined what EM meant to them and conceptualized their mentoring practices.

RQ1 - How mentors implement EM principles and practices

The EM training introduced mentors to key theoretical concepts that underpin effective mentor-mentee relationships, the EMOR framed these theoretical constructs into observable practices to identify whether and how these principles are operationalized in mentoring contexts, but the three mentors' unique interpretations of EM concepts, were influenced by the situated contexts of their CoPs, demonstrated the fluidity of theory in practice. As illustrated in their

individual case analysis descriptions above, the mentors engaged socially with their mentees and adapted EM principles based on specific needs and challenges, constructing individualized understandings of EM. By examining patterns in the implementation of EMOR-defined features across the three mentor cases, this study explored how mentors navigated the alignment between theoretical concepts of EM and their practical applications, providing insight into how EM can be implemented in real-world settings.

Situated Inquiry

The mentoring sessions were analyzed to find practices identified as key features of Situated Inquiry. To situate mentorship in inquiry, educative mentors facilitate a space where the mentees are invited to openly share their experiences and where mentors encourage exploration of their practice to identify potential focus areas through probing questions and active listening. Table 4.10 decomposes the percentage of each key feature represented within the mentor's overall use of Situated Inquiry in their mentorship. This data shows that the mentors implemented Situated Inquiry by applying all the key features. While features such as inquiry questioning (34%) and modeling reasoning (30%) were strongly represented, areas like explicit encouragement of risk-taking (5%) could be further emphasized. Mentors facilitated discussions aimed at identifying teaching challenges and identifying strategies (Ia), constituting 10% of all Situated Inquiry. Occasionally, that led to the discovery of specific needs that could be a focus for further discussion in those sessions. Other times, those conversations developed into a goal for the mentee to target in planning lessons to be revisited across multiple sessions. For example, Xavier guided problem-solving with Xin, by stating, "[that] sounds like [it would be] a great goal," (Session 6) after his self-reflection, reinforcing the mentee's autonomy in deciding

whether to pursue the idea further. This flexibility allowed mentees to take ownership of their professional growth, with the mentors acting as facilitators rather than directors of inquiry.

Table 4.10

Mentor Use of Each Key Feature- Situated Inquiry

Key Feature	Samantha	Fiona	Xavier	Total
Ia- Guides identification of problems and strategies to set goals and strategies	10%	7%	10%	10%
Ib- Deepens mentee's thinking through inquiry questioning and active listening	33%	37%	33%	34%
Ic- Models reasoning and verbalizes their thought processes	37%	22%	28%	30%
Id- Encourages problem-solving, over offering definitive solutions	6%	11%	12%	10%
Ie- Encourages mentee(s) to test out their ideas and take risks	2%	7%	5%	5%
If- Invites mentee(s) to share their reflections on previously tested ideas	12%	15%	12%	12%

Mentors frequently leaned into using questioning practices and strategies to facilitate conversations with the mentees (Ib). This key feature accounted for 34% of all examples of Situated Inquiry, making it the most utilized strategy. Most of the questions were intended to prompt the mentee to initiate or clarify the sharing of ideas or experiences, probe the mentees for more information, go deeper in conversations, or open up the space for incorporated exploration with peers. In addition to guiding discussion about science and MI, the mentors would use prompting or probing-type questions about mentors' school, personal, or general teaching topics. The approach encouraged mentees to reflect critically and collaborate with peers during sessions, opening a space for mentees to elaborate on specific teaching activities, and blending reflection with practical exploration.

Mentors often modeled reasoning by sharing stories illustrating their problem-solving approaches when encountering teaching challenges (Ic). This practice, comprising 30% of all Situated Inquiry features, involved verbalizing thought processes to validate and empathize with mentees' experiences. For example, Samantha commiserated with her mentees by telling a story about an experience where her students were exhibiting the same hesitancy to open up in group discussions as her mentees. She shared:

> I have definitely had those where they were in complete silence… I had to modify every lab with my first modeling group. [It] was physical science and I worked with fire all the time… We were doing [energy] stations in physical science [like in MI] and one of [the stations] was the wool lighter thing. I had a kid I put next to me, and as soon as I turned my head, he's trying to burn his friend's shirt. I had to modify [the remaining stations]… Every group was assigned a station and we just rotated and watched. But yeah, that was chaos… it was something else. I hear you. I know it's frustrating too because it'll hold up time, especially when they're just sitting there staring at you. (Session 2).

This story situates her guidance and support within relatable professional contexts. These reasoning narratives provide examples of navigating challenges and empower mentees by normalizing the struggles associated with adopting new instructional methods.

Rather than offering definitive solutions, mentors encouraged mentees to navigate challenges independently (Id) in 10% of all Situated Inquiry examples. When they followed their suggestions with variations of statements encouraging mentees to try ideas they like, it was evident the mentors' advice was presented as an option to address a topic or concern, but should not be considered the only way. Fiona exemplified this support to Farah, who faced with concerns over scheduling and pacing restrictions, offering, "If you want [the activity map], I can

shoot that over to you. I don't know if that'll help with your timing but [it's available]" (Session 2). This offer was intended to assist the mentee with a specific problem they brought to the session, which they did without asserting that this material would be the exact solution to the problem. Statements like this by Fiona reinforced that while the mentor is a source for ideas and materials, the mentee maintains agency to decide whether a resource is appropriate for their intended lessons.

Encouraging mentees to test new ideas (Ie) accounted for only 5% of all Situated Inquiry practices, indicating that explicit encouragement was infrequent. However, mentors created an atmosphere where risk-taking was implicitly supported. The mentors were encouraging and valued the ideas of their mentees, like when Xavier told Xanthe, "I was thinking it'd be great if you wanted to try it out, because Sticky Tape, it's a good lab, but it's a little bit tricky" (Session 11a). Here, he acknowledged the difficulty of the lesson from his perspective, while also supporting the mentee's interest in attempting it with students. This careful balance between support and acknowledgment of challenges fostered a CoP environment conducive to mentee experimentation and risk-taking.

Mentors used open-ended questions and check-ins to initiate conversations about topics relevant to their current practice and long-term goals (If). These open-ended questions, which comprised 12% of Situated Inquiry practices, would allow the mentees to lead the discussion by offering them space and time to reflect on previously tested ideas or teaching experiences. When she asked, "How did your game of science go?" (Session 1) Samantha invited Sora to share the outcomes of a specific activity, fostering a reflective space for discussion. These reflections were often integrated into broader conversations, enabling mentors to align their guidance with the mentees' ongoing professional narratives and goals.

Collaborative Learning and Learning

Through Collaborative Learning, planning, and learning, the mentors share experiences and challenges that leverage them to integrate mentees' perspectives into reflective discussions. Mentoring sessions included opportunities for the mentor and mentees to explore lessons, develop solutions to potential problems, and create new materials based on shared ideas. The data in Table 4.11 shows the percentage of each mentor's total use of Collaborative Learning practices as defined by the key features of the component.

Table 4.11

Mentor Use of Each Key Feature- Collaborative Learning

Key Feature	Samantha	Fiona	Xavier	Total (%)
Ca- Uses mentoring for their own reflection and growth	15%	33%	20%	21%
Cb- Creates collaborative learning opportunities, building mutual respect	-	11%	6%	5%
Cc- Monitors mentee progress and chooses tasks to support their growth	-	11%	2%	3%
Cd- Explores lesson content, sequence, and structure	48%	30%	33%	37%
Ce- Assesses artifacts or data to determine next steps for instruction	5%	-	6%	5%
Cf- Values the ideas and insights of the mentee equally to their own	33%	15%	33%	29%

From this information, it is visible that only Xavier included all of these key features of Collaborative Learning in mentorship, but there was support that the mentors overall provided opportunities to share in the thinking and planning around problem-solving. Notably, the mentors were able to spend a significant amount of their time during mentoring sessions focused on the MI pedagogy and the specific lessons that make up the MI curriculum (37%), but only minimally

included some opportunities to collaborate (5%) or create new lessons using the pedagogy itself (5%).

The mentors often utilized mentoring sessions for their own reflection and growth (Ca). With 21% of Collaborative Learning instances recorded in Table 4.8, mentors frequently employed storytelling as a self-reflective tool. For instance, Fiona shared an anecdote about adapting a lesson from an Advanced Placement (AP) class, framing her decision-making process as, “I found this because I did it with AP and thought 'what if we changed it?'” (Session 5). This rhetorical question demonstrated her thinking and reasoning as she reflected on the decision. In another example, Xavier showed vulnerability to his mentee when he shared that he did not understand an idea from a lesson. Turning a statement of frustration into an opportunity to learn more and get advice from his mentee, he divulged, “I wonder [why] it's on the K scale… I spent time saying I don't like the K scale. I want to make sense of this… What do you think?... What do you do with your students?” (Session 10). These moments reflected a collaborative dynamic where mentors modeled reflective practices and sought guidance, emphasizing mutual growth.

On a few occasions, only 5% of all Collaborative Learning features, mentors included opportunities for the CoP to work together in learning new things (Cb). This happened subtly when Fiona intentionally volleyed a direct question from a visiting mentee about videotaping to another mentee to shift from a dependency on mentor knowledge to a peer-led discussion. She asked an experienced mentee, “Do you have any videotaping tips for [him]?” (Session 5), utilizing the CoP’s collective expertise. Samantha took a more explicit approach to facilitating collaborative activity during the spring in-person follow-up session by engaging visiting mentees in analyzing benchmark assessment data. She explained, “They had their results back for their fall [benchmark], so they were reflecting over the data and doing their preliminary [Education

Visualization and Analytics Solution (EVAAS)]... to see if students met their growth or exceeded growth" (VSI, Fall 2023). While this activity provided a collaborative framework for discussing MI and student achievement data, it lacked deeper analysis of student-specific outcomes or future plans, signaling room for more substantive engagement.

Progress monitoring was the least represented feature of the Collaborative Learning component. There was evidence through open-ended questioning strategies (Cc), but those often did not evolve into recognizable collaborative planning sessions. As an example, in one of his progress monitoring check-ins, Xavier probed his mentee's reflection on a specific MI practice by asking, "Your skills at whiteboarding/ discussion, are those where they need to be? Or would that be an area for [professional development]?" Through this inquiry, Xavier suggested an area for the mentee to consider for more training or development, which did not lead to a plan for moving forward. Such questions opened the door for reflection but rarely culminated in actionable next steps, suggesting a need for more structured dialogue around growth strategies.

Because the mentors were instructors for the MI curriculum, it was not surprising that 37% of the Collaborative Learning practices were focused on the lesson content or sequence (Cd). Conversations typically centered on pacing and lesson progression, with mentors frequently asking which lesson their mentees have completed or inquiring about what they have next up in the pacing. However, deeper collaboration occasionally emerged when mentees would share how they may skip or modify a lesson, leading to conversations about their reasoning that influenced others to try new ideas. For instance, Samantha, intrigued by her mentee's approach to a revised activity, reflected on potentially reverting to the mentee's version (Session 6, previously mentioned), exemplifying the mutual benefit and reciprocal nature of collaborative planning.

As shown in Table 4.11, only 5% of Collaborative Learning examples focused on discussing student artifacts, like whiteboard models, as a tool for planning lessons (Ce). This could only be found in practice during the review sessions, where the mentor could see some evidence of what the students were using in the recorded lessons. In one of the few examples, Samantha noticed that the students were using notebooks during a lesson, which led her to ask some probing questions to investigate how they were being used, such as, “I saw that you were starting out with pre-thoughts… are your students writing this in their notebooks too?” (Session 9a) After the mentee had affirmed, the discussion continued with the use of scientific notebooks effectively. While such exchanges provided insights into instructional practices, they fell short of integrating student artifacts as tools for collaborative lesson refinement.

Throughout the sessions, the mentors worked diligently to build strong connections with their mentees by soliciting their input and expertise, portraying 29% of Collaborative Learning features by demonstrating they saw genuine value in the ideas and experiences of the mentees (Cf). This was often seen in their various comments and the curiosity behind the questions they asked. Most often in the form of questions, there was a wide variety of examples where the mentors offered praise, showed pride, expressed genuine curiosity about something the mentee shared, or specifically sought their insight or advice. They may even go so far as to share those ideas in sessions with other people. Xavier was so intrigued by an idea to develop a common assessment, or bank of assessment questions, for the MI curriculum that Xanthe had (Session 11a) that he shared it with Xin to see if he also thought it was necessary and whether he would be on board to collaborate in its development (Session 11b). Xavier even mentioned it again in his reflective interview as a change that could apply to all the participants of the Summer Institute (VSI, Fall 2023). There were other times when the mentors sought some quality insight, like

when Samantha asked for advice regarding the process of preparing for NBCT, expressing, “I may try it, but I don't know if I'll be able to get it done in a year… And just [wonder] what order do you recommend doing?” (Session 1). Samantha’s vulnerable inquiry demonstrated the mentors' trust in their mentees’ knowledge and the value they placed on their experiences.

Bifocal Vision

Bifocal vision conversations are goal-centered, ensuring opportunities for the mentee to set up and refine their targets for growth in both the short-term and long-term. The mentee's short-term needs and immediate problems must be addressed in the conversations, but that should not be the majority focus of the sessions; instead, the mentor should assist in linking those short-term needs to the overall long-term goals. To get the best understanding of how to approach their mentorship, educative mentors would seek information about the mentee's beliefs and experience, allowing them to individualize their mentoring to respect their approach to teaching. When using this educative lens to analyze the three cases (see Table 4.12), a Bifocal Vision was represented through all key features, with only Xavier not explicitly indicating balancing the short and long-term focuses in sessions (Ba). During analysis, it was complicated to measure if the mentors focused too much on the short-term needs based on individual statements, which may account for the minimal indications for that key feature. This determination would have to be made based on an overall look at the conversation, but some specific examples of the mentors redirecting conversations could be included.

Table 4.12

Mentor Use of Each Key Feature- Bifocal Vision

Key Feature Indicator	Samantha	Fiona	Xavier	Total (%)
Ba- Ensures short-term needs do not monopolize sessions	2%	18%	-	4%
Bb- Develops short-term needs into long-term goals	19%	6%	2%	10%
Bc- Provides opportunities to set up and refine their goals	26%	24%	4%	16%
Bd- Probes the mentee's beliefs, experience, and knowledge of best practices	26%	6%	49%	32%
Be- Tailors mentoring based on their understanding of mentee	16%	18%	33%	24%
Bf- Respects mentee's approach to teaching, while supporting best practices	12%	29%	11%	14%

The ability to ensure that short-term needs did not monopolize sessions (Ba) was challenging to measure through isolated statements without looking broadly at any given session as a whole, evident in only 4% of all examples of Bifocal Vision. There were some incidental signs of this happening through explicit attempts by the mentor to refocus and redirect statements from the mentors, such as Fiona reassuring her by telling him, "It's just a lot, but with the whole pacing thing, you'll be fine. I think you'll be able to catch up as long as you solidify the [science context]" (Session 11). In this exchange, the mentee felt pessimistic about his class performance, and while she began by listening, she shifted the focus by validating his experience and redirected back to his goals/readiness. This example, though rare, exemplifies the value of redirection in aligning immediate concerns with broader objectives.

Conversations about short-term needs into conversations about long-term goals (Bb) were facilitated through strategic questioning to connect mentees' immediate challenges with evidence of progress toward the goals. Table 4.12 shows that this occurred in 10% of all Bifocal Vision implemented by the three mentees; however, there was no guarantee that the mentees would have short-term goals that related to the long-term goals, making it challenging to locate moments where the mentor was able to guide the mentees in connecting them. Samantha demonstrated this by addressing her mentee's difficulties with lesson pacing. Samantha was wrapping up a session when her mentee shared that she was having difficulty with a lesson. She reassured her mentee by stating, "I can see how you're not only being intentional when you're doing whiteboard meetings, but also it helps with your timing and making sure they're still getting to the point" (Session 10). Samantha's observation provided evidence for the mentee that showed a connection between the short-term goal to be more intentional with the whiteboard with the long-term goal of getting the material covered within the pacing time restrictions, effectively linking a short-term improvement to the broader goal of mastering pacing within the curriculum.

Mentors frequently provided opportunities for goal evaluation (Bc), though purposeful revisions were less common. This partial representation of the key feature resulted in it holding 16% of the overall Bifocal Vision component use across the cases. Reviewing the goals was most often done at the end of the semester or school year, through questioning. While the mentors would check in with their mentees and collaboratively monitor progress in general, as described as part of Collaborative Learning, the mentors would also intentionally include conversations that specifically addressed progress monitoring of goals. The mentors would ask questions about the mentees' beliefs about their own goal progress or may have used

observations from their recorded lessons as evidence of their progress in the goal. On rare occasions, those conversations would include an opportunity for the goal to be revised. During a lesson review session, Samantha included all of these practices when she shared:

> We talked a lot about how you grew from the last one to this one in the questioning and the style of your whiteboard meeting, even how you presented the breakouts—how you had them do a demo first. Do you feel like all of that is growth as well, or do you feel like there's anything you want to piggyback off of and say, 'I want to make some more changes to this?' (Session 16b).

During this monologue, she recalled their discussion about the mentee's growth in the goal. Then, she transitioned to providing evidence of her growth from lessons before inviting the mentee to reflect on this growth. Finally, she asked the mentee to share her insights about the goal by asking if she intended to change it. This illustrates a layered approach to goal monitoring, beginning with evidence-based reflection and concluding with an invitation for mentee input on potential goal adjustments.

The mentors' ability to probe mentees' beliefs, experiences, and knowledge of best practices (Bd) revealed significant variance across the cases. While it was the most represented overall (32%), Samantha (26%) and Xavier (49%) showed much higher relative use of this feature than Fiona (6%), as modeled in Table 4.12. Mentors would ask questions seeking to gather information about the mentee and discover connections to learn about their pedagogical and epistemological beliefs; however, this occasionally included experiences outside of the science classroom. Xavier demonstrated a nuanced understanding of his mentees by engaging in discussions that extended beyond classroom practices, incorporating insights from their personal and professional histories. For example, he referenced Xin's pre-teaching career and

extracurricular activities to build rapport and tailor his guidance, but some other examples of making connections were more personal and were not included as EM practices. Engaging with a mentee's diverse experiences can enhance trust and create opportunities to contextualize best practices in teaching. In contrast, Fiona relied on active listening to accommodate her mentee's frequent self-disclosures, aligning her mentorship approach with her mentee's communicative style. This presents as an infrequent EM practice due to Farah disclosing much information about herself unprompted, which lessened the likelihood that Fiona would ask questions to facilitate this exploration. These efforts demonstrate the importance of holistic mentorship that balances fostering rapport and maintaining focus on professional development.

Individualization based on the specific needs and experiences of the mentee (Be) emerged as a critical aspect of effective mentoring, as the three cases focused 24% of their examples of Bifocal Vision rooted in the connections mentors established during discussions and goal-setting. Using those connections and recalling details about the mentees, the mentors honed in on the individual needs of the mentees in their practice. This resulted in the mentors having different structures and routines for how they planned and conducted their sessions, framed their feedback, and made suggestions. For instance, Xavier recognized the financial constraints of his mentee's rural school and responded by offering tangible support, such as materials and personal delivery. This approach illustrates practical responsiveness and a commitment to addressing systemic barriers that could hinder the mentee's implementation of best practices, reinforcing the mentee's capacity to succeed within a challenging context. Similarly, Samantha understood that Safira was up against a different pacing and timeline because she was teaching AP Biology. By recommending modifications to the MI curriculum and drawing on her own experiences, Samantha provided both practical solutions and validation, creating a mentorship dynamic that is

grounded in empathy and expertise. Fiona's individualization took the form of adjusting session content to accommodate Farah's dual role as a teacher and graduate student. Incorporating lighter topics and recognizing milestones such as the mentee's graduation demonstrated an awareness of the mentee's emotional and cognitive load, prioritizing well-being alongside professional development. These intentions were not always overt; many required observations across multiple sessions to be fully appreciated, suggesting that individualization is a dynamic process that requires sustained attentiveness and flexibility.

There were not many clear examples of the mentors having to be explicitly respectful of something their mentee was doing in their lessons that differed from their own teaching (Bf), as it made up 14% of all Bifocal Vision occurrences in the study, because they were all using the same MI curriculum. However, some mentees struggled with implementing MI in their classrooms, as they were battling school or county pacing requirements and state testing pressure. For instance, Xavier demonstrated this balance when addressing Xanthe's preference for multiple-choice assessments due to time constraints. Specifically, Xanthe expressed that she did not think she had time to conduct complete labs for the topic and that she wanted to find a multiple-choice test her students could do with a scantron and then move to the next topic quickly. Rather than dismissing her approach, he reframed it as being a good strategy when used as a pre- and post-assessment strategy that could be used to support a partial use of MI for that unit, explaining:

> You can, at least particularly using Modeling Instruction, go back, and when you give [the multiple-choice test] to them at the end of the semester, then you actually have a benchmark for what they learned that you taught them versus what they learned because

they already knew it, or whatever the reason, and that's easy to do with a scantron (Session 12a)

This example reminded the mentee that MI was the focus, was one of her goals, and that he understood the pressure she was under, all in a way that did not reveal that he disagreed that using a scantron test was the best method for assessing her students, which preserved rapport and reinforced long-term goals. Fiona faced similar challenges with Finn's reluctance to adopt full MI practices, despite having set the goal of implementing it in all his classes. Instead of insisting on fidelity to the MI curriculum, she strategically suggested incremental best-practice changes. These examples reflect a pragmatic respect for mentees' autonomy and constraints while changing pedagogical practices.

Reflective Discourse

Educative mentorship requires that mentors both encourage and participate in reflective conversations. Through their review of lessons, the mentors modeled reflective thinking about the pedagogy and methods they are all implementing, encouraging mentees to critically examine their own lesson designs and consider purposeful adjustments to their teaching practices. In these reflective moments, the mentors provided insight that encouraged examining problems from multiple perspectives, including evaluating their lesson differentiation and planning for the needs of a diverse student body. While the theoretical framework of Reflective Discourse was evident across the three case studies, its practical application across the three mentors was inconsistent, as highlighted in Table 4.13. The data indicates that while mentors frequently included their own reflections in discussions (38%), they were less effective at stimulating mentees to engage in a deeper exploration of their practices (14%) or integrating these reflections into plans for addressing specific student needs (2%).

Table 4.13

Mentor Use of Each Key Feature- Reflective Discourse

Key Feature	Samantha	Fiona	Xavier	Total (%)
Ra- Explicitly models reflective thinking and pedagogical reasoning	20%	40%	53%	38%
Rb- Asks purposeful questions to develop mentee's reflection skills	30%	-	21%	24%
Rc- Stimulates deep thinking about how and why certain changes are made	28%	-	3%	14%
Rd- Helps examine a problem from multiple perspectives	10%	40%	19%	16%
Re- Guides reflection to what degree a lesson is inclusive, equitable, and accessible	10%	20%	2%	6%
Rf- Supports developing plans that meet the needs of diverse students	2%	-	2%	2%

There were many opportunities for the mentors to share their reflections about how they reasoned through pedagogy in their lessons (Ra) with their mentees, making up 38% of all attempts to implement Reflective Discourse. This modeling occurred both during collaborative reviews of mentees' lessons and through narratives of their own teaching experiences. They used reflective narratives about lessons they had taught to demonstrate their reasoning and decision-making processes. On rare occasions, the mentors would demonstrate reflective thinking organically within the CoP because of something a mentee shared, offering a reactive response to what they heard and expressing what it brought up for them regarding their practices. During a session discussing chromosomal mutations, a mentee shared a modification they made to include some of the beneficial mutations that typically get left out of these lessons. Fiona spontaneously reflected, "I didn't think about this. When we're talking about sickle cell and how it helps with

malaria, so mutations aren't always bad" (Session 5). Such moments demonstrated how CoPs served as platforms for structured and emergent reflective practices, allowing mentors to normalize self-reflection within mentoring sessions.

Purposeful questioning was utilized in 24% of Reflective Discourse to develop mentees' self-reflection (Rb). The mentors' questions often encouraged mentees to critically assess their experiences, compare approaches, and explore their decision-making. Using questions, the mentor avoided the temptation to identify problems directly and allowed the mentee to develop self-reflection skills. During an intentionally reflective session that explored the mentee's recorded lesson, Samantha asked a question to get her mentee thinking deeply about the facilitation of the whiteboard meeting, a part of her lesson specifically planned to encourage student discourse about the science topic. She asked, "How do you think this whiteboard meeting compared to the first lesson?" (Session 9a). This question elicited a detailed 186-word response from the mentee that included her strengths and skills to improve, requiring no further explicit prompting by the mentor, demonstrating the potential of targeted questioning to provoke meaningful self-analysis. However, the success of this strategy varied, often contingent on the mentees' natural inclination towards reflection.

Through their inquiry-based conversations, the mentors engaged in Reflective Discourse 14% of the time by questioning the mentees' reasoning to probe for deeper exploration (Rc) of why the lesson went a certain way. Similar to how they prompted the reflection through questioning, the mentors also probed the mentees to look deeper and more critically at their decisions. For example, during an individual review with Sora, Samantha questioned, "You changed this thing up, and I loved it, and your data was awesome. So, what made you decide to go from the oceanic ecosystem to more of the forest ecosystem?" (Session 16a). This question

posed by Samantha focused on Sora's reflection through targeted critical thinking, focusing on the reasoning behind her decisions. This level of questioning encouraged mentees to revisit their planning processes and connect them to lesson outcomes. While there were conversations where the mentor would ask open-ended questions about what mentees thought happened in a particular lesson, this expansion into a critical examination of specific decisions was rare, reflecting a missed opportunity for deeper reflective engagement.

Mentors occasionally broadened reflective discussions by framing problems through diverse perspectives (Rd), accounting for 16% of Reflective Discourse. By framing a potential problem using multiple points of view, the mentee could consider antecedents and consequences more holistically. Typically, the questions bring attention to the experience from a student's perspective or through a scenario for a possible future to plan for. When Xanthe expressed frustration about her students not taking initiative, Xavier asked, "Down the line where will these kids end up? Is this the end of science for them?" (Session 9a), emphasizing the broader implications of MI for students' future learning. Xavier offered the perspective that not all of her students are planning on heading into college-level biology, so what she was teaching them with MI was, "setting them up. The things you're doing will help them in the long run. They can't see it right now. And you may not see it right now. But it certainly helps in the long run" (Session 9a). In this example, Xavier's different lens was used to bring the overall purpose of what the mentee was attempting back into her purview, preparing her to start problem-solving the issue. Considering alternative perspectives helped mentees contextualize their teaching within larger educational goals, fostering a more comprehensive understanding of their practices.

Reflections on equity and inclusivity (Re) were scarce, comprising just 6% of Reflective Discourse. Discussions were often focused on scaffolding or differentiating lessons for standard

or advanced-level coursework. In one example, Fiona shared about using MI in an inclusion setting: "I had inclusion every year. They grew. Now, were they proficient? No, but they grew. So that was huge" (Session 5). While Fiona was sharing her own experience, the discussion between them led to Farah sharing her experience, but they did not transition the conversation to planning or assessing the students. While such reflections added value, the limited frequency of these equity-focused conversations highlights an area for growth in EM practices.

The lessons being taught by the mentors and mentees were part of the MI curriculum, which may have had an impact on the amount of time that the CoPs had to use their reflections to make changes to lessons they intend to teach in the future (Rf). This EM practice was only found twice across all the mentoring sessions, making up 2% of all Reflective Discourse during the academic year. In both examples, the conversation focused on making future plans related to how the mentees planned to use the MI materials. For example, during a session reflecting on a past lesson with Safira, Samantha asked, "So you want to change [or] flip it around this semester?", inquiring about changes she planned to make for the next semester regarding that lesson specifically (Session 16b). While conversations like this occasionally prompted mentees to consider adjustments for upcoming semesters, these reflections often lacked depth and specificity regarding pedagogical intentions.

Focus on Student Thinking and Experiences

Focusing on what students are thinking and experiencing during lessons is another important component of EM. Student Thinking shifts discussions from centering on the teacher's actions to examining the effects of teaching on students. Ideally, all members of the CoP would share artifacts of learning, such as assessment data or examples of student work, to analyze students' cognitive processes and incorporate these insights into lesson planning and instructional

decisions, connecting theory and method to their classrooms. As evident in Table 4.14, this component was not implemented evenly, with many gaps across all three mentors. This is the only component with two key features not discovered in any of the mentor cases (Te and Tf), and findings were rare in others.

Table 4.14

Mentor Use of Each Key Feature- Focus on Student Thinking

Key Feature	Samantha	Fiona	Xavier	Total (%)
Ta- Focuses on student thinking rather than teacher behaviors or actions	50%	67%	50%	54%
Tb- Uses observation and/or data to help elicit and interpret students' ideas, and how to use students' thinking in instructional decisions	25%	-	20%	17%
Tc- Aligns talk about student thinking with student-centered theory and practices	25%	25%	15%	21%
Td- Guides development of plans to gauge student learning	-	8%	15%	8%
Te- Supports analysis of data and models how to probe and interpret student thinking	-	-	-	0%
Tf- Supports using data from assessments to plan future assessments and lessons	-	-	-	0%

A significant proportion (54%) of the examples of this component involved mentors directing discussions toward student outcomes rather than teacher practices (Ta). However, this emphasis was often surface-level, limited to generic inquiries about how the mentee felt the students were doing with MI lessons and science concepts. While nominally focused on students, these questions rarely explored deeper insights into student thinking, engagement, or progress. For example, Xavier prompted Xanthe to reflect on what he noticed students doing in the room while reviewing recorded lessons, commenting, "You just happen to have two kids that were real

knuckleheads…I felt bad for the girl that shared a group with them because she kind of had to put up with these two knuckleheads. And I guess, I mean, they still got the work done" (Session 4a). He followed up by asking her for more information about their tasks and how they were progressing. This conversation focused on students' actions in the lesson, but lacked the depth to develop mentees' interpretive skills regarding student cognition significantly.

The use of learning artifacts or data to interpret students' ideas (Tb) was underrepresented, with only 17% of examples aligning with this key feature of Student Thinking. As previously discussed, the CoPs prioritized implementing the MI curriculum, resulting in limited opportunities for mentees to develop new lesson plans based on student artifacts or data. Instead of directly facilitating mentees' analysis of student data, mentors often relied on anecdotal recollections to illustrate how they had interpreted their students' ideas in similar past situations. Observations of mentors modeling how to analyze Student Thinking through artifacts produced few concrete examples. To gain more nuanced insights into practice, separating this indicator into two distinct categories may be helpful: identifying examples of interpreting student data and demonstrating how to use students' thinking to inform instructional decisions.

Alignment of discussions with student-centered theory and practices (Tc) accounted for 21% of all examples of mentors focusing on Student Thinking, though this was found most often during discussions regarding MI pedagogical approaches for the students. Additionally, these discussions were typically implicit, as mentors validated mentees' reflections on lesson efficacy, such as when Samantha validated Sora's reflection on a lesson's effectiveness for the students by expressing:

> [It's good], that idea on which ones you felt like your kids got more out of and which ones you [think] 'yeah, I'm good with that one, I can take that out.' So if you make those

changes, each group presenting on specific ones, they're still getting those concepts and they've been exposed to different stations to see how energy is flowing (Session 9a). Samantha encouraged Sora to refine their lessons by focusing on which aspects students understood best while preserving essential MI practices. This dialogue highlights the adaptability of MI to meet both instructional goals and student needs, though it lacked a systematic connection to broader theories of student-centered learning.

The mentors would occasionally discuss specific lessons or assessments in reference to the students' roles and actions (Td), though only representing 8%, it was not a frequently practiced feature of Student Thinking. The few occasions were primarily for planning purposes, though some examples included exploration of how/what the students were thinking during lessons. In one noteworthy example, Fiona encouraged mentees to reflect on assessment data by asking how the mentees felt their students compared in data to the same time last year. She emboldened them to use assessment data to discover, "Is the modeling really working? And what data could we have looked at to figure that out? Because that's what I'm interested in. Because that's what we need to know. Is it working or isn't it?" (Session 5). Fiona demonstrated that the purpose of using MI is to improve student thinking and the data in their assessments could help them determine if their reform-oriented practices are effective. While this was an example of guided thinking, the conversation did not culminate in actionable plans to improve assessments or align them with insights into student thinking.

No examples (0%) were identified in which mentors actively supported mentees in analyzing assessment data to interpret Student Thinking (Te) or using these insights to design future assessments and lessons (Tf). These missing practices were primarily attributed to the absence of artifacts and examples of student work in the formal mentoring sessions. While

Samantha reflected that mentees occasionally shared artifacts showcasing student success in their informal group chat (VSI, Fall 2023), these artifacts were not revisited in subsequent discussions for deeper analysis or exploration; therefore, these instances could not be substantiated as evidence of this practice. Overall, the key features emphasizing Student Thinking were the least represented, offering limited insight into how this aspect was applied in the context of EM.

RQ2 - Components and practices of EM consistently implemented, and difficulties

Over the two academic semesters of their mentorships, all three cases showed evidence of the educative use of questions, statements, and stories to connect with the mentees, facilitate discussions that model reflection and reasoning, focus on the goals and needs of the individuals in the CoP, and collaboratively improve general and science-specific teaching practices. The mentors included many different types of questions and suggestive statements that would be considered educative. Still, they also used some traditional mentoring practices to engage with mentees more directly, indicating that the mentors faced some challenges as they embarked on their first attempt at operationalizing the components of EM with their CoPs. Patterns in the implementation of specific components and key features highlighted areas that were consistently practiced and identified missed opportunities where the educative nature of mentoring could have been improved to better align the theoretical and practical components of EM.

Frequency and Consistency

There were differences in the individual mentor's frequency and consistency when compared. Overall, all cases had a considerably high-level representation of EM components and features. This indicated that each mentor made personal decisions regarding how frequently they would use EM with their mentees during specific sessions, as well as how they included the EM practices consistently as part of their mentoring routine. Overall, the frequency of EM

components was similar for all three mentors, with the most observed being Situated Inquiry, followed closely by Collaborative Learning and Bifocal Vision. The Student Thinking components represented a stark difference from the other components, as the least used component for all the mentors. There is a sizable variance in the inclusion of Reflective Discourse between the mentors, due to Fiona's markedly lower rate than the other mentors.

The indicators that appeared most frequently were not necessarily the same as those used most consistently throughout the academic year. High averages of an EM component illustrated which individual components or practices the mentors repeated most frequently throughout the entire academic year, but there were no clear patterns of how the components were used in any given session. As seen with Samantha (see Table 4.15), individual sessions could have required or relied on specific EM components and neglected others, resulting in high-frequency scores that do not reflect consistency for including a specific key feature that indicates that the practices could be considered incidental or occasional.

Table 4.15

Consistency of Inclusion Across Mentoring Cases (by Main Component)

EM Component	Samantha	Fiona	Xavier	All Three
Situated Inquiry	93%	67%	93%	84%
Collaborative Learning	87%	53%	87%	76%
Bifocal Vision	100%	53%	93%	82%
Reflective Discourse	100%	13%	93%	69%
Focus on Student Thinking	33%	60%	60%	51%

Note. Percentage indicates how often at least one key feature of the component was observed across all 15 sessions for that mentor and all 45 sessions combined.

In contrast, high consistency percentages suggest that a mentor used the component as a part of their mentoring routine over several sessions, indicating a habitual inclusion of EM as standard practice. To clarify, Samantha most frequently used Situated Inquiry and Reflective Discourse during the school year, while Table 4.15 shows that she included practices of Bifocal Vision in 100% of her sessions, making it her most consistent. This demonstrates that one session can be substantial due to having multiple uses of a single component, but may not be presented as consistently strong across many sessions. Similarly, a mentor can be implementing an EM component consistently, but may have many single examples, like Xavier's consistent implementation of bifocal thinking despite not having many examples in individual mentoring sessions (Table 4.15, Xavier's EM Implementation).

Fiona's low consistency in all components impacted the overall average (See Table 4.15), but all three mentors incorporated three out of the five components into practice in over 50% of their sessions. Two of the mentors had levels of consistency above 60% for all indicators, with most being above 85%, indicating that the mentors could repeatedly apply the EM practices with their CoP. At 84%, Situated Inquiry is the most consistently implemented component of EM across the cases, followed closely by Bifocal Vision at 82%. Collaborative learning was included in 76% of all sessions with the CoPs, as there were explicitly planned collaborative opportunities for planning that were not evident in the sessions, but maintained a relatively consistent feature. Reflective discourse had the widest difference between the consistency levels across the cases, with Samantha and Xavier having levels above 90%. In comparison, Fiona only included explicit Reflective Discourse in 13% of her sessions.

Across all the mentoring cases, the leading component in frequency and consistency was Situated Inquiry. This was the only component where each key feature indicator was found at

least once in all three case studies, representing 28% of all the EM components found in the mentoring sessions, the highest percentage and most qualified overall. The six key features that comprise the theoretical ideas of Situated Inquiry were used most consistently across all the sessions, appearing in 38 of the 45 sessions (84%), with each mentor including elements of Situated Inquiry in over 10, or 67% of their fifteen sessions. One of the main reasons this educative component was so widely represented was that when mentors used questions and active listening to help identify a problem of practice (Ib), they also addressed other components. For example, utilizing inquiry and active listening can indicate that the mentor asks probing questions, but other indicators also describe asking specific types of questions. In this situation, using inquiry as a practice is an umbrella component that includes key features of other components, some of which were co-coded together during the deductive analysis, including:

- The mentor **guides** the mentee to identify a problem of practice and using the identified problem to set goals and to determine strategies to achieve them (Ia).
- The mentor **explores** lesson content, sequence, and structure with the mentee (Cd).
- The mentor **probes** the mentee's beliefs, prior experience, readiness, knowledge, or skills related to research-based best practices in teaching science (Bd).
- The mentor **purposefully asks questions** to develop the mentee's reflection skills (Rb).
- The mentor **engages** the mentee in conversations focusing on student thinking rather than teacher behaviors or actions (Ta).
- The mentor **facilitates conversations** about student thinking in a way aligned with contemporary learning theories and student-centered, reform-oriented practices (Tc).

These co-coded key features included language that describes an observable practice that would be utilized through an overall questioning approach (Ib). This sort of overlap in the coding

scheme may not accurately represent the actual frequency or consistency in which the mentors were using inquiry (Ib) when engaging with their mentees, as the classification during observation may be reduced to identifying a single code, resulting in the omission of the other indicator. However, it also provided ample examples of practical application of how the components of Situated Inquiry were integrated into other key features throughout EM.

Missed Opportunities

As previously stated, some features of EM were not as evident in the mentoring sessions, some because the mentors were met with challenges, and others because the mentors made no attempts to include them. Focus on Student Thinking was, by far, the least frequently included EM component, representing only 38 of the total 135 sessions (28%). In this component, two key feature indicators were not found in any of the cases, specifically the practices of analyzing student data and using it as a discussion about probing student thinking or as a planning tool for lessons and assessments. The focus in lesson planning or student-centered conversations was typically restricted to how MI was used as a curriculum. The lessons and materials were already planned as part of the curriculum, so the importance of designing and modifying was likely low compared to building the mentees' confidence in shifting their teaching methods. The mentors were intentional about using questioning in their discussions and centering the sessions around talking about science content and the specific goals of their mentees, but turning those reflections and shared experiences into actionable tasks that would build or create materials targeted at improving the experience of students in those lessons was missing. The mentors did discuss students, with some questioning to probe the mentees in reflecting on what they believed students were thinking or why they were struggling. These discussions left room for the mentors

to include more proactive strategies that got the mentees to evaluate what students were doing and thinking using examples of their work.

Related to working collaboratively with the CoPs, there was a notable absence of learning opportunities created by mentor where the CoP could delve into a problem as a group of peers. Xavier discussed a collaborative activity for himself and the mentees, which was observable but never initiated or addressed after those first suggestions. He was still separating the sessions at that time, so any collaboration would have proved difficult. Opportunity to collaborate was also missed when the mentors used storytelling to demonstrate or explain. While there were stories shared by all members of the CoP that explored mutual problems, without intentionally drawing connections between the stories and facilitating discussions about the application of what they could learn from those stories, these occurrences could not be considered explicitly educative because the mentee is not actively engaged. During the fall and spring in-person Summer Institute follow-up workshops, the mentors led workshops that introduced new MI content to the mentees before facilitating mentoring sessions that had the potential to include some Collaborative Learning as they reviewed the new MI information in discussion together. Unfortunately, the differentiation between their instructor and mentor roles was weak, leading the mentors to lead the conversations and spend more time answering questions the mentees had about specific MI curriculum, making it unclear whether this would qualify as collaborative EM.

Another missed opportunity was the mentors' methods to provide and review their feedback with their mentees. It was evident that sharing feedback was done to help the mentees identify areas that were successful and those that could be potential areas of focus for goals or changes. During the sessions devoted to discussing the mentees' recorded lessons, the mentors relied on providing feedback based on their own observations and perspectives, where they

dispensed praise and suggested areas of focus, but did not include opportunities for the mentee to reflect or explore potential problems. For example, Fiona shared her opinions on Farah's lesson:

> What I really loved was when they made a flowchart of start to finish… they can even do [it] before and add to it after, because, like my kids, they just want to go in and run in and do it and didn't really read the directions. That would be a good way to make sure they did (Session 7).

This example demonstrated another missed opportunity. The review sessions also saw an increased use of suggestions and opinions that did not clearly connect to the EM components. Fiona shared her insight, following praise for a specific activity in Farah's lesson, before offering a suggestion that would address a concern she found. This would have been more educative had Fiona used questioning to guide Farah in seeing the students' lack of reading instructions.

One of the most human, but not educative, exchanges was when problems presented by the mentee were not attended to, either because the mentor did not have a direct answer, or the problem felt unsolvable. For example, Fiona's mentee brought up a student who was giving her a particularly difficult time, and Fiona replied that she would, "keep praying about that one," (Session 7). During a discussion about a mentee's attendance inconsistencies, Xavier simply said "I don't know what to do about that," (Session 13a) and the problem was not addressed. These statements stop the conversation before the mentee can feel a sense of resolve over the situation. With an educative lens, these may have been tricky topics, but putting the problem-solving back into the hands of the mentee through carefully considered questioning may have improved the chance that a solution was possible. For the first year of implementation, these missed opportunities and challenges are not regarded as deficits of the EM approach, but rather practices

that may be addressed and acknowledged through self-reflection and additional professional development support.

RQ3 - Key characteristics of decision-making in educative mentoring practices

Knowing how the mentors used EM in their CoPs and what challenges they faced in their implementation begins to connect the practical and theoretical concepts of this mode of science teacher mentorship. After the full academic year facilitating the CoPs with their MI mentees, the mentors were asked to reflect on their experiences including EM, and share insights about their processes and motivations that informed how they operationalized EM practices, through a video-stimulated interview (VSI). From their responses, four big ideas emerged as key characteristics in the mentors' decision-making processes that influenced their implementation of EM during this specific academic school year. Figure 4.1 models how this process transpired through the lenses of connected relationships with the mentees, shared benefits and roles with the CoP, individualized needs-based focus, and each mentor's personal convictions and knowledge.

Figure 4.1

Themes in the Characteristics of Mentors' Decision-making

Each mentor shared the beliefs and motivations that guided their intentions for utilizing EM within their CoP. They explained how they structured their meetings, decided where to focus discussions, and how they managed relationships. This process was self-reflective for all three

mentors as they shared positive shifts and changes that they plan to make in future CoPs. They offered feedback and reflection about their understanding of EM, including what support they received that strengthened their practices and additional support that they believe could make EM clearer and easier to implement. The thorough dive into their beliefs, intentions, motivations, and reflection highlighted common ideas and beliefs that guided the mentors' implementation of EM with their mentee(s). Their responses revealed that they were motivated by the connections they had and could build with their mentees, the mutual benefits of collaborating with fellow MI educators, the needs of their mentees, their own personal convictions, and the EM training they received from SIMIRS.

Mentoring Through Connection With Others

The relationships mentors built with their mentees played a critical role in shaping their mentoring decisions. While they frequently mentioned the importance of relationships in interviews, their descriptions highlighted how meaningful connections formed the foundation for effective mentorship. They expressed that these relationships needed to be cultivated more intentionally than other professional relationships to ensure a strong sense of trust and support within the CoP. Samantha emphasized that simply spending time together was not enough to build strong relationships, stating, "I don't think it's the mode in which you connect, it is truly like we're connecting, that will be enough for each other." Her perspective reinforced the idea that genuine, meaningful engagement was more important for developing a successful mentor-mentee dynamic than the format or frequency of meetings.

The mentors also recognized that each mentee's personality influenced their interactions, requiring them to adapt their approach. Xavier described, "Xanthe is more like chatting with my daughter. And I have good conversations with my daughter. But she's young enough that I kind

of look at her that way, versus Xin, which I look more like a peer or colleague." Their differing dynamics shaped the tone and structure of their mentoring sessions. Similarly, Fiona adjusted her approach based on the level of trust she had with her mentees. She reflected on how a lack of connection with one of her mentees impacted her ability to provide meaningful feedback, stating, "I don't think he had a lot of trust in me, because we didn't have that relationship, so it was really hard to give him feedback." Her experience demonstrated that without a strong relationship, mentees struggled to engage with the CoP and were less receptive to mentorship. This was evident in Xavier's relationship with Xin. Xavier saw similarities between Xin's journey and his early career. He explained, "I see a lot of parallels between what [he] went through and what I went through as a lateral entry… and so it was kind of fun to watch him and think back, how much is he like me or, or not?" This sense of identification shaped Xavier's approach, as he engaged Xin in reflective discussions similar to those he had, or wished were asked by mentors he had early in his career.

To foster these essential connections, the mentors deliberately built rapport with their mentees, often incorporating personal conversations into their sessions. Xavier, for example, ended one meeting with Xanthe by inquiring about her baby and mother, joking about her mom moving closer to help with the new grandchild, and sharing a personal story about his family. This exchange demonstrated how casual, personal conversations helped strengthen the mentor-mentee relationship, reinforcing a sense of trust needed for mentorship.

Balance of Sharing and Learning

The mentors navigated their roles within the CoPs by emphasizing a balance between sharing their knowledge and learning alongside their mentees. They viewed their mentorship as a collaborative process, where professional growth was a shared endeavor rather than a one-

directional exchange of expertise. When deciding who should lead the CoPs, the mentors strongly believed that all members should act and operate as peers and fellow teachers working towards a common professional growth goal. They all agreed that there should be no clear "leader" or expert for their sessions. The relationship dynamic should be that of peers, and it was essential to the mentors that they are not seen as experts. Despite having the most experience using MI, Fiona recognized that others in her CoP had valuable insights from their years in the classroom or unique career experiences. She was adamant that mentoring was about relationship-building rather than authority, stating, "I don't ever want to feel like I'm in charge, because I'm not an 'in charge' kind of person… I think it is more of a relationship, not a 'this is what you need to be doing' kind of thing." This demonstrated her belief that their role was not to be the ultimate source of knowledge but rather a contributor to a shared professional learning space and should not be seen as perfect or all-knowing. Samantha reinforced this idea, contrasting traditional mentorship with EM, explaining, "As a traditional mentor, you are not really human… This is the complete opposite. You want them to see you as a human... We're not in the same building, but we're in this together." EM allowed her to be seen as a teacher who could share ideas, not an evaluator or administrator. This perspective allowed her to engage authentically with her mentees and facilitated an environment where everyone could share openly. As a similar sentiment, Xavier expressed, "I don't know if the role at that moment was any different than it ever was, which is the community of practice." To him, his role in EM was not fundamentally different from his usual approach, feeling he had always mentored through a community-driven model, exchanging ideas and experiences rather than dictating best practices.

This equal and balanced approach to mentorship resulted in a dynamic where both mentors and mentees benefited from the experience. This motivated them when making

decisions about how they interacted as part of these CoPs. Xavier described this motivation: " You're working with a group of teachers who are interested in improving their practice. And so, they're already that kind of teacher. Most of the time when you're working with them, I get as much as I give." The mentees inspired him through their curiosity about MI. He noted that this ongoing exchange of ideas played a role in his decision to continue mentoring even beyond his expected retirement. Besides motivating him to keep teaching science, the mentor and mentees gained fresh ideas, perspectives, and support for their current and future goals.

The mentors also actively sought knowledge from their mentees. Samantha discussed the NBCT process she was considering with her mentee. Xavier shared his extensive collection of teaching materials with teachers who needed them. Fiona, who had recently transitioned into a new role in an elementary setting, received a helpful tool from her mentee, significantly supporting her adaptation. She acknowledged the impact of this exchange, sharing, "She knew I was in a new job and had no idea what I was doing. I learned a lot from [her]... she helped me way more than I probably even helped her." The overall impression from the mentors was that being a mentor who can work alongside their CoP to learn new things and share ideas about best reaching students was rewarding, which informed their approach to mentorship.

Individualized Mentorship

The mentors made decisions about their mentoring practices based on the individualized needs of their mentees. They used their background knowledge of mentees' experiences, needs, and personalities to guide their mentorship. This knowledge shaped their session focus, influenced feedback, and informed goal-setting. By considering mentees' time and needs, mentors intentionally planned sessions that adhered to time limits and remained on topic, allowing for personalized and effective mentorship.

All mentors began sessions with general check-in questions and follow-up open-ended probing to determine mentees' needs. Fiona structured her sessions to include these check-ins, often navigating personal or professional topics. She explained, “The beginning was kind of planned like, ‘I need to check on [her] and ask how are you doing’ because, mentally, we need to check, but then get them to business.” Given the open-ended nature of the mentoring approach, session focus varied. While some meetings centered explicitly on MI science lessons, check-ins often guided discussions toward professional concerns or personal experiences, such as sharing grievances or celebrating achievements.

The flexible nature of mentorship allowed mentors to adjust their support based on the mentee’s prior knowledge and skills. Samantha exemplified this in her CoP, stating, “Safira has the experience and because she's done modeling before, she already had exposure to the storyline before, so her questions are different than Sora's.” She adapted her mentoring approach to meet the specific needs of each mentee, ensuring that support was relevant and appropriately scaffolded. Xavier also prioritized equitable experiences for all mentees. This contributed to his decision to conduct separate sessions, recognizing that a joint meeting would be impractical given their different subjects. He explained, “I think if we had tried to do joint meetings while they were teaching two different subjects, it certainly would have been awkward.” However, he acknowledged the drawback that this separation limited collaboration opportunities for mentees to solve problems together. Samantha also saw the value in individualized sessions, particularly when reviewing lessons, as she believed it fostered honest reflection and goal-setting. She shared, “It helped me with the intentionality of how to question each of them, when to question each of them, when to ask somebody to share.” This approach demonstrates how mentors tailored their questioning and interactions based on their mentees' unique needs.

Reflection and Feedback Importance

Reflection emerged as a central theme in the mentors' responses. Throughout the study, the mentors actively engaged in reflection, both individually and within their CoPs. The feedback sessions on the mentees' lessons offered a structured collaborative opportunity for the mentees to contemplate their perspectives based on their experiences teaching with MI.

As mentioned, the mentors were influenced by their connections with their mentees. Mentors emphasized that strong connections with their mentees contributed to a more open and honest CoP, which, in turn, enhanced reflection. In connected CoPs, members felt comfortable sharing their experiences candidly while receiving constructive feedback from mentors. This vulnerability fostered open conversations and constructive evaluations of practices. Samantha explained this dynamic as a: "closer relationship and so you did feel more comfortable sharing a lot more things than you would before." To model reflection, the mentors frequently told reflective stories and shared how they reasoned through past experiences in their teaching. They recognized that this practice, valuable in their MI teaching, was equally impactful in their mentoring. Specifically, Xavier used his storytelling to demonstrate his shared experiences and illuminate best practices in MI, which sometimes led him to realize something about his own teaching.

Despite its expressed importance, mentors initially needed to adjust their approaches to ensure mentees actively engaged in self-reflection rather than passively receiving feedback. They reassessed their questioning strategies, intending to shift their focus from providing direct observations and recommendations to guiding mentees toward generating their insights. Samantha recalled a few times when she had to adjust her approach and provide opportunities for mentees to reflect and generate ideas through inquiry rather than using directive approaches,

such as offering suggestions or referring strictly to the curriculum plans. Describing a time when she changed a direct statement into an open-ended question mid-sentence, she noted that the initial conversation felt like a routine lesson review. This realization prompted her to shift into "reflective mode" to add value to the discussion. She explained, "That's what's going to continue to make us better, being a reflective educator and focusing on why we did what we did," underscoring her commitment to modeling reflective practice for her mentees.

Mentors intentionally incorporated dedicated reflection sessions into their mentoring, using feedback as a co-reflective process. They structured sessions around reviewing mentees' recorded MI lessons, typically providing their insights and suggestions. Fiona described her structured approach to feedback: "As I watched the videos, I wrote down things that sparked either love or 'why don't you try this next time' kind of thing. I feel like we should always start with good." This informal but intentional structure helped maintain a balanced and constructive tone in feedback sessions. While mentors played a dominant role in providing feedback, they later recognized the need for mentees to take greater ownership of the reflection process. Each mentor identified this as an area for growth. Xavier wanted mentees to lead their lesson reviews by identifying their strengths and areas for improvement. This shift would allow mentors to make more educative choices, guiding mentees toward self-identified problem areas rather than prescribing solutions, rather than providing them. Fiona reinforced this idea, suggesting that mentees engage in more structured self-reflection: "Like we're looking at where [they] were at the beginning and where [they] are now after a year under [their] belt. What do we still need to work on?" Samantha also recognized the value of collaborative reflection, adding that she needed to plan sessions where the mentees could reflect on lessons together, incorporating more collaboration in the reflection process.

Mentors also value reflection as a tool for their own growth, particularly when sharing their experiences with SIMIRS researchers. In one instance, Xavier gained a new perspective on his mentoring after watching a recorded session and discussing an observation made by a researcher. He responded, “It's good you picked up on it, because I did not see that until watching it the second time around,” illustrating how external feedback contributed to his reflective process. He further emphasized that the opportunity to reflect was personally motivating, aligning with his high expectations for quality mentoring.

Influenced by Teacher Beliefs and Experience

Using their MI and experience as reform-oriented teachers as a foundation for EM, the mentors explored how to interpret the components in practice. Each had to set an intention to change or grow in their mentoring practice. Xavier explained that he had to believe in the method and make conscious decisions about how to do that, which he could do because he saw an alignment between EM and MI teaching.

As experienced MI teachers, the mentors naturally drew upon their prior knowledge when making mentoring decisions. Their strong belief in MI pedagogy and curriculum significantly influenced their mentoring. When asked how much of an influence her MI background and EM training had on her mentorship during this study, Samantha said that the split was, “about 90/10… the 90% is modeling with my kids. This is how my brain works now. I've been doing that longer than I've been mentoring… it really is just like where I go.” Her approach to mentoring adults mirrored how she facilitated learning in her classroom, reinforcing the deep connection between MI and EM that informed her mentoring. Mentoring was also shaped by the beliefs that both mentors and mentees held about science teaching and learning. When these beliefs aligned, the mentoring process was natural. However, Fiona encountered

challenges when her mentees' beliefs about teaching differed from her own. She explained, “I can deal with all kinds of personalities; we have to as educators, but beliefs—I think that was the biggest struggle.” Recognizing this mismatch, she adapted her approach to support her mentees better while navigating these differences.

The mentors strongly preferred using EM when the primary focus was MI, which their mentees had committed to implementing. Xavier was motivated by having a specific focus on science teaching. He expressed, “We spent all this time talking about chemistry, and then now you're going to teach chemistry, and we're going to work together with you teaching chemistry. I think that worked out well.” Fiona decided to focus on MI during sessions because, as she explained, “she had all the classroom management stuff down pat… it had nothing to do with being a teacher, just [focus on] what is my one part that she needed help on.” Her mentoring was more specific and targeted when centering conversations on MI This allowed the mentors to help their mentees set clear, actionable goals supported by contextual questioning. Samantha attributed this focused approach to fostering more profound reflections among mentees. She explained, “They understood the pedagogy behind it all, and so it was always open for us regarding a great dialogue. Like [asking] ‘What lab would you guys choose to do here? Did you make any changes in this model?’ as we did our model discussions.” This emphasis on MI allowed mentors and mentees to engage in meaningful dialogue, further strengthening the impact of EM within their CoPs.

The mentors’ experiences as MI Summer Institute instructors also shaped their mentoring styles. Xavier’s role as an instructor often influenced his questioning and storytelling, sometimes leading him to default to problem-solving rather than engaging collaboratively with his mentees. Reflecting on this, he acknowledged the challenge of shifting from his instructor role to a peer-

mentoring role, because he was no longer in a specific science classroom. As a result, much of his feedback was from previous experience, and he could not be as collaborative as he would have liked.

Training Facilitated Changes in Mentoring

The shift to EM required a deliberate commitment to adopting new skills, similar to the commitment they expect from their mentees to implement MI and reform their science teaching practices. For the mentors, this was initiated when they committed to the SIMIRS project and were first introduced to EM theory. All three mentors mentioned the training they received about the components of EM as a factor in how they conducted their mentorship. Samantha compared its influence to other mentoring training she received to clarify its influence. She explained, "I've mentored with other programs before… we went through the training, as you know, mentors and things like that, but it was more of a formal mentor." This training introduced her to a collaborative method that differed from other, more rigid methods, which she felt was explicitly important to her mentoring her CoP.

One of the most impactful training strategies mentioned by both Samantha and Fiona was role-playing. This method helped them visualize EM in practice. Fiona appreciated how it clarified expectations, explaining, "[the roleplay] gave us a little insight on what y'all were kind of looking for, and what was expected of us." Likewise, Samantha mentioned, "The roleplay was definitely helpful. Having time to review each of the components and discuss within our groups was helpful." They believed the experience of investigating the new method through collaboration and modeling helped them connect the latest ideas to mentoring methods they were already familiar with.

To further support the mentors, they were provided with an EM Framework model outlining the components and key features (Figure 2.1). Xavier felt strongly about continuing to use the framework for the EM practices throughout the academic year. He consistently referred to it during mentoring sessions. As an example of its use, he shared, “In this last meeting that I had with my mentees, I went back and pulled out the educative mentoring flowchart, and then I just focused on two of the things.” Using the model shaped his mentoring decisions and ensured that he remained aligned with EM principles.

As previously mentioned, relationship building was instrumental to the mentoring they each provided. Therefore, one particular aspect of the training that mentors highly valued was the designated time during the MI Summer Institute to engage with their mentees in person. This opportunity to build connections before the academic year proved invaluable. Fiona noted that this experience was distinct from previous interactions as workshop instructors: “Even as the instructor, yes, we knew them in class, but we didn't know them, you know. So, I was very grateful that you made us do the group stuff where we had to get to know them.” The mentors felt that establishing these relationships early on facilitated a stronger foundation for the mentorship process.

While the mentors generally reflected positively on their training experiences, they also offered constructive feedback about additional support to strengthen their EM. This demonstrated a commitment to EM and the decision to continue using it in their CoPs. Fiona advocated for creating opportunities for mentors to co-reflect, adjust practices, and plan improvements to their collaborative implementation of EM, suggesting organizing a CoP for the mentors themselves. One specific idea the EM CoP could utilize is incorporating videos or clips of exemplary EM practices, explaining, “I'm a very visual person, so the more examples that I

see, the better." She believed that seeing EM in action and analyzing those examples would support mentors in understanding effective implementation. Xavier made a similar suggestion, proposing a curated bank of EM-aligned questions to guide mentors. He identified a particular challenge in transitioning to educative feedback during lesson reviews with his mentees, expressing, "I don't know what other people did." He believed that it would be a great addition to the training to offer examples of people giving feedback, detailing the experience could include, "...have my example, which would be too much feedback, and you have somebody else's example with not enough feedback, and someone in the middle." This active learning strategy would allow mentors to evaluate and plan their feedback accordingly. While Samantha did not provide specific recommendations, she echoed the other mentors about the value of ongoing reflection, stating, "any of those moments where we as mentors [think] it could have been better, we can incorporate those into the training for mentors." This sentiment underscored her commitment to refining and sustaining effective EM practices for herself, and future mentors.

Summary

Chapter 4 shared each mentor case through a detailed description of their recorded mentoring sessions, mentoring logs, feedback on mentee-submitted recorded lessons, and semi-structured and video-stimulated interviews. Findings for each mentor explore their use of EM within their CoP and themes in their mentorship patterns. Findings from across the cases describe the frequency and consistency patterns in the EM practices identified throughout the academic year and the challenges the mentors faced as they developed as educative mentors. The findings from the VSI described the themes and factors that impacted the mentors' choices in their mentorship. The next chapter will discuss the conclusions of these cases and some future implications of this work within science education professional development research.

CHAPTER 5- DISCUSSION

"Tell Me and I Forget. Show Me and I May Remember. Involve Me and I Learn."

-Benjamin Franklin

This study explored the implementation of educative mentoring (EM) by three mentors guiding secondary science teachers in adopting Modeling Instruction (MI) over one academic year. This research focuses on understanding how mentors navigated the complexities of incorporating EM practices within a community of practice (CoP), examining their decision-making, successes, and challenges in fostering the reform-oriented teaching approach. By investigating how mentors supported mentees through EM, this study aims to address gaps in the research on mentoring in-service science teachers, providing insights to improve training programs for science educators. Findings from this study also build empirical connections between mentors' actions and conceptual literature of EM, particularly those of Feiman-Nemser (2001), Bradbury (2010), and Wexler (2020), and theoretical frameworks of social constructivism (Lave & Wagner, 1991; Vygotsky, 1978). This research contributes efforts to foster science teachers' individual and collective professional development through collaboration, inquiry, goal-setting, and reflection components of EM, thus supporting reform of teaching practices to meet the needs of science students (NGSS Lead States, 2013; NRC, 2012).

This chapter first discusses the findings concerning the three mentors' implementation of EM, focusing on the significant themes, challenges, and decision-making processes that shaped their approach. Next, it provides the implications of these findings for future mentoring practices and research, focusing on how EM can better support reform-oriented teaching while identifying opportunities to refine mentoring approaches for greater consistency and impact.

Practices of Educative Mentoring

Through the year of this study, the mentors constructed their understanding of EM through social interactions with their CoPs, demonstrating practices aligned with the EM components presented to them in the EM Framework (Figure 2.1), outlined in the Educative Mentoring Observation Rubric (EMOR) (Appendix D). In particular, the mentors exemplified EM components of Situated Inquiry, Collaborative Learning, Bifocal Vision, and Reflective Discourse, while placing the least emphasis on the Student Thinking. Their implementation of these components supports the foundational works of Bradbury (2010), Feiman-Nemsar (2001), and Wexler (2020), demonstrating that the curation of ideas regarding effective collaborative mentorship is actionable. Mentors employed questioning strategies to foster Situated Inquiry, encouraging reflection and context-specific problem-solving. Collaborative Learning was evident in activities such as shared lesson planning and storytelling, which promoted trust and co-constructed knowledge, aligning with the work of Lave and Wenger (1991). The component of Bifocal Vision was demonstrated by addressing both immediate classroom challenges and long-term professional goals. However, a low number of occurrences focusing on revisiting or revising goals over the year were observed in all mentors, as demonstrated in Table 4.12, revealed areas for further development in this component. The following sections further discuss some of the findings related to the mentors' implementation of EM during this study, including variations in their implementation, specific practices they employed, and challenges met by the mentors during their experiences.

EM Components Situated in Inquiry

Situated inquiry was the most practiced EM component overall, supporting it as a foundational practice across all three mentoring cases, identified with the EMOR in 39 of 45

sessions (87%) across all mentors (see Table 4.3, Table 4.6, and Table 4.9). Mentors consistently used questioning to drive inquiry and support their mentees' professional growth through Situated Inquiry, defined by Bradbury (2010) as mentors guiding mentees through ongoing inquiry, critical thinking, and decision-making informed by real classroom experiences. Mentors facilitated an environment of inquiry by asking questions, which enabled mentors to foster development and implementation of all other EM components,

This study furthers that work by demonstrating that the mentors' use of questioning can be the pathway to the growth of all EM practices, such as facilitating collaboration between peers in professional learning environments, prompting reflective discourse, investigating mentees' potential problems of practice for goal-setting, and probing problem-solving processes regarding their science-specific teaching. Specifically, the mentors may ask probing or prompting questions to seek information, like asking the mentee if a particular skill could be a candidate for further development or set as a goal (Xavier, Session 10). Mentors could ask questions that probe more profound reflective discourse, like asking the mentee what adjustments they plan to make to a lesson when they teach it again (Samantha, Session 16a). A mentor could ask how the mentee's short, or long-term goal is progressing to demonstrate Bifocal Vision (Fiona, Session 2). Questions that inquire about a mentee's future plans or ask for suggestions for their own lessons show collaborative lesson planning (Samantha, Session 2). These examples demonstrate that having strong inquiry skills supports the implementation of other EM components, aligning with Stanulis et al. (2019), who highlighted the role of inquiry-driven mentoring in encouraging mentees to experiment with and reflect on reform-based teaching strategies.

Collaborative Reflection and Thinking

Through the study, the mentors had many opportunities to engage collaboratively with their mentees by sharing experiences, discussing challenges, and reflecting on their practices. For example, Samantha and her mentees frequently discussed lesson content, sequence, and structure, sharing their experiences and ideas for planning labs and activities, supporting Langdon and Ward's (2015) claims that Collaborative Learning is important to mentorship because it fosters a social-constructivist approach where mentors and mentees work together to build knowledge and develop new teaching practices. For instance, Xavier and Xanthe worked together to reimagine exam formats in one session and introduced using Vernier probes in MI lessons in another, both are examples of Xanthe working with Xavier to incorporate new ideas into her teaching.

All three mentors engaged their mentees in collaborative inquiry to address real-world teaching challenges. For instance, Samantha's facilitation of shared discussions between Sora and Safira not only enhanced their instructional strategies for future MI units, but also created a sense of camaraderie and mutual support, by discussing the prom. These findings align with Melville & Bartley (2010) idea that collaborative thinking with mentees enhances the instructional practices of the mentee, while fostering broader insights regarding these claims of collaborative reflection to specify Reflective Discourse as a tool for analyzing teaching practices, interpreting student learning data, and collaboratively solving instructional challenges. Mentors facilitated discussions that encouraged mentees to identify problems and develop strategies collaboratively. For example, Fiona discussed strategies for improving time management and student engagement with Farah, encouraging her to share her experiences and frustrations, while developing solutions with her collaboratively. This reflected Loucks-Horsley et al.'s (2010)

assertion that Collaborative Learning empowers teachers to navigate instructional changes effectively. Fiona used probing questions to take ownership of the process and think creatively about possible changes.

Reflective discourse was a central feature throughout the year, as mentors modeled critical reflection and engaged mentees in collaborative analysis. This was specifically evident in the recorded-lesson review sessions held by all three mentors, as the mentors and mentees discussed a past lesson and collaborated in planning changes, reinforcing the claims of Walker and Ardell (2020) that suggest EM dialogues that address problems of practice collaboratively create a safe space for reflective growth. For example, Fiona used Reflective Discourse during a review of Farah's first recorded lesson. She built a safe, friendly space by highlighting positive examples before suggesting improvement. However, during these review sessions, the mentors often relied more heavily on direct feedback, limiting opportunities for mentee-driven dialogue, like when Xavier was rewatching clips of the recorded lessons back with Xanthe when he made a comment about the "knucklehead" boys in the video, providing his opinions and direct observations about their behavior without engaging Xanthe a reflective discussion to analyze the situation herself.

This study also reveals that collaborative interactions and shared leadership between the mentors and mentees deepen the mentor's reflective insights. While mentors often initiated discussions through questioning, the ensuing dialogues were sustained and guided by the active participation of all CoP members. This reduced the mentors' speaking time to approximately 50% (see Table 4.2, Table 4.5, and Table 4.8), reflecting a balanced distribution of responsibility to share and listen within the CoP. This dynamic was evident across all three cases, as mentors and mentees engaged in shared leadership and collaborative inquiry. For example, in Session 1,

Samantha spent 50% of the time talking (see Table 4.2), where all members shared their first MI unit plans and approaches to classroom management for labs. The balanced speaking time of the mentors and the shared leadership observed in this study align with Meeker's (2020) mathematical findings that a collaborative group dynamic, like Samantha and her mentees when contributing equally to the discussion, foster a sense of shared responsibility and mutual growth.

Notable Limited Implementation of the Focus on Student Thinking

Despite the general focus of reform-oriented teaching being placed on the students taking the lead in their learning (Bybee, 2014; Jackson et al., 2008; Rudolph, 2019; Stanulis et al., 2019), there was a sizable gap in the practical evidence of that focus during the mentoring sessions. In the context of EM, this involves using student-generated data and artifacts to ground mentoring discussions in real-world classroom experiences. Student Thinking, including using student artifacts and data to inform planning, was not frequently found, only being observed using the EMOR in 23 of 45 sessions (51%) across all the mentors as indicated in Table 4.3, Table 4.6, and Table 4.9. While the mentors did inquire with the mentees about their students and commented on their interactions when appropriate, the explicit Student Thinking to inform teaching was not found as often as expected when reviewing the recorded lessons. Aydin et al. (2013) emphasizes that shifting the emphasis from teacher actions to student thinking encourages mentees to develop skills aligned with reform-based practices, such as MI, which prioritizes student-driven exploration and critical reasoning. If conversations did included topics of student work or thinking, they were often limited to a question probing for more context regarding a different issue, like when Xavier asked Xanthe about the boys in her recorded lesson that seemed off task, limiting the discussion to gain more information about the activities the students were doing without probing for reasoning or reflection. Addressing this gap in EM regarding focusing

on student thinking presents a significant opportunity for mentors to enhance their EM practices to align with Preminger et al.'s (2024) arguments that mentorship that includes the analysis of student data supports mentees to noticing, interpreting, and responding to student ideas and sensemaking, which can inform and improve their reform-based science practices.

Variations in EM Consistency

Despite the presence of all five EM components, their frequency and consistency varied significantly across mentoring sessions, even with the same mentor. Notably, even the most consistent mentor, Xavier, only seven of his 15 sessions (47%) exhibited all of the EM key feature indicators (see Table 4.9), despite having the most evidence of EM practices overall. This inconsistency is a natural part of the mentoring as each session may not present the same opportunities, demonstrating the dynamic and context-specific nature of mentoring claims of Orland-Barak & Hasin (2010), and further accounting for that variability in mentoring can occur due to influences of contexts unique to any given session. This was the case with Fiona. During Session 13 with Farah, she showed low levels of EM, finding zero evidence of Collaborative Learning. However, when observed through the year, not only was it clear that she/he did employ practices of Collaborative Learning, but that was also one of her overall most frequently implemented components. This suggests that single-session observations may not capture the full scope of EM practices. Further, if a random session were selected for observation to determine if a mentor was considered educative, there could be some specific practices or entire components of EM that may be missed, of which there was otherwise evidence in other sessions.

The findings also suggest that greater uniformity could strengthen the mentoring process. For example, mentors sometimes struggled to balance offering suggestions with encouraging independent problem-solving. Xavier's consistent integration of multiple EM components

provided mentees with developmental opportunities, such as supporting Xin in expanding his MI experience to new subject areas. Whereas, there were some slight inconsistencies in Samantha's sessions, such as when she would answer direct questions about classroom challenges with a direct response, rather than initiating their own exploration through guided inquiry. In this more direct approach, the mentees did not have a substantial opportunity to develop the reflective look at their own practice that Hobson et al. (2009) and Richter et al. (2013) emphasize as important to developing mentee self-efficacy and overall professional growth. This reinforces a need for Samantha to become more intentional about stepping outside a directive role and embody the consistent implementation of EM components, such as using an inquiry-based approach, as Desimone and Garett (2015) recommend. She reflected in her VSI that she had moments where she would have to remind herself to return to inquiry, setting the intention to continue learning and practicing EM components. In contrast, providing more explicit guidelines and additional training on integrating EM components could help address these inconsistencies and improve mentoring outcomes.

Mentors' Decision-Making in Implementing Educative Mentoring

After being introduced to the principles and five components of EM, each mentor conceptualized the practices and decided how they would become educative with mentees during the academic year. Analysis of the VSI found multiple factors influencing the mentors' EM practices, such as the type of relationships and strength of their connections, the needs and goals of their mentees, their reform-oriented teaching and MI experience, and targeted EM training (Figure 4.1). These findings emphasize that learning involves building on prior knowledge and experiences and actively constructing understanding through engagement with peers (Bandura, 1977; Dewey, 1938; Lave & Wegner, 1991; Vygotsky, 1978) is central to making decisions

about how to implement the components and key features of EM. The following sections discuss how these influences impacted the mentors' implementation of EM throughout the academic year with their CoPs.

Influence of Connection and Relationships

Although relationships and connections are not explicitly components of the EM framework, the five components are situated in strong connections and reciprocal relationships between the members of the CoP. It was repeatedly suggested in the VSI that the mentors were motivated by their connections with their mentees, as peers of pedagogy and mutual learners, to utilize more EM practices in their sessions. Fiona believed strongly that even having the most years of MI experience in her CoP, she was not the leader, and she was adamant that she was just a teacher learning and sharing with other teachers. By sharing responsibility for the sessions and controlling discussions and topics, the mentor could operate as a peer member of the CoP. Samantha's mentoring sessions with Sora and Safira exemplified this dynamic through their collaborative discussions, Samantha not only guided her mentees in sharing ideas about methods for using MI in an upcoming lesson, but when one of her mentees made a suggestion, she reflected on her own practices and considered making a change to the way she approached her lesson. This iterative process illustrates Trevethan & Sandretto's (2017) assertion that EM fosters reciprocal growth as mentors deepen their own understanding and practices through engagement with their mentees, as all three mentors were able to benefit as an integral part of the CoP (Bradbury, 2010; Feiman-Nemser, 2001a, 2001b; Stanulis et al., 2012; Wexler, 2020).

In all three cases, strong relational dynamics facilitated the effective implementation of mentoring strategies and fostered positive outcomes. Samantha's CoP was very connected, where they shared their challenges and triumphs in their formal sessions, but also shared pictures

and stories informally through a group chat. This frequent and casual display of openness in their communication highlights the foundational role of trust in mentorship. Similarly, Xavier's individualized approach was rooted in his recognition of the unique challenges faced by his mentees, allowing him to build meaningful connections that supported their professional development. These findings align with findings of Lin et al.'s (2013) study, affirming how collaboration between mentors and mentees fosters trust, dialogue, and professional growth, affirming that strong mentoring relationships support the implementation of reform-oriented practices like MI, as they encourage open dialogue and critical reflection on instructional practices.

In this study, the strength of the mentor-mentee relationship significantly influenced the mentee's confidence, as perceived by the mentor, to try new or innovative MI practices in their classrooms. For example, Xavier indicated he had a strong-bonded relationship with Xin because their early career and teaching experiences were similar. During sessions when only Xin was in attendance, the sessions included more evidence of EM practices (Table 4.8). During these sessions, Xavier demonstrated a deep interest in Xin's ideas by fostering a collaborative, non-directive mentoring relationship. This approach supported Michailidi and Stavrou's (2021) claim that mentors often shift toward less directive, inquiry-based methods as mentoring relationships deepen. In contrast, his sessions with Xanthe reinforced the idea that a more directive mentoring style can hinder mentees' ability to develop their teaching practices independently (Michailidi & Stavrou, 2021). For instance, during one session, Xanthe expressed hesitation about fully integrating MI into her teaching when discussing assessments, suggesting that a less directive approach might have Specifically, Xanthe mentioned being unsure about switching to a model based assessment, despite Xavier's encouragement, which emphasizes Wexler's (2020) assertion

that collaborative mentorship, like EM, fosters risk-taking and innovation in teaching, which was reduced in the relationship Xavier reported as less connective.

Influence of Balancing Individual Needs and Goals

The mentors in this study placed significant importance on tailoring their mentorship approaches to the specific needs of their mentees, reflecting Feiman-Nemser's (2001) emphasis on tailoring support to mentees' personalities, needs, and goals. They all made intentional decisions about mentoring formats, balancing individual and collaborative sessions to foster personalized guidance and collective reflection. For example, Samantha determined that feedback on recorded lessons was best conducted one-on-one, though she maintained a collaborative structure for all other mentoring sessions. Similarly, Xavier decided to meet with his mentees on a regularly separate basis, where he could support their different subject-specific MI needs. However, while Fiona typically mentored a single mentee during most virtual sessions, she excelled in the in-person session at the MI Summer Institute follow-up training, demonstrating the highest number of EM indicators (Table 4.6, Session 5). In this session, she seamlessly integrated a visiting mentee into the CoP (Table 4.5, Mentee Attendance). She facilitated discussions on MI lesson planning with minimal talk time, allowing mentees to participate actively in the conversation. These decisions are evidence of the variety of interactions Koch and Appleton (2007) conclude encompass successful mentoring, which include the mentors engaging with their mentees in one-to-one interactions, group discussions, and professional development workshops that address the specific needs of each mentee in the CoP.

Beyond structured sessions, mentors made more nuanced choices to individualize their support. For instance, Fiona intentionally excluded science-related topics from a session to

support an overwhelmed Farah. At the same time, Samantha adjusted her feedback delivery to be more positive in response to a mentee's self-critical tendencies. These adaptations exemplify subtle EM practices of Bifocal Vision, which includes the key feature of inquiring about the beliefs, experiences, and knowledge of individual mentees, such as taking note of personality traits and idiosyncrasies that may not have been overtly mentioned in conversation to inform goals and reflection. Richmond et al.'s (2017) study further explains that the mentor and mentees build connective relationships that prioritized rapport-building during informal sessions to complement the formal session development. For example, Fiona noticed that Farah was not feeling well, so the session did not deepen into an educative discussion about science. Instead, it focused on personal updates and could still support her mentee's well-being during their time together. These interactions deepened trust within the CoP, fostering an environment where members could share failures and untested ideas without fear.

Based on their VSI, the mentors argued that this was imperative to the process and one of the mutual benefits of mentoring. These examples show how mentors individualized their mentorship in alignment with Aydin et al.'s (2013) advice to use strategies for assessing each mentee's understanding and experience, expanding this guidance to include nuanced adaptations based on each mentee's unique strengths, weaknesses, and personalities. The individualization of each mentor's approach strengthened their relationships, fostering trust and rapport within the CoP, and were seen as essential to their EM mentoring process.

While mentees' immediate concerns largely drove mentoring sessions, mentors dedicated time in most sessions to discuss plans and experiences centered on science content or pedagogy (see Table 4.2, Table 4.5, Table 4.8), demonstrating a long-term focus on implementing MI practices critical to building trust and engagement, consistent with Hobson et al.'s (2009)

assertion that addressing immediate needs helps build trust and credibility within the mentoring relationship. In this study, mentors did have opportunities to demonstrate Bifocal Vision, described by Wexler (2020) as essential for helping mentees manage short-term needs and long-term goals, ensuring that mentees were equipped to manage current challenges while building sustainable reform-oriented practices. However, not many examples explicitly connected these immediate concerns to overarching professional development goals. For example, Xavier transitioned to individual meetings with each mentee after their needs evolved in the new semester, while still maintaining his focus on applying the MI practices with each mentee, emphasizing both short-term problem-solving and future-oriented growth. All three mentors allowed more focus on the mentees' immediate needs as their sessions were predominantly determined by the open-ended check-in questions that allowed them to bring up discussion topics. To include a goal-oriented approach, the mentors set initial goals with their mentees at the beginning of the academic year (Table 4.10, Ia), and revisited them on occasion (Table 4.12, Bc). However, Samantha and Fiona acknowledged the importance of revisiting and refining goals to ensure continuous professional growth, reflecting that they must intentionally include opportunities to revise those goals and use them to inform specific reflections in following years. Their lack of consistent redirection toward long-term objectives suggests a need for greater intentionality in fostering reform-oriented teaching practices, as emphasized by Davis and Krajcik's (2005) findings that encouraging teachers to think critically about their practices leads to more effective implementation of reform-based instruction, indicating that more of a focus is needed on connecting to long-term goals of development of reformed practices.

One strategy that could strengthen Bifocal Vision is to integrate targeted feedback on video-recorded lessons. Mentors indicated in their VSIs that they would like mentees to take

ownership of their video observations by selecting specific segments for mentor review, directly connecting these moments to their instructional goals. This practice aligns with Hudson's (2015) findings that feedback is more insightful and impactful when focused on specific aspects of teaching, such as setting a goal with the mentees to diversify questioning techniques that can be developed into actionable changes in their practice that can be revisited often. By refining their approach to video analysis, mentors can enhance their ability to link immediate classroom experiences with long-term pedagogical development, thereby reinforcing the principles of EM.

Influence of Reform-Oriented Teaching Experiences

The findings of this multiple-case study highlight the influence of mentors' prior experiences with MI on shaping their mentoring practices. As reflected in their VSIs, the mentors valued connecting with their mentees over shared MI science teaching experiences and targeting reform-oriented science teaching practices. According to Hestenes (2010), Jackson et al. (2008), and Wells et al. (1995), MI incorporates the facilitation of student-led inquiry to build knowledge about science concepts through model development and model deployment cycles. As reform-oriented MI teachers, the mentors used their existing teaching skills and knowledge to facilitate learning within the CoP, fostering an environment that mirrored the collaborative, inquiry-driven nature of MI classrooms.

A key influence of their MI background was the mentor's facilitative approach to mentoring, aligning with the inquiry-based and student-centered nature of MI to explore teaching challenges through questioning and collaborative discussion, rather than providing direct solutions, mentors prompted mentees to analyze student responses and teaching dilemmas, fostering reflection and iterative problem-solving. Examples of their reform-oriented teaching practices in their mentorship included the inquiry skills identified most often in their sessions and

their facilitative roles when engaging in collaborative discussions. All three mentors incorporated inquiry-based mentorship by using questioning to guide reflective discussions with their mentees. Samantha posed open-ended questions to prompt analysis of Student Thinking, fostering a reflective approach centered on individual student misconceptions. In contrast, Fiona encouraged comparisons of different instructional strategies, guiding her mentees to evaluate multiple pedagogical approaches. Meanwhile, Xavier employed Socratic dialogue, challenging mentees to justify their instructional choices and refine their methods based on student responses. These distinct approaches illustrate the varied yet complementary ways inquiry-based mentorship was implemented. These approaches align with Nam et al. (2013), demonstrating how inquiry-based mentorship deepens reflection and enhances instructional reasoning, mirroring MI's student-centered approach in a mentoring context.

Modeling and using models are central skill sets that the mentors have, and it requires pedagogical content knowledge (PCK) to be implemented effectively. PCK is a specific knowledge about pedagogy specific to teaching distinct content, such as modeling in science instruction (Barnett & Friedrichsen, 2015; Can-Kucuk et al., 2022). The mentors utilized their modeling-specific knowledge and actively supported the mentees in constructing understanding regarding models and modeling as a science and engineering practice (SEP). For example, Samantha focused some discussions on using whiteboard meetings in their classes, prompting her mentees to question their effectiveness. Similarly, Fiona facilitated collaborative discussions about models, prompting her mentees to consider alternative instructional strategies. While both highlighted modeling as a concept, Xavier discussed using Vernier probes in labs, a hands-on tool to enhance conceptual understanding through modeling. These examples collectively show how mentors adapted their MI expertise to different contexts, reinforcing the role of models in

science learning through inquiry-driven approaches. Through these EM practices implemented by the mentors, the mentees received collaborative and reflective support to conceptualize and teach modeling in their MI classrooms, as established in Barnett & Friedrichsen's (2015) study, emphasizing mentors possessing strong PCK as a factor to effectively supporting and developing their mentees' MI teaching practices. Conversely, a traditional, or generalized mentor may not have sufficient PCK about modeling as an SEP to offer this heightened level of support.

By drawing upon their prior MI experiences, the mentors effectively bridged their instructional expertise with their mentoring responsibilities aligned with Gul et al.'s (2019) findings that science-specific mentoring effectively creates sustainable changes in teaching practices and develops leadership skills among science teachers. Their knowledge of modeling and inquiry-driven facilitation not only enriched their mentoring practices but also reinforced the parallels between effective science teaching and effective mentoring.

Influence of Educative Mentoring Training and the Visual Framework

In their VSI responses, the mentors expressed they found the training for EM to be valuable to informing their mentoring practices during this study, including many ideas reflecting Maxwell et al.'s (2024) requirements for effectively training mentors, explicitly mentioning the active learning opportunities that allowed them to collaborate, the used of a research-based approach with clear guidelines, and training alongside their mentees. This applies to distinct phases of their training. When introducing the concepts of EM, the mentors were provided collaborative opportunities for mentors to construct their understanding of the EM components and potential practices. Both Samantha and Fiona found the role-playing aspect of the training particularly helpful, giving the mentors insight into what was expected of them and helped them visualize EM in practice. To support their comprehension of EM components,

including underlying theories and best practices, the mentors were provided with a physical copy of the EM Framework (see Figure 2.1) to guide their learning and reflection. Xavier referred to the model during his mentoring sessions to ensure alignment with EM principles, supporting Guo et al. (2020), who emphasized the value of visual aids in maintaining focus on mentoring goals. He also utilized the model during interviews to stimulate his recollection and deepen his reflection. As a follow-up and extension of their initial training, the mentors learned alongside their mentees to practice EM components, supporting Richmond et al.'s (2017) claim that both the mentors and mentees need professional development to support the development of the CoP. Fiona appreciated the designated time to learn collaboratively with their mentees in person, which facilitated relationship-building.

Their VSI responses also identified areas for change and improvement in the training and support they received, reinforcing the importance of sustained and responsive professional development for mentors, also emphasized in Maxwell et al.'s (2024) meta-synthesis study of practical mentor training. To create opportunities of extended learning that echoes Stanulis et al.'s (2019) findings that mentors need to be able to meet and reflect collaboratively on their mentorship, Fiona suggested that the mentors form their own CoP to co-reflect, make adjustments, and plan improvements to their implementation of EM collaboratively. As supplementary support for learning EM practices, Xavier proposed a curated bank of EM-aligned questions to guide mentors. He believed seeing examples of people giving feedback would help mentors understand effective implementation. Fiona also recommended incorporating videos or clips of exemplary EM practices to accomplish a similar goal of supporting visualizing model practices. She believed that additional support in fostering inquiry-driven discussions could have enhanced her effectiveness with her mentees.

The feedback the mentors provided further demonstrates their reflective approach to their practice and exploration of strategies for growth in areas of challenge. Samantha emphasized the value of ongoing reflection and insisted that those reflections must be incorporated into future mentor training. This demonstrates her commitment to ongoing reflection and research to refine and sustain effective EM practices.

Influence of Socially Constructed Understanding of Educative Mentoring

Preparing mentors in EM enabled each to develop their own understanding and make individualized decisions about implementation within their CoPs. They drew connections between EM and their use of MI in the classroom and their role in training science teachers at the MI Summer Institute. This aligns with Desimone and Garett's (2015) claim that professional development is most effective when contextualized within the daily experiences of science teachers. By integrating new insights about EM with their existing knowledge of best practices in science teaching, the mentors developed a more comprehensive and nuanced understanding of effective mentorship.

However, despite receiving the same EM training and sustained support from the SIMIRS research team, the mentors exhibited notable differences in both the frequency and consistency of their EM practices. There were variances in the mentor's experiences, including differences in implementation in both frequency and consistency, which demonstrates the complexity of the process through which mentors translate what they learned from the training into their mentoring practices mirroring Bradbury's (2010) description of learning EM as an evolving process with no single "right" answer that requires mentors to critically examine their approaches, set goals, and experiment with reform-based strategies. Therefore, the discrepancies in implementation observed in this study suggest that mastering EM is not simply a matter of

exposure to training but rather an intricate process influenced by personal teaching philosophies, prior experiences, and contextual factors. For instance, while Fiona implemented fewer EM practices in Reflective Discourse and sustained collaboration than the other mentors, she demonstrated development EM practices across all components (Table 4.5), highlighting the reality that mentors construct their mentoring identities differently.

Limitations

This multiple-case study has several limitations that should be acknowledged. First, limited generalizability is a concern, as the study focuses on three mentors within the SIMIRS project, all of whom support the implementation of MI in science education. While MI applies to various scientific disciplines, this study only examines mentors working with biology and chemistry instructors, restricting its applicability to a broader range of science educators and settings (Yin, 2018). Additionally, with only three mentors serving as case studies, the findings provide in-depth insights but limit the ability to draw broad conclusions about mentoring effectiveness across diverse teaching environments (Miles et al., 2014). A larger sample could enhance the study's external validity and offer a more comprehensive understanding of mentoring practices.

Second, self-reported data and researcher interpretation pose potential challenges. Semi-structured interviews rely on mentor self-reports, which may be subject to recall or social desirability bias, potentially influencing how mentoring practices are portrayed (Groves et al., 2009). Furthermore, qualitative analysis inherently involves researcher interpretation, which, despite efforts to maintain rigor through triangulation and systematic coding, may introduce bias. Another key limitation is the complexity of managing data across multiple cases, which requires meticulous documentation and analysis. The overlapping descriptions and ambiguous language

within the EMOR framework made it difficult to distinctly code certain practices, reducing the precision of the analysis. This challenge underscores the need for more precise definitions in future research (Yin, 2018). These data-related limitations highlight the need for future studies to replicate findings in varied contexts to strengthen generalizability and mitigate interpretive constraints (Mertens, 2020).

Implications for Science Teaching Practice

The findings from this study present important implications for advancing EM in science teaching. First, there is a critical need for sustained, context-specific training for EM to deepen understanding of effective mentoring practices. This study emphasizes the need for targeted training in EM frameworks (Bradbury, 2010, 2022), as all three mentors attributed their ability to implement EM practices to the training they received. However, the variation in their implementation suggests that some aspects of the training may need refinement to better address the complexities of reform-oriented mentorship (Mullen & Klimaitis, 2021), highlighting the essential role of continuous support. This study contributes to the mentoring literature that calls for guidelines in training EM practices (Bradbury, 2022; Hudson, 2005; Hudson et al., 2008; Leeder et al., 2022), highlighting the need for further exploration of effective EM training models. By addressing these gaps, researchers and practitioners can better support mentors in navigating the multifaceted demands of EM and ultimately enhance the impact of reform-oriented teaching initiatives. Future research should explore how different training models and on-going support structures influence mentors' capacity to implement EM practices over time and how these programs can be customized to meet diverse needs through on-going professional, training programs that offer guidance on navigating challenges in virtual or resource-limited

environments, incorporate interactive activities that replicate real-world teaching and mentoring dynamics, and prioritizing relationship-building strategies (Maxwell et al., 2024).

Second, there is a demand for ongoing collaborative opportunities to enhance mentors' conceptualization and implementation of EM practices. The training that introduced the mentors to the main theoretical components of EM did not provide explicit expectations for the practices to implement them. The mentors constructed their understanding of EM practices while working with their CoPs. Without sustained professional development, the mentors maintained gaps in their EM understanding (Aspfors & Fransson, 2015) inhibiting the inclusion of some critical reflective EM key features, as advocated by EM frameworks (Bradbury, 2010; Feiman-Nemser, 2001; Wexler, 2020). On-going support, such as mentoring-specific CoPs, should be prioritized in future EM training programs to enable participants to apply, extend, and deepen their understanding and skills through observation, practice, and peer feedback (Maxwell et al., 2024; Trabona et al., 2019). Additional support from other mentors would allow for collaborative inquiry that can target inconsistencies in their questioning techniques and address the notable gap in the use of student artifacts in mentoring discussions to deepen reflective practices collaboratively in mentoring conversations. By embedding collaborative reflection into future EM professional development, mentors can continuously refine their EM practices and develop shared tools, fostering sustained professional growth (Stanulis et al., 2019).

Third, there is a requisite need to carefully consider mentors' beliefs and pedagogical experience when selecting them to guide teachers in reforming their science teaching practices. Current mentorship selection processes are often informal and may not adequately consider a mentor’s commitment to student-centered, inquiry-driven teaching approaches (Schwille, 2008). This risks the perpetuation of ineffective teaching practices, as mentees may replicate their

mentors' methods without critical evaluation (Luft et al., 2011; Thompson et al., 2015). This study demonstrated the advantages of selecting mentors with strong subject matter knowledge and experience with evidence-based pedagogies, providing targeted guidance for understanding and delivering distinct MI practices (Melton et al., 2019). The emphasis on science-specific domain knowledge and pedagogical content knowledge (PCK) contributed significantly to the mentees' implementation of MI (Barnett & Friedrichsen, 2015; Gilbert & Justi, 2016; Gul et al., 2019). The mentors in this study asserted that shared commitment to reform-oriented science instruction and prior experience with MI pedagogy were central to their success, aligning with Barnett and Friedrichsen's (2015) assertion that science-specific teaching practices are key to effective mentorship supporting the development of science teachers. To enhance future EM assignments, selection criteria should adopt a holistic approach to evaluate potential mentors' beliefs about reform-oriented teaching, previous experience in mentorship, and alignment with evidence-based practices. Carefully selecting mentors who possess both subject matter expertise and a commitment to evidence-based teaching practices, ensures that mentors are well-equipped to support meaningful professional growth and the integration of innovative pedagogies like MI (Aydin et al., 2013; Preminger et al., 2024).

Implications for Future Science Education Research

The findings from this study highlight several key areas for future research in EM within science teaching. First, future research is essential to clarify the types of questions that are most effective in inquiry-led mentoring, which is important to establishing best practice in EM. Mentors frequently and consistently used Situated Inquiry, though further analysis showed a variety of question types aimed at achieving multiple purposes. While Situated Inquiry was frequently used by mentors, a wide variety of question types were also employed to achieve

different purposes. This diversity highlights the need for further research to identify which question types most effectively elicit inquiry-based reflection and deeper thinking from mentees (Kim & Silver, 2016, 2021). Questioning is a fundamental inquiry practice in MI that mentors in the study leveraged to facilitate growth within their CoPs (Jackson et al., 2008). Further, Plyman and Bell (2021) emphasize how varied questioning levels shape mentee thinking during collaborative activities, influencing the cognitive demands on mentees and the depth of their responses. Given the centrality of questioning use to MI and EM, mentors could benefit from expanding the variety and number of questions they use to promote critical reflection. Broadly defined *probing questions*–questions that seek more or deeper information–are commonly used in Reflective Discourse, though they are often too generalized to capture the specific functions they serve. Developing a detailed framework to specify the types and purposes of probing questions could provide more explicit guidance for mentors and improve the accuracy of evaluative tools for EM. Expanding research on the relationship between question types and mentee outcomes would not only deepen understanding of inquiry as it pertains to EM, particularly in facilitating reflective discourse and critical thinking in CoPs.

Second, future research is to improve the functionality of the EMOR. Refining the EMOR (Appendix D) is necessary to clarify EM component guidelines and descriptions of EM practices, which were determined to be essential by Maxwell et al. (2024) for the professional development of EM practices. Given the limitations of this study and the existing gap in empirical research on examples of EM practices, this study highlights the need for more precise, practice-based examples to enhance the EMOR's usability as a tool to determine if a mentor uses educative practices. While the EMOR provided a valuable structure for identifying mentoring practices, case study data revealed that mentors enacted EM in ways not always clearly captured

by the existing framework. Variability in mentor approaches, overlapping EMOR indicators, ambiguous descriptions, and a lack of observable examples complicated the evaluation process. This underscores the need for empirical studies to refine the framework with clearer descriptions of practice-based examples. Findings from this study suggest that refining the EMOR should involve integrating concrete, observable examples drawn from mentor-mentee interactions that connect the practices to the theoretical components of EM. Specific instances, such as how mentors provided educative feedback or facilitated inquiry-driven discussions, can help clarify vague indicators and offer more apparent distinctions between EM components. Additionally, revisions should account for variations in mentoring strategies across different contexts, ensuring the framework remains adaptable while maintaining its theoretical foundations (Mullen & Klimaitis, 2021). Using the data from this case study to refine the EMOR, researchers and practitioners can develop a more actionable tool that better supports mentors in implementing EM effectively. Future work should strengthen the framework with detailed, context-specific examples and provide more straightforward guidance on how mentors can align their practices with reform-oriented mentoring principles.

Third, future research is necessary to modify the EM Framework to demonstrate the relational dimensions of EM better. The EM Framework presented in this study (Figure 2.1) requires modification to explicitly incorporate the role of building strong, connective relationships between the mentors and their mentee(s) in facilitating EM. The findings from this study emphasize the importance of trust, mutual respect, and collaboration in fostering both immediate and long-term professional growth. These relational dimensions align with existing mentoring literature, highlighting the importance of social connections' role in meeting EM objectives (Lin et al., 2013; Trevethan & Sandretto, 2017; Wenger, 1998). This study suggests

that strong social relationships are not merely supportive but foundational to EM, shaping both the mentoring process and mentees' professional transformation. Mentors' decisions regarding their mentoring often centered on their connections with mentees, reinforcing the value of socially supported learning within science teaching CoPs. To reflect this relational dimension observed in this study, the EM framework should be revised to acknowledge the social context in which EM occurs more explicitly. Findings from this study support the validity of the EM framework by demonstrating how its core components were enacted across multiple cases (Yin, 2018), though application varied based on contextual factors. The study confirmed the framework's flexible, nonlinear structure, aligning with research on adaptive mentoring frameworks that emphasize context-driven implementation (Barnett & Friedrichsen, 2015; Richmond et al., 2017). Additionally, while the findings reinforced the framework's emphasis on inquiry-driven mentoring and reflective discourse (Bradbury, 2010; Feiman-Nemser, 2001; Wexler, 2020), they also highlighted the need to explicitly account for relational engagement as a foundational element of effective mentorship (Lave & Wenger, 1991; Lin et al., 2013). These results suggest that while the EM framework provides a helpful structure for EM, further refinement is necessary to enhance its applicability across diverse mentoring contexts. Future research should explore how best to balance educative measures with relationship-building in science-specific CoPs. A revised EM framework that integrates social connection as a contextual element would strengthen its EM's theoretical foundation and enhance its practical application in reform-oriented science education.

Fourth, future research needs to explore the effectiveness of EM across in-person and virtual mentoring. To strengthen the impact of reform-oriented teaching initiatives, EM needs to be explored in diverse educational contexts (Mullen & Klimaitis, 2021; Stokes et al., 2020).

Teachers in rural areas often have limited access to collaborative support, especially when they are the only science teachers in their schools, which can hinder the adoption of new pedagogies (Glover et al., 2016; Oliver, 2007; Supovitz & Turner, 2000). The immediate scope of the SIMIRS research focused on reaching rural teachers interested in learning and implementing MI, with mentoring sessions primarily conducted virtually to accommodate the challenge of geographical isolation and encourage science teachers to participate. Virtual mentoring has been shown to offer flexible and accessible support, promoting collaboration and providing resources for teachers in remote areas (Annetta & Shymansky, 2006; Fletcher & Mullen, 2012). This approach can enhance professional development for educators by improving their self-efficacy and changing their perceptions of professional practice (Owen, 2015). However, variation in the implementation of EM between virtual and in-person sessions was noted, particularly regarding engagement, topics discussed, and interaction time. Though it was beyond the scope of this study, a comparative study to see how EM is implemented in virtual and in-person formats would produce valuable insights into a more contextualized exploration of the effectiveness of EM for science teaching. Further study will help determine if virtual EM provides equitable support for rural science teachers (McConnell et al., 2013).

Summary

This chapter discussed the implementation of EM by three mentors who guided secondary science teachers in adopting MI. The findings underscored the potential of EM to foster reform-oriented teaching through practices grounded in Situated Inquiry, Collaborative Learning, and Reflective Discourse. However, the study also revealed critical gaps, particularly in the consistent application of EM components like Bifocal Vision and Student Thinking. These inconsistencies pointed to mentors' challenges in balancing immediate classroom needs with

long-term professional growth goals. The importance of mentor-mentee relationships emerged as a cornerstone of effective mentoring, highlighting the role of trust and adaptability in navigating diverse teaching contexts. Mentors who tailored their approaches to individual mentee needs demonstrated more significant success in fostering instructional change, emphasizing the value of relational dynamics in mentorship. Nonetheless, the variability in EM implementation suggested more comprehensive training and precise guidelines to ensure mentors are equipped to integrate all EM components effectively.

This study contributed to the growing body of research on mentoring in science education by offering insights into the practical challenges of aligning mentorship practices with reform-oriented goals. It also highlighted the importance of refining mentorship training, enhancing EM frameworks to account for relational elements, and addressing the unique demands of virtual and rural mentorship contexts. The findings highlighted the need for more targeted training emphasizing Reflective Discourse, questioning techniques, and integrating student-generated data into mentoring conversations. Additionally, mentorship programs were recommended to prioritize selecting mentors with strong subject matter expertise and alignment with reform-oriented pedagogies.

The findings of this study call for continuing to equip mentors with the skills and tools necessary to bridge the gap between theory and practice. Future research was suggested to explore the impact of virtual mentorship, refine EM frameworks to better incorporate relational dynamics, and examine how mentoring strategies influence long-term teacher development. By addressing these areas, educators and researchers can strengthen the capacity of mentorship programs to advance science teaching reform, ultimately enhancing teacher development and student outcomes in science education.

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APPENDICIES

APPENDIX A

Perceptions Interview Protocols (I-IVb)

I. Before Initial EM Training

Good (morning/afternoon/evening) **[Insert Name]**. Thank you for volunteering to participate in this SIMIRS interview for mentoring beliefs and practices.

During our interview today, I will be asking you questions in four parts: background information about you, beliefs and conceptions about mentoring, and beliefs and conceptions about the roles of mentors and mentees, and then your beliefs about how to support a teacher that is just starting to use MI in their classroom. I will be asking about mentoring in general and specific to Modeling Instruction.

May I have your permission to record this interview for the purpose of our IRB approved research activities for the NSF grant-funded project, SIMIRS?

- **Yes**
- **No**

Background Information

In this first section of the interview I will be asking you to describe some of your experiences in teaching, as an educator and as a leader. As you've been asked to serve as a mentor for newly trained MI participants, I will be asking about any preparation you may have had for becoming a mentor, in this MI role or any other mentoring experience you may have.

1. Briefly describe your **teaching experience**
    a. How many years have you been teaching, in general?
    b. Describe your current teaching position
        i. Type of school
        ii. Environment/Culture
        iii. Administration
        iv. Subjects taught
2. Briefly describe your **experience with MI curriculum**
    a. How many of those years have you been teaching using the MI curriculum?
    b. When did you receive your MI training?
    c. What subjects have you taught during your career? Which of those include MI?
3. Briefly describe your **mentoring experience**
    a. Mentoring experience in science content?
    b. Mentoring experience with a mentee outside of your content area?
    c. Mentoring new MI teachers
4. Briefly describe any previous **preparation** you have received in becoming a mentor
    a. What type of training do you believe has prepared you to serve in a mentor role?
    b. What qualifications do you think were required before you were considered a mentor?

Mentoring Beliefs/Conceptions

In this second section, I will be asking about your beliefs and conceptualizations of mentoring. For these questions, we will begin by asking about mentoring in general, (**don't say this to mentors but just for interviewer reference: e.g. CT for a PST or Mentor to a beginning teacher [BT]**), and then we will move into asking questions specifically related to Modeling Instruction. If you prefer to discuss or explain these questions together, by comparing and contrasting, you are encouraged to answer naturally.

Beliefs about Mentoring

5. What do you believe you should achieve with mentoring?
    a. in general?
    b. specific to MI?
6. How would you achieve those goals?

Beliefs about Mentors

7. What do you think the role of a mentor teacher is
8. What does it mean to be an effective mentor?
    a. What do you think are attributes of effective mentors?
9. What do you think are necessary qualifications for being considered a mentor?
    a. in general?
    b. specific to MI?
10. What do you consider to be the benefit(s) for the **mentor** in a mentoring relationship?
    a. in general?
    b. specific to MI?
11. What are potential drawbacks for a mentor in a mentoring relationship?
    a. in general?
    b. specific to MI?

Beliefs about Mentees

12. What do you think the role of the mentee is?
13. What do you consider to be the benefit(s) for the **mentee** in a mentoring relationship?
    a. in general?
    b. specific to MI?
14. What are potential drawbacks for a mentor in a mentoring relationship?
    a. in general?
    b. specific to MI?

Mentoring Practices

In this third section, I will be asking you questions about what mentoring looks like in practice, including the roles and responsibilities of the mentor and mentee. Again, I will begin by asking about mentoring in general, (**don't say this to mentors but just for interviewer reference: e.g. CT for a PST, Mentor to a BT, coaching a peer teacher, or leading a PLC**), and then we will move into asking questions specifically related to Modeling Instruction, and you are welcome to answer these through compare and contrast together, if preferred.

15. Metaphors are one way we can think about mentoring. Metaphors are comparisons that put an image into our heads and guide the way we approach mentoring. What metaphors do you think best describe your views of a mentor you would want to be and how you believe mentoring should be implemented?
    a. You can use the following prompt to help you develop a metaphor:
        i. ***I think that a good mentor is ( )***
        ii. ***Good mentoring is ( )***
16. How often should a mentor be meeting with a mentee?
17. Imagine you are mentoring a teacher attempting to implement MI, what does your meeting with the teacher look like? What are you (the mentor) doing? What is the mentee doing?
    a. Pre-Conference
    b. Post-Conference
    c. As-needed or "emergency" meeting
    d. What strategies would you use to support this teacher?
18. How would this be similar or different from mentoring in general?

Supporting Modeling Instruction

For this fourth section, I will be inquiring about Modeling Instruction, specifically about the aspects of teaching MI that teachers new to MI will need support with.

19. What aspects of MI do you think teachers would struggle with ***the most*** when they first implement MI?
    a. Why?
20. How would you help them?
21. What aspect of MI do you think teachers would struggle with ***the least*** when first implementing MI?
    a. Why?
22. What "signs" or "signals" would you look for to determine if a mentee was having a difficult time with a component of MI?
    a. How would you address them in this context?

Closing Thoughts

23. Please share any other thoughts on mentoring or MI that you want to share?

Thank you for your time today. Your responses will be very helpful in our research. Do you mind if I (or a member or our research team) contact you in the future if the need arises for clarifying questions?

How would you like to be contacted in this case?

II. After Initial EM training

Good (morning/afternoon/evening) **[Insert Name]**. Thank you for volunteering to participate in this SIMIRS interview for mentoring beliefs and practices.

During our interview today, I will be asking you questions that will refer to the educative mentoring training you participated in, any changes to your mentoring perceptions, and a look at how you may implement educative mentoring in your future MI mentee relationships.

May I have your permission to record this interview for the purpose of our IRB approved research activities for the NSF grant-funded project, SIMIRS?

- **Yes**
- **No**

Post Educative Mentoring Professional Development/Training

1. Do you feel (more) prepared for mentoring as a result of this training?
2. Do you think training like this would have helped you when you first started mentoring?
3. What are the most important new insights you gained from the training?
4. What new questions have come to mind as a result of the training that you hope to answer as you mentor your mentee teachers?
    a. How do you expect to find answers/solutions to these questions?

Mentoring Perceptions and Practices

5. Have you experienced any changes in your views of mentoring (e.g., goals of mentoring, roles of a mentor, or mentor-mentee relationships) as a result of the training?
    a. If so, what are they
    b. Why do you think these views have changed?
6. You mentioned that mentoring is **[pull in metaphors from chart below]**. Now that you have participated in educative mentoring training, what changes would you make to your original metaphor?

Individual mentoring metaphors mentioned in IPI
M2101- Siblings (versus Parent and Child), have to see each other as equals. There is some give and take. Parents are high up and you don't open up as much!
M2102- Mentors are wild and crazy and fun to be around. Mentors are like bartenders. Because you can meet after a hard day, lay it out to the bartender, and then can/won't judge you. Can give some advice you can take it or leave it.
M2103- The best mentor is Yoda, "Do or Do not there is No Try"... Just do it. Don't worry about it, I got it, just do it.
M2104- Tour Guide- gives you details you don't see, the inside story. You can do things alone, but the tour guide would help you see more details and have a deeper experience. See the ins and outs.

Individual mentoring metaphors mentioned in IPI
M2105- A good pair of tennis shoes. Supportive. Having the cushion in the right place at the right time. You need the support at the right time. A good pair of tennis shoes are reliable. Eventually they run out, a good mentor realizes when the time has run out.
M2106- A coach with a rookie learning the sport. Experienced person that the rookie can learn from.
M2107- Guide on the side, sage on the stage. For mentoring you want to be the mentor that causes the mentee to do the thinking.
M2108- A puppy - puppies need nurturing, training, time, attention. The puppy has its own mind so it will still be its own person and do things the way it wants to do them.
M2110- Ranger/guide through the forest showing the different paths you can take
M2112- I think a good mentor is like a good you know, sports coach, you teach, or you don't teach-- you encourage your player to practice, to reflect, to hone their craft, so that they can get better and better and better. Because you don't; you can have a lot of natural talent. But if you don't develop it, you can't be your best.
M2111- Okay, so I'm a coffee drinker. I can drink my coffee black. I drink it with cream, that's how it's preferred. It makes it softer and smoother. I have a tendency not to add sugar anymore because it's just too over the top. So there has to be a balance and that flavor and it has to fit the way you drink your coffee has to fit you. You have to have a perfect cup of coffee and I have to have one and they may not be the exact. right may not be the same. You might want sugar I might like cream
M2112- it's a little bit like you're trying to grow a plant. And I mean, as the mentor, it's like, I can make sure it has water, I can make sure there's fertilization and it's got the right amount of sun and like, you know, whatever support that there there needs to be. And then there's a good bit of it that the mentee is going to have to take those things and grow

Goals and Changes

7. What practices in mentoring are you prepared to change/improve as a result of this training?
8. Do you foresee any particular barriers or issues to arise as you attempt to implement educative mentoring?
    a. For yourself?
    b. For your mentee?
9. How do you feel about implementing educative mentoring?
    a. How comfortable are you with it?
10. How likely are you to implement the key strategies of educative mentoring?
    a. Why?

Closing Thoughts

11. Please share any other thoughts on mentoring or MI that you want to share?

Thank you for your time today. Your responses will be very helpful in our research. Do you mind if I (or a member or our research team) contact you in the future if the need arises for clarifying questions?

How would you like to be contacted in this case?

III. After the Summer Institute Workshop Sessions

Good (morning/afternoon/evening) **[Insert Name]**. Thank you for volunteering to participate in this SIMIRS interview for mentoring beliefs and practices.

Now that we have completed all the portions of the educative mentoring training, the informational session where we explored the components and scenarios, and the teambuilding session where you began to build your community of practice, we will be talking about how you plan to incorporate the components of educative mentoring into your communities of practice. We will focus on each of the components separately.

May I have your permission to record this interview for the purpose of our IRB approved research activities for the NSF grant-funded project, SIMIRS?

- **Yes**
- **No**

Mentoring Practices (Intended Goals & Planned Mentoring Strategies)

1. You are going to support assigned mentees in implementing MI this academic year. What would be your major goal(s) of mentoring this fall and this year?
2. What mentoring strategies do you plan to use to achieve those goals? Why do you think those strategies would work?
3. During the Summer Institute, you had some opportunities to interact with your mentees. In what ways have those opportunities influenced your goal setting for mentoring and planning mentoring activities for this coming academic year?
4. How do you feel about implementing educative mentoring? What components of EM do you feel most comfortable to implement? Why? What components do you think would be most challenging to implement? Why?
5. What barriers or issues do you foresee to arise as you mentor your mentees? How would you handle them?

Modeling Instruction

6. What aspects of MI do you think teachers in general and your mentees specifically would struggle with ***the most*** when they first implement MI this fall? Why? How would you help them?
7. What aspect of MI do you think teachers in general and your mentees specifically would struggle with ***the least*** when first implementing MI? Why?
8. What "signs" or "signals" would you look for to determine if your mentee was having a difficult time with a component of MI? How would you address them in this context?

Closing Thoughts

9. Please share any other thoughts on mentoring or MI that you want to share.

Thank you for your time today. Your responses will be very helpful in our research. Do you mind if I (or a member of our research team) contact you in the future if the need arises for clarifying questions?

How would you like to be contacted in this case?

IV. At the End of Each Semester During Cohort 1

Good (morning/afternoon/evening) **[Insert Name]**. Thank you for volunteering to participate in this SIMIRS interview for mentoring beliefs and practices.

This interview will reflect back on your mentoring experience this semester to get some insights into what went well and what needs more support.

May I have your permission to record this interview for the purpose of our IRB approved research activities for the NSF grant-funded project, SIMIRS?

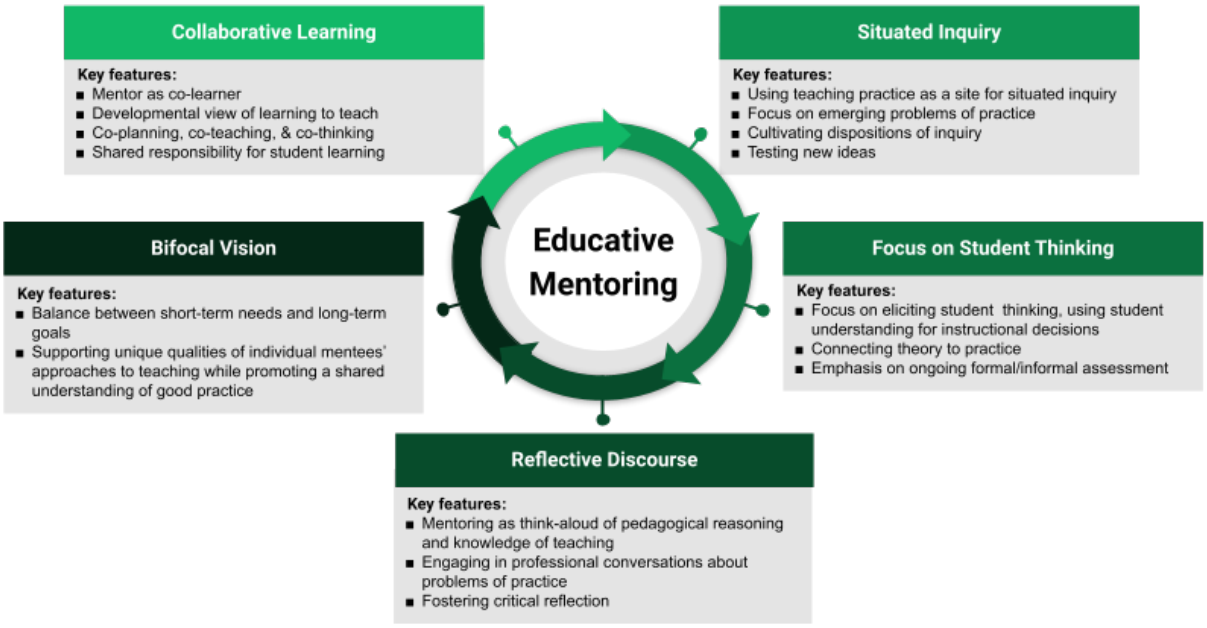
- **Yes**
- **No**

General Reflection of Mentoring Experience

1. Looking back on your mentoring experience this semester, what aspects of your mentoring went well, and what aspects of your mentoring that you would like to improve next semester?

Utilizing Educative Mentoring

For the next question we will refer back to the Educative Mentoring diagram that we introduced last spring (2022). Take a few moments to review the components and key features. Let me know when you feel you have a good grasp on the ideas.



2. In what ways do you believe you have incorporated educative mentoring strategies into your mentoring meetings?
    a. What do you think you were most successful in implementing?
    b. Which component(s) (if any) has been difficult to implement?
    c. Which component of EM do you think you need more practice implementing?

Supporting Mentee MI Implementation

3. What do you think is most critical to your mentee's successful implementation of MI?
    a. Why do you think this is so imperative?
4. How have you supported your mentee in addressing that critical component for implementing MI (based on the answer to the previous question)?
5. What changes in your mentoring would you like to make next semester?
    a. Why?
6. How would you describe your relationship with your mentee teachers?
7. How has this mentoring experience affected you?

[skip to question 12 for fall semester]

IVb. Additional Questions to ask after both semesters are completed

8. Briefly explain mentoring in terms of roles of mentor or mentees, goals of mentoring, mentor-mentee relationships, best mentoring practices, etc.?
9. Have there been any changes in your perceptions of mentoring in relation to the roles within the mentoring relationship?
    a. If so, describe those changes and explain why you believe the changes have occurred.
10. Have there been any changes in your perceptions of mentoring in relation to your goals of mentoring?
    a. If so, describe those changes and explain why you believe the changes have occurred.
11. Have there been any changes in your perceptions of mentoring in relation to the practices you perceive as fruitful to the mentoring process?
    a. If so, describe those changes and explain why you believe the changes have occurred.

Closing Thoughts

12. Please share any other thoughts on mentoring or MI that you want to share.

Thank you for your time today. Your responses will be very helpful in our research. Do you mind if I (or a member of our research team) contact you in the future if the need arises for clarifying questions?

How would you like to be contacted in this case?

APPENDIX B

Video-Stimulated Interview Protocol

Good (morning/afternoon/evening) **[Insert Name]**. Thank you for volunteering to participate in this additional SIMIRS interview for mentoring beliefs and practices.

During this interview, I will present you with some video clips from the mentoring sessions that you submitted to the research team. For each of the videos, I will ask you questions to reflect back on your mentoring experience this semester to get some insights into what went well and what needs more support.

May I have your permission to record this interview for the purpose of our IRB approved research activities for the NSF grant-funded project, SIMIRS?

- **Yes**
- **No**

Directions: Introduce the video that will be shared, including when the session took place and which mentees were in attendance in the session.
[Repeat the intent of the questions for each video presented to the mentor. Questions do not need to be worded exactly the same for each video clip. At any time a question can, and should be, followed up with "Why do you think that?"]

Before viewing the video clip

1. What can you share about the context of this session?

After viewing the video clip

2. What was happening in this clip? Try to recall what may have been going on before, during, and after this part of your mentoring session.
3. What do you think was important in this clip?
    a. Why do you think that?
4. Why did you focus on that? Tell me more about why you focused on that *(If necessary describe what the mentor did next)*
5. At this moment, what were you thinking about or considering?
    a. What other courses of action were you considering or were available to you?
6. What let you know that was the right decision to make at this point?
7. What information did you use in making this decision?
8. How much time pressure did you feel in making this decision?
9. If the mentee had said X instead of Y, how would that have influenced your decisions and/or assessment?
10. What did you do after this?
    a. What was the reason for doing that? What influenced your decision?

Additional questions to ask depending on the interaction with the mentor		
Thoughts, beliefs, and emotions	**Impressions of others**	**Impressions of self**
➔ What were you doing/trying to do at this point in the visit? ➔ What were you noticing/hearing at this point? ➔ Were there any other thoughts going through your mind? ➔ Can you tell me what you felt at this point? ➔ Can you recall more details about your feelings? ➔ Why did you make that statement/ask that question?	➔ What did you think the mentee was thinking about you at this point? ➔ What were your impressions of the mentee's actions at this point? ➔ Why do you think the mentee made that statement at this moment?	➔ What do you notice about your actions at this point? ➔ What about your behavior at this point surprises you?

Closing Thoughts

11. Please share any other thoughts on mentoring or MI that you want to share.

Thank you for your time today. Your responses will be helpful in our research. Do you mind if I (or a member of our research team) contact you in the future if the need arises for clarifying questions?

How would you like to be contacted in this case?

APPENDIX C

Mentor Log Template

Goal:
To capture the frequency, duration, nature and content of your mentee interactions. In order to understand those interactions, we are requesting that mentors document these mentoring activities into this mentoring log.

Directions for recording any mentor interaction on this form:

1. Include each interaction under the appropriate mentee's name in the bracketed red columns.
2. Date: Provide the date of the interaction.
3. Activity: Provide the type of mentoring activity that occurred on that date. Could be (but is not limited to): email exchange, phone call, text exchange, in-person meeting, virtual meeting.
4. Duration: Provide an estimate of how much time you spent for each activity addressing the mentee's needs or requests. If this was an email exchange, you may sum up the total time it took you to read and respond to the email.
5. Description: Describe the purpose of the correspondence, what you did and how you did it, and the outcome of the correspondence.

For recording biweekly sessions on this form: Please indicate the date of the session (should be the same across all mentees), the duration of the session, and a very brief description of the goal for that session (e.g., Reviewing GoReact feedback).

Other:

- If you feel the form is not capturing certain exchanges between yourself and your mentee, feel free to add additional pieces to the log to allow you to capture those interactions.
- If you need additional rows on the mentoring log, add rows as you see fit and number them accordingly

Activity	**[name]**	**[name]**	**[name]**	**[name]**
1	Date: Activity Type: Duration: Description:	Date: Activity Type: Duration: Description:	Date: Activity Type: Duration: Description:	Date: Activity Type: Duration: Description:

APPENDIX D

Educative Mentoring Observation Rubric (EMOR) Descriptors

Tag	Component	Descriptor (Look For)
Ia	**Situated Inquiry-1,2,3a**	The mentor guides the mentee to identify a problem of practice and use the identified problem to set goals and to determine strategies to achieve them.
Ib	**Situated Inquiry-1,2,3b**	The mentor uses inquiry-oriented approaches by actively listening and asking questions in a way that deepens the mentee's thinking about the emerging problem of practice.
Ic	**Situated Inquiry-1,2,3c**	The mentor models how they reason out about a particular problem of practice, verbalizing their thought processes.
Id	**Situated Inquiry-4d**	While discussing a problem of practice, the mentor does not respond with definitive solutions but rather encourages the mentee to think about possible solution(s).
Ie	**Situated Inquiry-4e**	The mentor encourages the mentee to test out their ideas.
If	**Situated Inquiry-4f**	The mentor invites the mentee to share their reflections on previously tested ideas.
Ca	**Collaborative Learning-1,2a**	The mentor uses mentoring as an opportunity for their own reflection and professional growth as well as the mentee's.
Cb	**Collaborative Learning-1,2b**	The mentor creates collaborative learning opportunities with the mentee building mutual respect.
Cc	**Collaborative Learning-1,2c**	The mentor monitors the progress of the mentee and strategically chooses developmentally appropriate tasks to support their professional growth.
Cd	**Collaborative Learning-3,4d**	The mentor explores lesson content, sequence, and structure with the mentee.
Ce	**Collaborative Learning-3,4e**	The mentor assesses student artifacts or student data with the mentee and determines the next steps for instruction together.
Cf	**Collaborative Learning-3,4f**	The mentor values the ideas and insights of the mentee equally to theirs.
Ba	**Bifocal Vision-1a**	The mentor is attentive to the mentee's short-term needs, but the mentor does not allow these conversations to take up the majority of mentoring sessions.
Bb	**Bifocal Vision-1b**	The mentor develops conversations about short-term needs into conversations about long-term goals that will ensure the success of the mentee in the future.
Bc	**Bifocal Vision-1c**	The mentor provides opportunities for the mentee to set up and refine their short-term and long-term goals that are developmentally appropriate for them.

Tag	Component	Descriptor (Look For)
Bd	**Bifocal Vision-2d**	The mentor probes the mentee's beliefs, prior experience, readiness, knowledge, or skills related to research-based best practices in teaching science.
Be	**Bifocal Vision-2e**	The mentor tailors mentoring based on their understanding of the mentee to best support the mentee's implementation of research-based best practices in teaching science.
Bf	**Bifocal Vision-2f**	The mentor respects the mentee's preferred approach to teaching, while promoting a shared understanding of best practices using examples and student artifacts/data drawn from practice.
Ra	**Reflective Discourse-1,2a**	The mentor makes their reflective thinking that guides pedagogical reasoning and actions explicit and visible to the mentee.
Rb	**Reflective Discourse-1,2b**	The mentor purposefully asks questions to develop the mentee's skill to reflect on practice.
Rc	**Reflective Discourse-1,2c**	The mentor engages the mentee in professional conversations to stimulate deep thinking about teaching, focusing on how and why certain changes are made (e.g., action and rationale).
Rd	**Reflective Discourse-3d**	The mentor helps the mentee to examine a problem of practice from multiple perspectives.
Re	**Reflective Discourse-3e**	The mentor guides the mentee to reflect on practice in terms of to what degree a lesson is inclusive, equitable, and accessible to diverse learners.
Rf	**Reflective Discourse-3f**	The mentor supports the mentee in developing assessment and instructional plans best suited to meet the needs of diverse students.
Ta	**Student Thinking-1,2a**	The mentor engages the mentee in conversations focusing on student thinking rather than teacher behaviors or actions.
Tb	**Student Thinking-1,2b**	The mentor uses observation and/or student data to help the mentee develop an understanding of how to elicit and interpret students' ideas, and how to use students' thinking in instructional decisions
Tc	**Student Thinking-1,2c**	The mentor facilitates conversations about student thinking in a way aligned with contemporary learning theories and student-centered, reform-oriented practices.
Td	**Student Thinking-3d**	The mentor guides the mentee to develop appropriate formal and/or informal formative assessment plans to gauge student learning.
Te	**Student Thinking-3e**	The mentor engages the mentee in analyzing their assessment data, and modeling how to probe and interpret student thinking.
Tf	**Student Thinking-3f**	The mentor supports the mentee to use the information from assessments in planning subsequent assessments and lessons.

APPENDIX E.1

Summary of Educative Mentoring Practice Indicators- Samantha

EM Indicator	Fall 2022					Spring 2023										Total Frequency	Total Consistency
	1	2	5	6	7	9a	9b	10	11	12	13	14	15	16a	16b		
Situated Inquiry																	
Ia						1	3			1						5	20%
Ib		1	1				4	2	2		2		1		3	16	53%
Ic	2	3		1			2	3	3	1	1			2		18	60%
Id		1	1		1											3	20%
Ie				1												1	7%
If	1					1		1	1	1					1	6	40%
Total	3	5	2	2	1	2	9	6	6	3	3	0	1	2	4	49	93%
Collaborative Learning																	
Ca	1			2	1									2		6	27%
Cb																0	0%
Cc																0	0%
Cd	4	2		1	2	2	2	2	1	2	1					19	67%
Ce							1		1							2	13%
Cf	3			2		2		1				2		1	2	13	47%
	8	2	0	5	3	4	3	3	2	2	1	2	0	3	2	40	87%
Bifocal Vision																	
Ba												1				1	7%
Bb		1				1	1	3							2	8	33%
Bc					1	3	3		2				1		1	11	40%
Bd	4	1	1		1	1	1							2		11	47%
Be		2						1		1	1	1		1		7	40%
Bf		1	1	1				2								5	27%
Total	4	5	2	1	2	5	5	6	2	1	1	2	1	3	3	43	100%
Reflective Discourse																	
Ra	1		1	2		1			2	1	1	1				10	53%
Rb					1	5	3	1		2					3	15	40%
Rc						3	1						1	5	4	14	33%
Rd						2		1						2		5	20%
Re	1						1							1	2	5	27%
Rf		1														1	7%
Total	2	1	1	2	1	11	5	2	2	3	1	1	1	8	9	50	100%
Focus on Student Thinking																	
Ta			1	2		1	2								2	8	33%
Tb			1	1			1								1	4	27%
Tc						3	1									4	13%
Td																0	0%
Te																0	0%
Tf																0	0%
Total	0	0	2	3	0	4	4	0	0	0	0	0	0	0	3	16	33%
Total Codes per Session	17	13	7	13	7	26	26	17	12	9	6	5	3	16	21		83%

APPENDIX E.2

Summary of Educative Mentoring Practice Indicators- Fiona

EM Indicator	Fall 2022							Spring 2023								Total Frequency	Total Consistency
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Situated Inquiry Total																	
Ia	1					1										2	13%
Ib	2	2	1					1		2		1		1		10	47%
Ic		1		1		1					2	1				6	33%
Id	1		1									1				3	20%
Ie		1						1								2	13%
If		1									2	1				4	20%
Total	4	5	2	1	0	2	0	2	0	2	4	4	0	1	0	27	67%
Collaborative Learning Total																	
Ca		3	1	1						1	3					9	33%
Cb			1	1							1					3	20%
Cc			1											2		3	13%
Cd		1	1	1		2		1						2		8	40%
Ce																0	0%
Cf		1	2	1												4	20%
Total	0	5	6	4	0	2	0	1	0	1	4	0	0	4	0	27	53%
Bifocal Vision Total																	
Ba					1		1			1						3	20%
Bb		1														1	7%
Bc	3						1									4	27%
Bd								1								1	7%
Be		1					1					1				3	20%
Bf							2			1				2		5	33%
Total	3	2	0	0	1	0	5	1	0	2	0	1	0	2	0	17	53%
Reflective Discourse Total																	
Ra				2												2	7%
Rb																0	0%
Rc																0	0%
Rd				1							1					2	13%
Re				1												1	7%
Rf																0	0%
Total	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	5	13%
Student Thinking Total																	
Ta		1	1						1	1	1			2	1	8	47%
Tb																0	0%
Tc								2						1		3	13%
Td				1												1	7%
Te																0	0%
Tf																0	0%
Total	0	1	1	1	0	0	0	2	1	1	1	0	0	3	1	12	60%
Total Codes per Session	7	13	9	10	1	4	5	6	1	6	10	5	0	10	1		49%

APPENDIX E.3

Summary of Educative Mentoring Practice Indicators- Xavier

EM Indicators	Fall 2022					Spring 2023										Total Frequency	Total Consistency
	1	4a	4b	5	6	7	9a	9b	10	11a	11b	12a	12b	13a	13b		
Situated Inquiry Total																	
Ia		1	1	1	1		2					1		1		8	47%
Ib		1	3	2	4	1	1	1	1	2	2	1	4	2	1	26	93%
Ic		1	1	2	2		2	1		2	1	2	1	3	4	22	80%
Id			1		1			1	1	1	1	2		1		9	53%
Ie			1		1			1	1							4	27%
If						1		1	1		1	1	1	1	2	9	53%
Total	0	3	7	5	9	2	5	5	4	5	5	7	6	8	7	78	93%
Collaborative Learning Total																	
Ca	2		1					2	1	1	2		1	2	1	13	60%
Cb				1					1		2					4	20%
Cc									1							1	7%
Cd	3	1	1					2	2	2	1	3	2	2	2	21	73%
Ce			2						1	1						4	20%
Cf			2		2			3	4		7		1	1	1	21	53%
Total	5	1	6	1	2	0	0	7	10	4	12	3	4	5	4	64	87%
Bifocal Vision Total																	
Ba																0	0%
Bb									1							1	7%
Bc					1								1			2	13%
Bd	2	3		5	1	2	2	2		2		1		2		22	67%
Be	3	1	1				2	3	1		1	2	1			15	30%
Bf												4		1		5	13%
Total	5	4	1	5	2	2	4	5	2	2	1	7	2	3	0	45	93%
Reflective Discourse Total																	
Ra	4		1	1	2		2	3	2	5	4	4	2	3		33	80%
Rb			3	3		1				1			1	3	1	13	47%
Rc				1			1									2	13%
Rd			1	2	2	1	1	1		1	1		1		1	12	67%
Re				1												1	7%
Rf												1				1	7%
Total	4	0	5	8	4	2	4	4	2	7	5	5	4	6	2	62	93%
Student Thinking Total																	
Ta			1	2		1	1		2	1	1			1		10	53%
Tb				1					1			2				4	20%
Tc			1						1			1				3	20%
Td				1						1	1					3	20%
Te																0	0%
Tf																0	0%
Total	0	0	2	4	0	1	1	0	4	2	2	3	0	1	0	20	60%
Total Codes per Session	14	8	21	23	17	7	14	21	22	20	25	25	16	23	13		85%