UNDERSTANDING CHANGE IN STUDENTS' COMPETENCE BELIEFS:
A MIXED METHODS STUDY

By

Stephanie Hyewon Shin

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Educational Psychology and Educational Technology – Doctor of Philosophy

2025

ABSTRACT

Recent calls in motivation research emphasize understanding motivation as a situative phenomenon that emerges through dynamic teacher-student interactions (Turner & Nolen, 2015). Competence-related beliefs are especially important for supporting students' effort, persistence, and learning in challenging subject areas like science. This mixed methods study examined whether and how competence-supportive instruction relates to students' competence beliefs during a science unit. The quantitative strand drew on survey data from 17 middle school science teachers and their students (n = 346) to identify potential sources of change in students' competence beliefs. Teachers' competence-supportive instruction positively predicted gains in students' competence beliefs over time, even after accounting for initial science interest and prior achievement, both of which were also significant predictors. Analyses also revealed distinct classroom-level patterns of change in students' competence beliefs, with some classrooms characterized by relatively uniform increases, others demonstrating relatively uniform decreases, and still others showing substantial individual variation. To further explore these classroom-specific patterns, the qualitative strand examined three classroom cases that focused on how teachers enacted competence-supportive strategies and how students' daily competence perceptions unfolded across multiple lessons. State-space grids (SSGs) embedded in each case provided a lens into daily teacher-student interactions. While all teachers implemented competence-supportive strategies in some form, they differed in how these strategies were framed, enacted, and experienced by students. This study highlights the nuanced ways in which competence-supportive instruction and student characteristics intersect to shape students' competence beliefs and underscores the value of using mixed methods approaches for capturing both broad patterns and situated, daily classroom processes in the study of motivation.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest gratitude to my advisor, Dr. Jennifer Schmidt, for your unwavering guidance, encouragement, and support. Thank you for being the kind of advisor who genuinely cares for her students' well-being and for always believing in me. Your mentorship has been truly invaluable, and this dissertation journey would not have been possible without you.

I am also sincerely grateful to my committee members, Dr. Lisa Linnenbrink-Garcia, Dr. Michael Lachney, and Dr. Ellen Usher, for your thoughtful feedback and insightful suggestions that helped strengthen and refine this work. Your perspectives pushed me to think more deeply and critically throughout the process.

To my friends and colleagues in the EPET program, thank you for your support, collaboration, and the many conversations that made my research and graduate experience more meaningful and enriching.

Finally, I am deeply grateful to my family and friends. Special thanks to my parents, thank you for your unwavering support and constant prayers. And to my husband, thank you for your unconditional love, patience, and belief in me. Your presence was a steady source of strength throughout this journey.

This milestone would not have been possible without each of you. Thank you from the bottom of my heart.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION ………………………………………………………………….. 1

CHAPTER 2: LITERATURE REVIEW ……………………………………………………….... 5

CHAPTER 3: QUANTITATIVE DATA STRAND …………………………………………… 31

CHAPTER 4: QUALITATIVE DATA STRAND ……………………………………………... 50

CHAPTER 5: INTEGRATED DISCUSSION ………………………………………………... 101

REFERENCES …………………………………………………………………………….... 120

APPENDIX A: SURVEY ITEMS ……………………………………………………………. 140

APPENDIX B: LESSON SUMMARY BY CASE …………………………………………… 141

APPENDIX C: SUMMARY OF COMPETENCE SUPPORT DIMENSIONS BY CASE ….. 142

CHAPTER 1: INTRODUCTION

Students' competence beliefs, or their perceptions of their capabilities to succeed, represent a key motivational construct across several prominent theories of motivation. These theoretical frameworks emphasize competence beliefs through related constructs including self-efficacy beliefs from social cognitive theory (Bandura, 1997; Schunk & DiBenedetto, 2020), expectancies for success from situated expectancy-value theory (Eccles & Wigfield, 2020), and need for competence from self-determination theory (Ryan & Deci, 2017). Across these frameworks, positive competence beliefs are associated with students' achievement-related behaviors (e.g., effort, persistence), engagement, and academic achievement (Usher, 2015). Competence beliefs are especially important in the field of science, technology, engineering, and mathematics (STEM), where students encounter cognitively demanding tasks and inquiry-based activities that require sustained effort and persistence (Constantinou et al., 2018; Lai, 2018). Students who perceive themselves as competent are more likely to approach challenges as opportunities for growth, whereas those with lower competence beliefs may disengage or avoid challenging tasks. Furthermore, students' competence beliefs are closely connected to students' STEM identity development and influence their long-term career aspirations to pursue STEM-related careers (Franks & Capraro, 2019; Perez et al., 2019; Sadler et al., 2013).

While the importance of competence beliefs is well-established, students' competence beliefs in STEM subjects tend to decline throughout secondary school (Marsh & Martin, 2011; Kosovich et al., 2017; Robinson et al., 2019). This decline can be attributed, in part, to increasingly competitive environments and more challenging coursework in these subjects (Krapp & Prenzel, 2011; Morgan & Gerber, 2016; Patall et al., 2018). Additionally, classroom environments that do not adequately support students' increasing need for autonomy may further contribute to motivational declines (Eccles et al., 1983). As students transition into secondary school, they likely encounter fewer opportunities to engage in meaningful decisions about their learning and experience less emotionally supportive relationships with their teachers, which may further undermine their competence beliefs (Bru et al., 2010; Wigfield & Cambria, 2010). This decreasing trend is concerning as secondary school represents a critical period when competence beliefs begin to shape students' classroom engagement, academic performance, and future career aspirations (Eccles & Wigfield, 2020; Muenks et al., 2018). To support long-term engagement in success in STEM, it is essential to understand how these beliefs develop during this developmental period and identify ways to effectively support them in classroom settings.

Although students' competence beliefs in STEM typically decline, this average decreasing trend is neither uniform nor linear. Some students maintain or even show increases in their competence beliefs over time (Robinson et al., 2022; Wang et al., 2017). This variability necessitates examining potential factors underlying the divergent patterns of change. Students' individual characteristics (e.g., initial subject interest, prior achievement) likely interact with their immediate classroom experiences, particularly through their interactions with teachers (Eccles & Wigfield, 2020; Robinson et al., 2019). Students with lower subject interest or lower academic achievement may be more susceptible to declines, whereas students with higher initial interest or stronger prior achievement may be more likely to sustain or strengthen their competence beliefs over time. These individual differences may be especially pronounced depending on the instructional context, particularly when teachers employ instructional strategies that emphasize growth, effort, and meaningful learning opportunities while promoting autonomy to support competence beliefs (Cheon et al., 2020). Likewise, teachers' self-beliefs about their role in supporting student motivation and learning also contribute to variations in students' competence beliefs. Teachers who feel confident in supporting student learning tend to implement more adaptive instructional strategies, such as individualized guidance and emotionally supportive interactions rather than relying on rigid or simplified instructional approaches, which can inadvertently signal low expectations and undermine students' competence beliefs (Depaepe & König, 2018; Hornstra et al., 2018; Reyes et al., 2012; Teig et al., 2019; Woodcock et al., 2022). Hence, one goal of this study was to investigate how potential factors related to students (e.g., initial science interest, prior achievement, and perceived teacher competence support) and teachers (e.g., teachers' self-efficacy beliefs) contribute to changes in students' competence beliefs across an instructional unit.

Beyond viewing competence beliefs as shaped by relatively stable individual characteristics, a dynamic systems perspective further suggests that competence beliefs change through ongoing, reciprocal interactions among the individual characteristics, classroom experiences, and teachers' instructional strategies (Dietrich et al., 2017; Hornstra et al., 2015; Kaplan et al., 2019; Tsai et al., 2008). Within these interactions, students and teachers collectively shape the classroom environment in ways that influence the development of competence beliefs. As students respond to instructional strategies, their competence-related cues (e.g., expressing uncertainty, withdrawal during challenging tasks, asking for help) reflect their immediate competence perceptions that signal whether they feel supported in their competence beliefs. These competence-related cues, in turn, can prompt teachers to adjust their strategies accordingly. Guided by their efficacy beliefs, teachers may refine their instructional approaches, such as providing additional guidance or reframing expectations and challenges, in ways that further shape students' competence perceptions. Over time, these recurring teacher-student interactions likely contribute to the classroom-wide patterns of change in students' competence beliefs (Hilpert & Marchand, 2018).

Given that competence beliefs emerge through dynamic and reciprocal interactions, it is essential to understand how these daily teacher-student interactions unfold over time in classroom settings. Prior research has often relied on single methodological approaches, such as survey measures or classroom observations, to assess teachers' instructional moves and students' motivational perceptions (e.g., Parrisius et al., 2022; Zeinstra et al., 2023). While useful, these approaches alone may obscure the complexity of ongoing teacher-student interactions that shape changes in students' competence beliefs. To address this, the present study employed an explanatory sequential mixed methods design to examine changes in students' competence beliefs in middle school science classrooms. The second goal of this study was to examine how teachers' competence-supportive strategies unfold alongside students' daily competence perceptions within classrooms that display unique change patterns in competence beliefs during an instructional unit. By integrating classroom observations with survey measures, this study may provide a more nuanced understanding of both student- and classroom-level perspectives that can inform how changes in students' competence beliefs emerge in real-time classrooms.

CHAPTER 2: LITERATURE REVIEW

In Chapter 2, I present a comprehensive literature review on competence beliefs within science education and key motivation theories. I examine empirical evidence for patterns of change in competence beliefs and review potential student- and teacher-related factors that may contribute to these changes, including students' subject interest, prior achievement, student perceptions of teachers' competence support, and teacher efficacy beliefs. Then, I discuss the role of teacher professional learning in supporting students' competence beliefs by shaping teachers' motivational beliefs, attitudes toward teaching, and instructional approaches. The review of literature highlights the dynamic interplay between teachers' instructional strategies and students' emerging competence perceptions to emphasize how daily teacher-student interactions shape changes in students' competence beliefs over time. Finally, I conclude by presenting three research questions that guide the present study aimed to understand changes in competence beliefs within the context of middle school science classrooms.

Competence Beliefs

Competence beliefs broadly refer to one's evaluative perceptions of their ability for a particular task or domain (Usher, 2015; Wigfield & Eccles, 2000). Across several contemporary motivation theories, competence beliefs are recognized as central to student learning by shaping achievement-related behaviors including effort and persistence and serving as key predictors of engagement and academic achievement (Marsh et al., 2019; Wigfield et al., 2015). Competence beliefs are represented in related constructs including self-efficacy beliefs within social-cognitive theory (Bandura, 1997), expectancies for success from situated expectancy-value theory (Eccles & Wigfield, 2020) and need for competence from self-determination theory (Deci & Ryan, 2002). In essence, these constructs converge around the question, 'Can I do this?" For the purpose of this study, the construct *competence beliefs* is used as an umbrella term encompassing these closely related constructs, all of which reflect students' perceptions of their academic abilities and performance.

Although subtle distinctions exist among these constructs, they consistently emphasize that students' perceptions of their abilities are often stronger predictors of positive academic functioning and educational outcomes than their actual ability (Schunk & Pajares, 2005; Usher, 2015). Given their importance, a number of studies have investigated how competence beliefs change over time. Prior research has suggested that competence beliefs typically decline across development, particularly during secondary school years (Kosovich et al., 2017; Robinson et al., 2019). However, other studies indicate a more varied pattern, with some students exhibiting stable levels or even demonstrating increasing trends in competence beliefs over time (e.g., Musu-Gillette et al., 2015; Parrisius et al., 2022). These diverse developmental trends in the have been attributed to differences in the sources of competence-related information students use to evaluate their abilities, including internal (e.g., subject interest), instructional (e.g., teacher practice), and social (e.g., teacher beliefs) factors (Han et al., 2021; Hornstra et al., 2021; Marsh et al., 2019). Collectively, these studies suggest that multiple factors within both students and teachers interplay to shape students' competence beliefs within the classroom. Understanding how these processes unfold is essential for informing instructional design that fosters adaptive motivation and positive academic outcomes (e.g., engagement; Usher et al., 2022).

Competence Beliefs in Science Education

Given the developmental changes in students' competence beliefs, scholars have examined how these beliefs may differ across specific academic domains, including science (e.g., Caprara et al., 2011; Guay et al., 2010; Green et al., 2007). Competence beliefs are often more domain-specific than other motivational constructs (e.g., achievement goals) as students begin to evaluate their abilities across subjects as they are exposed to different academic domains in school (Freiberger et al., 2012; Hornstra et al., 2016). Hence, exploring how domain-specific competence beliefs function is critical as students' experiences in a given subject domain may differentially shape the relations between their achievement-related behaviors (e.g., effort, persistence) and performance within that domain (Jansen et al., 2015).

Within the field of science education, *competence beliefs in science* reflect students' perceptions of their ability to successfully engage in science-related tasks, activities, and coursework (Vincent-Ruz & Schunn, 2017). Understanding how competence beliefs are developed, sustained, and supported within science is particularly relevant given the recent reforms emphasizing deeper conceptual understanding and application of scientific knowledge as articulated in the *Framework for K-12 Science Education* (National Research Council, 2012) and the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013). Achieving this vision requires that educators not only engage students in authentic science-related practices but also foster motivational beliefs toward learning science (Chen & Usher, 2013; Jansen et al., 2015; Morgan et al., 2016). However, evidence suggests that students tend to perceive science as a difficult subject, often accompanied by negative emotions such as anxiety (Patall et al., 2018; Simpkins et al., 2006; Udo et al., 2004). Such negative emotional states may diminish students' sense of competence and increase the perceived costs of investing time and effort to meet challenging academic demands, which can ultimately discourage their interest in pursuing science-related pathways. Given that students' interest in science and STEM fields more broadly, tends to decline over time (Aschbacher et al., 2010; Britner & Pajares, 2006; Simpkins et al., 2006), understanding how to cultivate positive competence beliefs is essential for sustaining students' learning, engagement, and performance in science-related fields.

Theoretical Frameworks for Understanding Competence Beliefs

Scholars have drawn on several theoretical frameworks to understand students' competence beliefs, which are commonly defined as individuals' perceptions of their abilities within a specific task or domain (Muenks et al., 2018). This study is guided by three well-established and empirically validated theoretical frameworks that examine competence beliefs in educational settings: self-determination theory (SDT; Deci & Ryan, 2002), social-cognitive theory (SCT; Bandura, 1997) and situated expectancy-value theory (SEVT; Eccles & Wigfield, 2020). These frameworks can offer a more integrated and comprehensive understanding of how students' competence beliefs develop and identify how they can be effectively supported in the classroom.

Self-Determination Theory

Along with the need for autonomy and relatedness, SDT represents competence beliefs as a basic psychological need (Ryan & Deci, 2017). Such *need for competence* is concerned with one's inherent tendency and desire to feel capable and effective in engaging in meaningful interactions with the environment. Students are driven by this need for competence that enables them to seek out challenges to develop and refine new skills and understandings. In assessing one's need for competence, SDT-based studies have measured competence beliefs in terms of the degree to which students' need for competence are fulfilled (i.e., competence need satisfaction; Cheon et al., 2020; Jang et al., 2010; Mouratidis et al., 2013).

Distinct from other competence-related beliefs (e.g., self-efficacy beliefs), competence need satisfaction is most optimal when accompanied by a sense of autonomy, which represents a need for actions to originate and result from individuals' volition and choice (Ryan & Deci, 2017). Further, the extent to which one's need for competence is satisfied for a particular task can vary depending on how much volition and choice one is given. Research guided by SDT showed that optimal learning outcomes including intrinsic motivation and engagement, occur when teachers engage in competence-supportive instruction by providing structure (e.g., clear expectations) are accompanied by autonomy support (e.g., providing rationales for expectations; Guay et al., 2017; Jang et al., 2010; Vansteenkiste et al., 2012). These findings suggest that the extent to which students' need for competence is met depends on whether they feel a sense of choice and control in their learning from their immediate environments (Ryan & Deci, 2020).

Social-Cognitive Theory

Students' competence beliefs from SCT are reflected in the construct of *self-efficacy beliefs*. Self-efficacy refers to students' self-beliefs about capabilities to successfully accomplish a designated task (Bandura, 1997). Compared to other constructs reflecting competence beliefs, self-efficacy is treated more as a domain- or task-specific construct which means that students' self-efficacy tends to vary across multiple performance contexts and specific content areas (e.g., science self-efficacy will be distinct from self-efficacy in other areas; Bong & Skaalvik, 2003). In academic settings, students with high self-efficacy tend to feel confident in their ability to organize and execute courses of action to successfully complete a task, which subsequently explains adaptive behaviors and outcomes including displaying help-seeking behaviors and setting more challenging goals (Linnenbrink & Pintrich, 2003; Usher & Pajares, 2008). Students' beliefs in their academic capabilities are shaped by how students select, weigh, integrate, and interpret four primary sources of information (Bandura, 1997; Usher et al., 2023). These multidimensional sources of information include one's personal mastery experiences (prior success) and from emotional and physiological states such as arousal and anxiety but can also develop indirectly from vicarious experiences (watching others succeed or fail), and verbal or social persuasions (encouragement by others).

Situated Expectancy-Value Theory

Within SEVT, competence beliefs are reflected in the construct of *expectancies for success* which refer to one's beliefs in their ability to produce expected outcomes for upcoming tasks in the future (Eccles & Wigfield, 2020). SEVT posits that students' competence beliefs (i.e., expectancies for success) and their value of the task directly shape their achievement-related behaviors, such as effort investment and persistence, which in turn, influence their performance (Eccles & Wigfield, 2002). Unlike other closely related constructs such as self-efficacy which is more task- or domain-specific, students' expectancies for success are often concerned with more general and stable ability beliefs in performing academic tasks across time or situations (Eccles et al., 1983).

SEVT also acknowledges that students' expectancies for success are situation-specific to highlight how they can vary across situations and are influenced by a range of personal and contextual characteristics. For example, students' previous achievement-related experiences and the affective memories associated with those experiences may interact with their immediate environment and the broader cultural context (e.g., societal expectations and roles; Eccles & Wigfield, 2020). As students become increasingly aware of their own abilities in a particular task or domain across development, they work towards developing mastery and refining their skills in ways that align with socio-cultural expectations (Wigfield & Eccles, 2000; Wigfield et al., 2015). These socio-cultural expectations are primarily communicated through their interactions with significant socializers including teachers and parents. Specifically in classroom settings, teachers' self-beliefs and instructional practices convey their expectations regarding students' abilities, potentially shaping how students perceive their own abilities within specific tasks or domains (Hornstra et al., 2018; Soltani & Askarizadeh, 2021). Because these perceptions can vary based on individual student characteristics (e.g., prior achievement), it is important to examine the range of classroom experiences to better understand variations in students' competence beliefs.

While competence beliefs are conceptualized with subtle distinctions across motivational theories, they share a common emphasis on students' perceptions of their ability to influence achievement-related outcomes. Across these theoretical variations, research consistently demonstrates that competence beliefs are positively linked to a range of educational outcomes, including achievement (Muenks et al., 2018). These findings underscore the broad relevance of competence beliefs for supporting student motivation and learning. Moreover, some evidence suggests that the relations between competence beliefs and educational outcomes vary across grade levels, gender, races, and cultural contexts (Butz & Usher, 2015; Muenks & Miele, 2017; Yu et al., 2022). Such variability highlights the need for differentiated instructional approaches in supporting students' competence beliefs that are responsive to the diverse characteristics and experiences of students. Hence, adopting a theoretically integrative perspective offers a more comprehensive understanding of how to support competence beliefs in classroom settings. This perspective not only acknowledges the shared motivational significance of competence beliefs across theoretical frameworks but also informs the design of instructional approaches that are attentive to students' individual differences. Building on this perspective, the following section examines potential student- and teacher-related factors that may contribute to changes in competence beliefs over time.

Students and Teachers as Sources of Change in Competence Beliefs

The three theoretical frameworks outlined above acknowledge how competence beliefs are central for student learning as they are linked to a range of adaptive outcomes, including engagement and academic performance (Muenks et al., 2018). Importantly, these frameworks also emphasize that competence beliefs are malleable and shaped by multiple sources of influence, including factors related to individual students and teachers. A growing body of theory and research supports this view that both student characteristics and contextual features of the classroom contribute to changes in students' competence beliefs over time (Ryan & Deci, 2017; Schunk & DiBenedetto, 2022; Wigfield & Eccles, 2000). At the individual level, students bring in pre-existing attributes that shape how they interpret and respond to instructional features of the classroom. For example, students' prior interest in a subject may reflect relatively stable motivational tendencies that influence their receptiveness to teachers' instructional strategies (Ainley & Ainley, 2011). Likewise, memories of previous achievement-related experiences, particularly those associated with strong emotions, can impact how students engage with learning tasks and perceive their abilities (Cook & Artino, 2016; Klassen & Usher, 2010). These individual differences in student characteristics may contribute to variability in how students experience instructional strategies and how their competence beliefs change over time.

Beyond student characteristics, contextual features of the classroom also play an important role in inducing change in students' competence beliefs (Ryan & Deci, 2020; Usher, 2015). Teachers' efficacy beliefs, which reflect their confidence in their ability to support student learning, have been linked to motivationally supportive instruction that promote adaptive learning outcomes (Schiefele & Schaffner, 2015; Tschannen-Moran & Hoy, 2001). For instance, teachers who use specific instructional strategies that communicate clear and high expectations, provide optimally challenging tasks, and deliver informational and encouraging feedback can help reinforce students' competence perceptions (Schmidt et al., 2015; Ryan & Deci, 2020). Together, these findings necessitate a more comprehensive understanding of how student- and teacher-related factors, both individually and collectively, contribute to patterns of change in students' competence beliefs. The following sections examine these potential factors in greater detail, with a particular focus on their relevance within science classrooms.

Subject-Related Interest

Subject-related interest reflects students' attitudes toward specific tasks or academic domains. It is characterized by feelings of enjoyment and is closely associated with the intrinsic value of the task or subject (Hidi & Renninger, 2006; Ryan & Deci, 2020). Interest plays a critical role in student learning as it has been shown to foster adaptive achievement-related behaviors, sustain engagement, and predict key academic outcomes (Harackiewicz et al., 2016). In relation to competence beliefs, SEVT suggests that students are likely to feel more competent when engaging in tasks they find valuable, particularly those they perceive as interesting or enjoyable (i.e., intrinsic value; Canning & Harackiewicz, 2015; Talsma et al., 2018). Similarly, SDT emphasizes interest in promoting intrinsic motivation, which encourages students to seek out challenges and opportunities to develop skills for inherent enjoyment and satisfaction (Ryan & Deci, 2020). Accordingly, interest is often conceptualized as a relatively stable motivational characteristic that sustains and enhances students' ongoing motivation and engagement within a subject area (Harackiewicz et al., 2016). Students with higher levels of interest are more likely to possess relevant knowledge and experience, which can strengthen their competence beliefs by supporting attention, effort, persistence and positive affect (Ainley et al., 2005; Patall et al., 2016; Thoman et al., 2011). In contrast, students with lower interest often lack background knowledge or prior experiences needed to feel confident in their abilities. These differences in interest can shape variations in how students respond to classroom tasks and influence their competence beliefs over time.

Research also suggests that students' levels of interest influence how they experience and respond to instructional strategies. For example, providing explanatory rationales for learning tasks has been shown to strengthen competence beliefs among students with higher initial interest as these students are more likely to connect the purpose of a task to personally meaningful goals (e.g., Canning & Harackiewicz, 2015; Durik & Harackiewicz, 2007). Alternatively, students with lower interests likely benefit more from instructional approaches that foster curiosity and involvement, such as activities that allow them to generate their own meaningful purposes and personalize the material to their everyday experiences (Durik et al., 2015). Externally provided rationales for students with lower interest may feel imposed that can potentially increase pressure to succeed and undermine their sense of competence. Overall, these findings indicate that instructional strategies impact students' competence beliefs differently depending on their levels of interest. For students with higher interest, direct explanations and challenges may be effective, whereas creating meaningful, personally relevant learning experiences may be beneficial for promoting both interest and competence among those with lower levels of interest.

Prior Achievement

Students' prior achievement is strongly related to their sense of competence in specific domains and how confident they feel in successfully completing future tasks (Guay et al., 2003; Lauermann et al., 2017; Usher & Pajares, 2008). Research consistently shows that students with higher achievement, as measured by grades or standardized tests, tend to report stronger competence beliefs (e.g., self-efficacy beliefs) than those with lower achievement levels (Marsh & Martin, 2011; Putwain et al., 2013; Valentine et al., 2004). These studies indicate that previous success reinforces students' confidence in their abilities and increases their willingness to invest effort in a particular domain or task. SCT also posits that mastery experiences are the most influential source of self-efficacy, as successful past performance provides self-persuasive information of one's competence, whereas repeated failures can diminish confidence in completing similar or same tasks in the future (Bandura, 1997; Usher & Pajares, 2008). For instance, prior success in domains such as science has been linked to stronger competence beliefs in that domain (e.g., science self-efficacy), which highlights how students' evaluations of their academic histories shape their perceptions of ability (Martin et al., 2019; Valentine et al., 2004). In turn, these domain-specific competence beliefs are associated with adaptive outcomes, such as increased enjoyment, sustained effort, and persistence, particularly when tasks become more challenging.

Students' prior academic achievement may also shape how they experience and respond to teachers' instructional approaches. Studies suggest that prior achievement can either buffer or intensify the effects of classroom environments characterized by low expectations or frequent social comparisons (Eccles & Wigfield, 2002; Wang, 2012). Specifically, instructional climates that lack sufficient challenge or convey low expectations were detrimental to perceived competence especially for students with lower achievement (Lazarides & Watt, 2015; Rubie-Davies, 2006; Wang et al., 2020). When teachers communicate low expectations, they may unintentionally signal a lack of confidence in students' abilities, which can especially be discouraging for students who have previously struggled to experience success. In contrast, providing appropriately challenging tasks along with appropriate guidance can help reinforce students' capability to meet high expectations and strengthen their competence beliefs (Yeager et al., 2014). These mastery experiences may be particularly important for students with lower achievement by prompting a sense of progress and building confidence to succeed with more challenging tasks (Rittmayer & Bayer, 2009; Rubie-Davies, 2010). Collectively, these findings highlight how students' prior achievement-related experiences shape the extent to which they are susceptible to certain teacher practices. This underscores the importance of creating learning environments that promote competence beliefs for all students, with particular attention to those who may be more vulnerable to diminished competence beliefs due to past academic failures.

Teacher Self-Efficacy Beliefs

Teachers' self-efficacy beliefs reflect how confident teachers feel in their ability to successfully bring about positive outcomes related to student motivation, learning, and performance through their instruction (Dellinger et al., 2008; Tschannen-Moran & Hoy, 2001). In specific domains such as science, teachers' self-efficacy refers to their own beliefs in their ability to teach science concepts as well as to manage classroom challenges related to science instruction (Cakiroglu et al., 2012; Yesilyurt et al., 2024). These teacher-related beliefs have been recognized as influential not only for teachers' own instructional decisions, but for shaping students' motivational beliefs including competence beliefs (e.g., self-efficacy, expectancies for success; Burić & Kim, 2020; Midgley et al., 1989).

Examining the consistency and quality of specific instructional strategies employed by teachers can inform how variations in students' competence beliefs emerge as a function of teachers' efficacy beliefs. Teachers who doubt their instructional abilities are more inclined to simplify tasks, and rely on rote, teacher-directed methods (e.g., Teig et al., 2019; Woodcock et al., 2022). Over time, these instructional strategies may limit opportunities to challenge students cognitively and experience mastery and growth, particularly for students with lower competence beliefs. For these students, repeated exposure to tasks that lack appropriate challenge or classroom environments with low expectations can reinforce negative competence beliefs and contribute to declines in their beliefs (Eccles & Wigfield, 2020). Conversely, teachers with higher self-efficacy beliefs are more likely to implement more varied, student-centered instructional strategies designed to address learning challenges and support students' ongoing mastery experiences. Specifically, these strategies include providing scaffolding (e.g., hints, cues, examples), offering social-emotional support (e.g., responding to students' frustration with encouragement), and maintaining high and clear expectations coupled with information feedback (Depaepe & König, 2018; Palmer et al., 2015; Ruzek et al., 2016). Through these instructional strategies, teachers may help foster positive gains in students' competence beliefs by promoting mastery experiences and affirming students' abilities during instruction (Aelterman et al., 2019; Jang et al., 2010; Patrick et al., 2007).

The role of teachers' efficacy beliefs may be particularly important in science education where recent reforms have emphasized the use of inquiry-based, student-centered approaches to support scientific reasoning and sense-making (Furtak et al., 2012; Odden & Russ, 2019). Teachers with higher science efficacy beliefs are more likely to adopt such approaches including the use of open-ended tasks and student-led investigations, whereas those with lower efficacy beliefs may rely on more traditional, teacher-directed approaches such as direct instruction or lecture (Baysal & Mutlu, 2021). Furthermore, teachers who feel confident in their instructional abilities also tend to invest more time in research-based strategies that encourage students to apply science concepts in real-world contexts and persist through challenges (Lauermann & Berger, 2021; Lotter et al., 2007). These instructional strategies are especially important for sustaining students' competence beliefs in science, a domain where students often encounter cognitively demanding tasks and experience heightened anxiety (Patall et al., 2018). Together, teachers' self-efficacy beliefs may shape how students' competence beliefs change through influencing the extent to which teachers consistently implement competence-supportive strategies during instruction. A systematic examination of these instructional patterns, particularly in science classrooms, can offer insight into the mechanisms through which teachers' self-efficacy beliefs may contribute to changes in students' competence beliefs.

Teacher Competence Support

Students' competence beliefs may also change in response to features of the classroom environment, particularly through how teachers support these beliefs during instruction. Teachers' use of specific instructional strategies can influence students' perceptions of competence support, which, in turn, impact their motivation and learning. Research using both student ratings and observational measures has consistently demonstrated the benefits of motivationally supportive instruction on student outcomes including promoting higher competence beliefs (e.g., self-efficacy) and more adaptive classroom functioning (e.g., engagement; Ryan & Patrick, 2001; Jang et al., 2010; Stroet et al., 2013). In contrast, motivationally undermining instruction has been associated with more maladaptive functioning (e.g., procrastinating behaviors) and negative learning outcomes (e.g., Opdenakker, 2021; Vansteenkiste et al., 2012). To promote competence beliefs, scholars emphasize the importance of designing instructional contexts that intentionally support students' competence beliefs through a theoretically integrated approach drawing from multiple motivational frameworks (e.g., Linnenbrink-Garcia et al., 2016). These frameworks converge upon four broad competence-supportive dimensions: (a) communicating clear expectations, goals, and norms; (b) providing academic challenge; (c) offering guidance, help, and modeling; and (d) delivering informational and encouraging feedback.

A central component of supporting students' competence beliefs involves teachers' clear communication of expectations, goals, and norms. These expectations, goals, and norms may apply to both academic and social aspects of the classroom environment (Patrick et al., 2007; Sierens et al., 2009). When teachers establish a well-structured environment, they provide students with a sense of consistency and predictability in both academic tasks and classroom interactions (Cheon et al., 2019; Guay et al., 2017). For academic tasks, explicitly articulating procedural steps and learning goals helps students understand what is expected and how to succeed. Similarly, promoting positive classroom norms, such as respectful collaboration, valuing others' contributions, and encouraging help-seeking, can foster a supportive and competence-enhancing classroom climate (Patrick et al., 2007). Prior research also supports this view by indicating that when teachers clearly communicate expectations, goals, and norms, students are more likely to embrace challenges and strive for mastery of given tasks (Simpkins et al., 2006).

Alongside clear expectations, providing appropriately challenging tasks aligned to students' existing skill level is essential for promoting students' competence beliefs (Csikszentmihalyi, 1990; Malmberg et al., 2013; Schmidt et al., 2015). In practice, academic challenges may involve gradually increasing the task difficulty or pressing students to elaborate on their understanding through follow-up questions that encourage deeper thinking and problem-solving (Butz & Usher, 2015; Chin, 2007; Rogat & Linnenbrink-Garcia, 2011). However, because perceptions of challenge are subjective, students' responses depend on both their perceived skill level and the instructional guidance provided by teachers (Strati et al., 2017).

When paired with appropriate guidance and scaffolding, challenging tasks calibrated to students' existing skills help students experience mastery, which reinforces their sense of competence and prepares them to deal with future challenges (Belland et al., 2013). Moreover, incorporating academic challenges conveys teachers' high expectations that signal to students that they are capable of succeeding, which can further strengthen competence beliefs (DeCastro-Ambrosetti & Cho, 2011; Siems-Muntoni et al., 2024).

To help students navigate academic challenges, it is important that teachers offer necessary guidance and scaffolding. Instructional strategies such as breaking down tasks into manageable steps, adjusting the level of task difficulty, asking guiding questions, and fostering collaborative effort can help students make meaningful progress (Chin, 2007; Näykki et al. 2021; Vansteenkiste et al., 2012; Vygotsky, 1978). With appropriate guidance and scaffolding, students are encouraged to monitor, evaluate, and refine their own learning progress, which can build confidence in their ability to meet the communicated expectations and challenges (Belland & Belland, 2017; Jang et al., 2010). Additionally, teachers can use social modeling to demonstrate effective guidance strategies for overcoming challenges (Van de Pol et al., 2010). Rather than presenting social models demonstrating flawless performance, modeling that showcases perseverance and adaptive strategy use can help students understand what competent functioning looks like, particularly when the model is relatable to students' own attributes (Schunk & Hanson, 1985; Shumow & Schmidt, 2014). Research also indicates that students who observe similar others such as peers successfully overcoming challenges and performing a task successfully are more likely to feel confident in their own abilities (Ahmad & Safaria, 2013; Ahn et al., 2017; Lent et al., 1996; Lin-Siegler et al., 2016).

Finally, providing encouraging and informational feedback is crucial in supporting students' competence beliefs (Chi et al., 2021; Wisniewski et al., 2020). When combined with appropriate guidance, feedback can help students track their progress toward communicated expectations and learning goals. Informational feedback, in particular, highlights what students have done well and explains how specific strategies contributed to their success, thereby affirming their sense of competence (Hattie & Timperley, 2007; Muenks et al., 2018). Additionally, feedback that normalizes mistakes as part of the learning can help students identify areas for improvement, monitor their progress, and adjust their strategies, which can allow them to sustain their confidence in their abilities (Adams et al., 2020; Leighton et al., 2018).

While students' perceptions of instructional strategies are essential for promoting changes in competence beliefs, the successful implementation of these strategies depends on the instructional supports and conditions available to teachers. Creating classroom environments where competence-supportive strategies are consistently enacted may require intentional professional learning (PL) that helps teachers develop the knowledge, skills, and efficacy beliefs needed to support students' competence beliefs. The following section examines how PL opportunities can create conditions that enable teachers to effectively promote students' competence beliefs through their daily instruction.

Professional Learning (PL) to Support Change in Students' Competence Beliefs

Given the central role of teachers' beliefs and instructional strategies in accounting for variations in students' competence beliefs, PL has been identified as a key mechanism for equipping teachers to promote student motivation and learning in their classrooms (Christensen et al., 2024; Rathgen, 2006). Research on PL emphasizes the need to not only strengthen instructional delivery but also address the challenges teachers may face in creating motivationally supportive environments. In response, a growing body of work has focused on designing PL experiences that help teachers implement motivationally supportive strategies for specific domains, such as science (Kleickmann et al., 2016; Marchand et al., 2021; Vivante & Vedder-Weiss, 2023). These experiences often engage teachers in iterative cycles of planning, implementation, and reflection in collaboration with education researchers to learn how to integrate motivational supports into their instruction (Marchand et al., 2021; Robertson et al., 2020). This collaborative structure likely reinforced teachers' motivational beliefs (e.g., teachers' self-efficacy beliefs) by providing both emotional and pedagogical support and ultimately empower them to apply evidence-based strategies designed to strengthen student motivation and learning (Cann et al., 2022; Fred et al., 2020).

Participation in research-based PL has also been linked to meaningful changes in teachers' efficacy beliefs, attitudes toward teaching, and instructional approaches (Dogan & Yurtseven, 2018; Higgins & Spitulnik, 2008). For example, Mouza (2009) found that teachers who engaged in research-based PL around technology integration demonstrated improvements in their instructional knowledge, confidence in using technology, and attitudes toward designing technology-enhanced learning experiences. Similarly, Lakshmanan et al. (2011) found that science teachers participating in PL exhibited increased use of inquiry-based instruction and gains in their teaching efficacy beliefs. Clearly, these findings speak to the importance of designing high-quality PL in supporting the development of adaptive teacher beliefs and more effective instructional approaches.

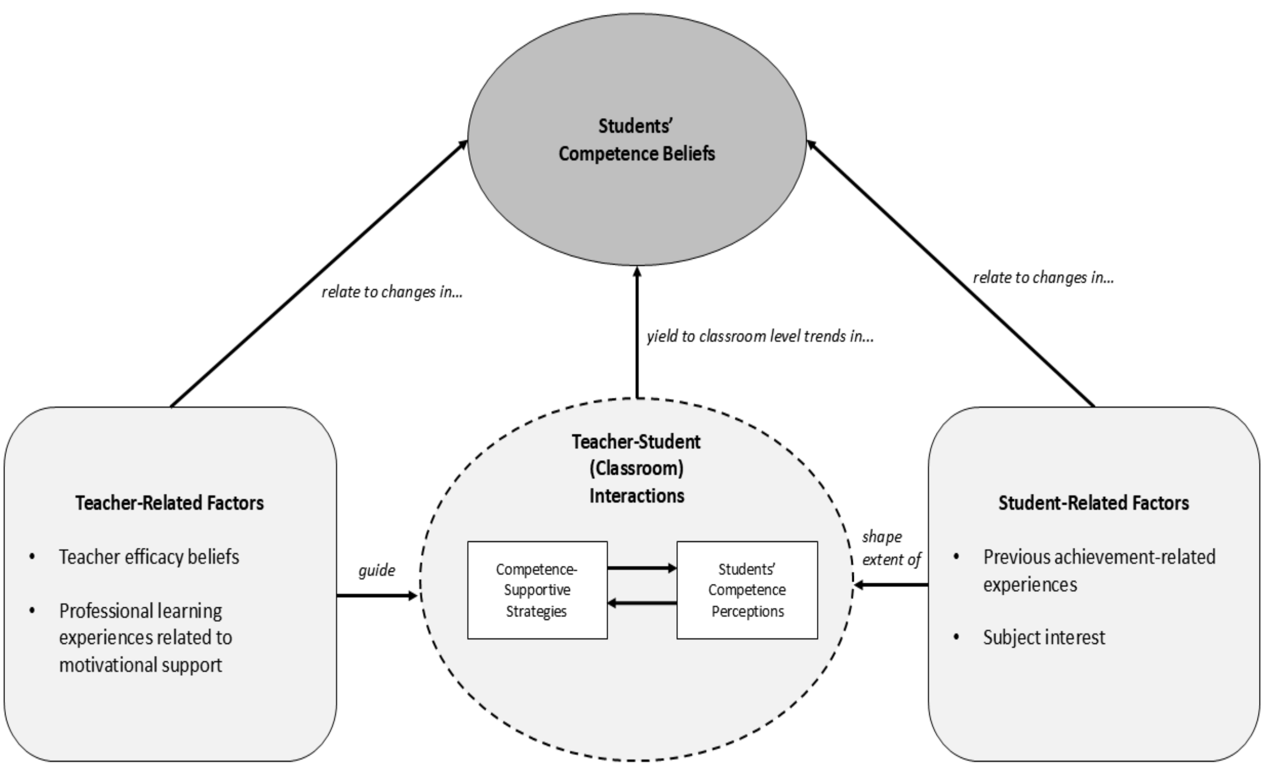
Importantly, the benefits of PL extend beyond inducing change in teachers' beliefs, attitudes, and instructional approaches to promote positive student outcomes. Indeed, research has shown that teachers who participated in PL opportunities focused on motivationally supportive instruction (e.g., teacher structure) are more likely to promote classroom environments that enhance students' competence need satisfaction, engagement, and skill development. These outcomes were explained by teachers' employing strategies that are perceived as motivationally supportive and cultivating a positive classroom climate (Cheon et al., 2020; Cheon et al., 2022). The need for PL experiences is particularly relevant in the field of science education where teachers are expected to implement inquiry-based approaches aligned with the *Framework for K-12 Science Education* standards (National Research Council, 2012). Such instructional reform presents challenges for science teachers, especially as they attempt to address the declines in students' motivation and engagement in science that often occur during secondary school years (Deneroff, 2016; Engels et al., 2021; Mansour et al., 2014; Patall et al., 2019; Vedder-Weiss & Fortus, 2011). In response to these challenges, some studies have examined how PL in science education can influence both teacher practices and student outcomes. Findings suggest that teachers' participation in inquiry-focused PL is associated with increased use of inquiry-based pedagogies, which in turn, support students' development of inquiry skills and engagement in scientific practices (e.g., questioning; Grigg et al., 2013; Nichols et al., 2017). Building on this body of work, the present study further explores how the instructional strategies employed by teachers, following their participation in PL, are related to changes in students' competence beliefs in science classrooms.

Examining Change Processes in Competence Beliefs Through Classroom Interactions

Examining changes in students' competence beliefs alongside the multiple factors within students and teachers that shape these changes reveals the dynamic and reciprocal nature of daily teacher-student interactions. As shown in Figure 1, competence beliefs do not change in isolation but are shaped through ongoing exchanges in which teachers' competence-supportive instruction plays a central role. At the same time, students bring in varying levels of prior achievement, subject interest, and past learning experiences, which shape how they perceive and respond to teachers' competence-supportive instruction. These responses, including students' momentary perceptions of their competence, offer cues that inform how teachers adjust their approaches to meet students' emerging needs. Figure 1 illustrates this conceptual model by situating teacher-student interactions as a key classroom process through which both student-related factors (e.g., prior successes and failures, subject interest) and teacher-related factors (e.g., teacher self-efficacy beliefs, professional learning experiences) contribute to changes in students' competence beliefs. Over time, these continuous and reciprocal influences between competence-supportive strategies and students' competence perceptions accumulate to shape the broader classroom environment and yield distinct patterns in students' competence beliefs.

Figure 1

Model of Teacher-Student Interactions and Sources of Influence on Competence Beliefs



Recognizing this interplay highlights the importance of understanding classrooms as dynamic systems that develop patterns of interactions in which teachers and students jointly co-construct classroom environments that either support or undermine students' developing sense of competence. A dynamic systems (DS) approach emphasizes that these interactions unfold across multiple, interrelated timescales, from moment-to-moment exchanges (micro-level) to longer-term developmental changes (macro-level), which together shape the quality of classroom interaction over time (Hollenstein, 2013; Marchand & Hilpert, 2020). A growing body of research using a DS approach in educational contexts has focused on capturing the nature of teacher-student interactions, particularly in relation to teachers' instructional (e.g., motivational support including competence beliefs; Turner & Christensen, 2020) or interpersonal behaviors or moves and students' classroom experiences, such as their perceptions of motivation and engagement (Ghafarpour & Moinzadeh, 2019; Pennings & Hollenstein, 2020; Stroet et al., 2013). To examine these interacting components, prior studies have employed both global or summative measures, such as student and teacher self-reports (Mainhard et al., 2011; Wubbels et al., 2017) and more recently, observational methods that capture the moment-to-moment dynamics of classroom interactions (Gray et al., 2020; Turner et al., 2014; Turner & Christensen, 2020; Zeinstra et al., 2023). While students' global or aggregated perceptions provide insight into teachers' overall instructional approaches toward the class as a whole, classroom observations offer a more process-oriented perspective by focusing on how specific instructional behaviors and students' classroom experiences unfold in real time (Mainhard et al., 2011; Pennings & Mainhard, 2016). Through these studies, findings revealed that teachers' and students' momentary behaviors and perceptions are reciprocally related. As these ongoing interactions unfold, they gradually stabilize into distinct interactional patterns that shape the broader classroom environment and instructional climate. Over time, these patterns contribute to specific outcomes, such as consistency of teachers' instructional strategies and the quality of students' overall classroom experiences (Ghafarpour & Moinzadeh, 2020; Steenbeek & van Geert, 2013).

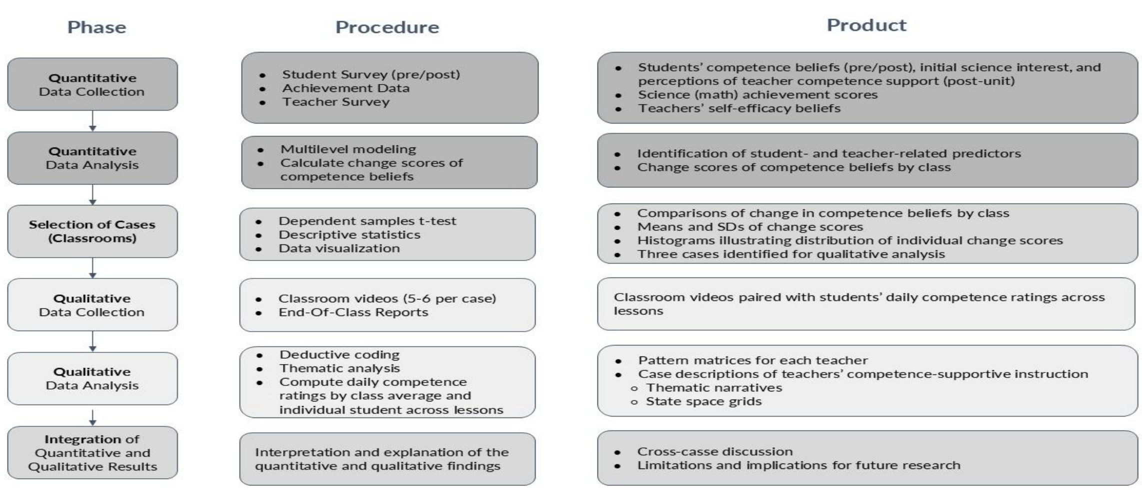
Building on this line of work, scholars have explored how shifts in teacher-student interaction patterns, such as variations in teachers' instructional approaches and students' classroom experiences (e.g., engagement), shape the overall quality of teacher-student interactions over time (Van den Berghe et al., 2016; Zeinstra et al., 2023). Given the transactional nature of these interactions, interaction patterns likely emerge as both teachers and students continuously respond and adapt to each other's behaviors and perceptions. To capture these dynamic processes, several studies have utilized state-space grids to visually map the co-occurrence of teacher and student behaviors and perceptions over time on a two-dimensional grid (Hollenstein, 2013). Each point on the grid represents a specific combination of motivational support and students' classroom experiences within a given moment or lesson (e.g., Gray et al., 2020; Turner & Christensen, 2020). Analyzing these teacher-student interaction patterns enabled scholars to identify "optimal" or favorable interaction states that are characterized by higher-quality motivational support paired with positive classroom experience (e.g., engagement) as well as "non-optimal" states, where low motivational support are paired with less adaptive classroom experiences (Turner et al., 2014). Examining changes in these interaction patterns across time can provide insight into when and how classrooms shift between more or less favorable states that can highlight instructional moments when teacher-student exchanges may either support or undermine students' competence beliefs (Mainhard et al., 2012). Guided by these findings, the present study adopted a DS approach to examine whether changes in teacher-student interaction patterns across an instructional unit may help explain changes in students' competence beliefs as reflected in teachers' use of competence-supportive strategies and students' daily competence perceptions.

Present Study and Research Questions

The present study aims to advance understanding of how students experience changes in competence beliefs within middle school science classrooms where teachers participated in PL focused on supporting students' motivation and engagement in science. Given the situated nature of competence beliefs (Nolen, 2024; Turner & Nolen, 2015), it is important to acknowledge that changes in students' competence beliefs are shaped by multiple factors within both students (e.g., subject interest, prior achievement) and teachers (e.g., teacher efficacy beliefs, teacher competence support), all of which are embedded within the unique context of classrooms. These factors unfold through daily teacher-student interactions whereby instructional moves and students' motivational perceptions mutually reinforce one another. Understanding how these reciprocal processes are particularly important in science education, where learning and doing science are viewed as a "situated practice" (Wilmes & Siry, 2021, p.73). This involves how teachers and students jointly engage in meaning-making of scientific phenomena by drawing upon a range of pedagogical, social, and material resources (e.g., instructional strategies; Hwang & Roth, 2011; Menninga et al., 2021; Moro et al., 2020). Prior research has primarily relied on single methodological approaches, most commonly surveys, to examine how teacher and student perceptions and behaviors relate to one another (e.g., Mainhard et al., 2011). While these approaches offer valuable insights into factors associated with motivational change, they may overlook the nuances of daily teacher-student exchanges, such as specific instructional moves and students' motivational perceptions, that shape interaction patterns over time. Integrating observational methods alongside survey measures can offer the opportunity to capture how teacher-student interactions unfold over time and how these dynamic processes contribute to changes in students' competence beliefs.

The present study extends prior work by using an explanatory sequential mixed-methods design in which a qualitative phase was conducted to elaborate on and contextualize findings from the preceding quantitative phase (Creswell & Plano Clark, 2018; Morgan et al., 2017). Figure 2 presents a flow diagram of the study's design. The quantitative strand investigated how student- and teacher-related factors were associated with changes in students' competence beliefs by using survey data from 17 science teachers and their students (n = 346). Then, changes in competence beliefs were assessed by change scores derived from student ratings of competence beliefs before and after the instructional unit, which allowed for identifying classroom-level trends. The subsequent qualitative phase focused on classrooms with distinct trends to explore how teacher-student interactions help explain these trends within specific instructional contexts. Specifically, each classroom case illustrated how teachers implemented competence-supportive strategies and how students perceived their own competence across multiple lessons.

Figure 2
Study Design



To that end, this study aimed to understand changes in students' competence beliefs in middle school science classrooms with two primary goals. First, it examined the extent to which student- and teacher-related factors are associated with changes in students' competence beliefs across an instructional unit. Second, it explored how patterns of teacher-student interactions, as reflected in teachers' competence-supportive strategies and students' daily competence perceptions, are manifested in classrooms with distinct patterns of change. By examining how these interactions unfold across multiple lessons, this study seeks to better understand the classroom processes that shape students' competence beliefs over time. Examining how these interactions unfold across lessons can help students understand how or why students experience changes in competence beliefs over time. Situated within the context of teachers who participated in PL focused on motivationally supportive instruction, this study addressed the following research questions:

1. How are student and teacher-related factors associated with changes in students' competence beliefs?
    a. To what extent do *student-related* factors, such as prior achievement and science interest, explain changes in competence beliefs?
    b. To what extent do *teacher-related* factors, such as teachers' self-efficacy beliefs and teacher competence support, explain changes in students' competence beliefs?
2. What classroom-level patterns of change in students' competence beliefs emerge during the instructional unit? For example, do some classrooms show relatively uniform increases or decreases in students' competence beliefs, while others exhibit substantial individual variation in competence beliefs?)

3. In classrooms showing distinct patterns of change in competence beliefs, how do teacher-student interactions unfold across an instructional unit? This question is addressed by examining (a) teachers' enactment of competence-supportive strategies and (b) students' daily perceptions of their own competence.

Researcher Positionality

I draw on my research background and teaching experiences in relation to this study. As an Asian American doctoral student studying education and psychology at a large public university in the United States, my focus on student motivation and engagement may shape how I interpret teachers' instructional practices. My prior teaching in varied school settings, including culturally and ethnically homogenous contexts, also informs how I view classroom interactions. I recognize that the diverse backgrounds of students in this study differ from those I have previously taught, which may limit my interpretations.

It is also important to acknowledge my involvement in the broader project in which this study is situated, including data collection in some classrooms. These experiences contributed to established relationships with the participating teachers and districts, which provided valuable insider knowledge for qualitative analysis. At the same time, this familiarity also raises the potential for bias in interpreting classroom interactions and developing case narratives. To address this, I incorporated feedback from other researchers on the team who had no prior relationships with the participants to help counterbalance interpretations and strengthen the credibility of findings.

CHAPTER 3: QUANTITATIVE DATA STRAND

In Chapter 3, I present the quantitative strand of the study, which examined changes in students' competence beliefs over the course of an instructional unit in middle school science classrooms. This phase of the study addressed two primary aims. First, I investigated whether and to what extent student-related (e.g., science interest, prior achievement) and teacher-related factors (e.g., teacher efficacy beliefs, teacher competence support) uniquely contributed to changes in students' competence beliefs. By examining these associations, I aimed to gain insight into how individual student characteristics and contextual features of the classroom may account for variability in students' competence beliefs over time. Second, I explored patterns of change in students' competence beliefs at the classroom level. This analysis informed the selection of classrooms for the subsequent qualitative phase by identifying "cases" that exhibited distinct patterns of change.

Method

Context, Setting, and Procedure

The present study was conducted as part of a larger design and development project aimed at creating professional learning (PL) focused on motivationally supportive science instruction (Marchand et al., 2021). During an earlier phase of the project, researchers collaborated with middle school science teachers to co-design a PL institute and support resources for teachers. Data from the present study was collected during a subsequent phase of the project, which involved a new cohort of middle school science teachers (rollout teachers) from four school districts who participated in the PL institute during the summer of 2021. During the PL, teachers were introduced to five motivation design principles (MDPs; belonging, competence, mastery goal orientation, autonomy, relevance), which collectively represent a theoretically integrative framework for supporting student motivation and engagement (Linnenbrink-Garcia et al., 2016). Following their participation in the PL institute, teachers consented to classroom data collection while implementing instructional strategies aligned with these principles during a chemistry unit in the subsequent school year.

Participating teachers and students were from schools across four large districts that serve diverse student populations and have adopted a curriculum aligned with the *Next Generation Science Standards* (NGSS). Teachers employed motivationally supportive strategies within a unit of instruction broadly focused on chemistry although specific curricula and instructional approaches varied by teacher and district. Curricula used by participating teachers included commercially available curricula, open-source curricula, district-generated resources, and self-developed instructional resources. The instructional units featured diverse learning activities designed to deepen students' understanding of physical science concepts such as chemical reactions, density and solubility, molecular structure, and conservation of matter. For example, some students conducted lab investigations involving chemical reactions such as mixing sulfuric acid with water or observing aluminum foil reacting with copper chloride solution, which prompted central scientific questions about the properties of substances. As the unit progressed, students further applied disciplinary core ideas, crosscutting concepts, and science and engineering practices through collaborative projects examining molecular structures and whole-class discussions about the relationships among mass, density, and volume. A more detailed description of instructional contexts, including specific activities and curricular materials used by teachers whose classrooms were selected for the qualitative strand, are provided in Chapter 4.

Data collection for the present study occurred throughout the 2021-2022 school year, beginning with teachers completing a survey prior to both their participation in PL and implementation of the instructional unit. The initial survey assessed various aspects of teachers' self-efficacy beliefs related to teaching and supporting students' motivation in science. At the start of the Fall 2021 semester, students completed pre-surveys that measured their initial interest and perceived competence in science approximately two weeks prior to the instructional unit. During the unit, teachers implemented motivationally supportive instructional strategies over a period that lasted approximately nine weeks. As part of the data collection, teachers recorded five to nine lessons using a *Swivl* device equipped with an external microphone and motion sensor, which tracked their movements throughout each lesson. To capture students' daily motivational experiences, End-of-Class Reports (ECRs) were administered at the end of selected class sessions. These brief surveys reflected students' daily perceptions of their own motivation and engagement following a given lesson. At the end of the instructional unit, students completed a post-survey that assessed their perceived competence in science and included additional measures related to their perceptions of teachers' competence support.

Participants

Participants were 17 seventh-grade science teachers (70.6% female, 88% White), including 8 teachers from public middle schools in a Midwestern state and 9 teachers from a Southwestern state. Four of these teachers had previously co-designed the PL institute and the remaining 13 were rollout teachers. On average, the participating teachers were 47.53 years old (*SD* = 9.65, range = 24-58) and had 15 years of teaching experience (*SD* = 8.33, range = 1 - 26). All but three teachers held master's degrees. Each teacher selected one of their class sections as a focal class for data collection. In total, 346 students consented to participate in the broader study, with the number of students consented per classroom ranging from 10 to 31. Student participants represented diverse racial and socioeconomic backgrounds (see Table 1).

Table 1
Student Participant Demographic Characteristics (n = 346)

Demographics	***n***	**%**
Gender		
Female	172	50%
Race/Ethnicity		
White	141	41%
African American or Black	60	17%
Hispanic or Latino	95	28%
Asian	10	3%
Native American, American Indian, or Alaska Native	2	1%
Other	5	1%
Multi-Racial	29	8%
Special Education Status	36	10%
English Language Learner (ELL)	19	6%

Data Sources and Study Measures

For the quantitative phase of data collection, data sources included a teacher survey administered prior to the PL, student surveys administered before and after the instructional unit in which teachers implemented what they learned in the PL, and student achievement data collected at the end of the unit. Each of these data sources and the measures arising from them are described below. The specific survey items are listed in Table A1 in Appendix A.

Student Survey

Students were asked to complete a survey both before and after the unit implementation. Each measure from the student survey referred to science and used the same 5-point Likert scale ranging from 1 (*not at all true*) to 5 (*very true*). Composite scores were calculated by computing the means across survey items. Examining missing data revealed that students' responses to the measures and their achievement scores were missing completely at random (MCAR), $\chi2$ =14.72, p =.74.

Competence beliefs. Students' competence beliefs (perceived competence) in science were measured at two time points, before and after the unit implementation. Four items (e.g., "I can do almost all the work in science if I don't give up.") adapted from the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000) were used to assess students' judgments about their confidence to perform adequately in science. The measure of students' competence beliefs demonstrated acceptable internal consistency for each time point, with reliability coefficients of $\alpha = 0.82$ (before unit implementation) and $\alpha = 0.87$ (after unit implementation). A confirmatory factor analysis (CFA) was also conducted separately for both time points to evaluate the measurement model. The single-factor structure was supported before unit implementation, χ^2 (2) = 1.728, $p = .421$, CFI = 1.000, TLI = 1.000, RMSEA = .000 and SRMR =.009, and partially supported after the unit implementation, χ^2 (2) = 12.254, $p = .002$, CFI = .985, TLI = .956, RMSEA = .121 and SRMR = .019.

Science interest. Students' interest in science was represented by four items (adapted from Conely, 2012; $\alpha = 0.93$) and were measured before the instructional unit. An example statement includes "I enjoy the subject of science." The measurement model was supported by single-factor structure in confirmatory factor analysis, χ^2 (2) = 8.022, $p = .018$, CFI = .995, TLI = .986, RMSEA = .005, and SRMR = .009.

Perceived teacher competence support. Students' perceptions of their teachers' competence support were measured after the instructional unit with 8 items developed as part of the broader study (e.g., "My teacher's expectations in science class are clear"; $\alpha = 0.85$). The measurement model was supported by a single-factor structure in confirmatory factor analysis, χ^2 (20) = 53.999, $p < .001$, CFI = .965, TLI = .951, RMSEA = .070, and SRMR = .035.

Prior Achievement

Students' prior achievement was assessed through using their 6th grade scores from Measures of Academic Progress (MAP) Growth assessment, a 43-item multiple choice state standardized test administered prior to unit implementation in Fall 2021. MAP Growth is a commonly used assessment for measuring achievement and growth in general subject domains including science and math and is appropriate for states that have adopted NGSS, or similar standards based on Framework for K-12 Science Education (Northwest Evaluation Association [NWEA], 2022). For the present study, students' 6th grade MAP Growth Math scores were used as an indicator of prior achievement. Because the participating districts did not administer the MAP Growth Science assessment every school year, 6th grade science scores from the 2020-2021 school year were not available for student participants. In contrast, the MAP Growth Math assessment is administered annually, which offers a more consistent and comparable measure of students' prior achievement across districts and grade levels. Prior research consistently demonstrates a strong positive association between students' achievement in math and science at the secondary school level given overlap in cognitive skills such as problem-solving and reasoning (Meece & Scantlebury, 2006; Roof & Chimuma, 2022). Scores are reported on the RIT (Rasch unIT) scales, which has a potential range between 100 and 350. Among students in the present study, MAP Growth Math for the 2020-2021 assessment ranged from 167 to 243, with a score of 228 or above indicating students in sixth grade meeting proficiency on the state assessment for the next grade or course (see Tran et al. (2022) for more information). These scores were then converted to percentile rank to indicate how well a student performed compared to similar students in the norm group.

Teacher Self-Efficacy Beliefs

Teacher self-efficacy beliefs was assessed before teachers' participation in PL and was represented by six items adapted from the Teacher Efficacy Scale (Lauermann & Karabenick, 2013; α = 0.76). All items were rated on a 5-point Likert scale ranging from 1 (*not at all true*) to 5 (*very true*) and began with the item stem, "I am confident that". Items assessed how confident teachers feel in teaching science and producing adaptive student motivational outcomes. An example statement includes "I can teach my lessons so that they are effective for student learning." Composite mean score was calculated to measure teacher efficacy beliefs.

Results

The following sections present the quantitative findings of the study to address the first and second research questions. The quantitative analyses first examined the extent to which variations in students' competence beliefs over the course of the instructional unit were associated with student- and teacher-related factors. Next, distinct classroom-level trends in students' competence beliefs were identified to understand broader patterns of change across classrooms. These patterns then guided case selection for the qualitative strand, which further explores how teachers' competence-supportive strategies and students' daily competence perceptions co-occur in classrooms exhibiting distinct patterns of change. Quantitative results were derived from students' pre- and post-unit surveys, prior (math) achievement scores, and the teacher survey before the PL. The following section integrates the analytic approach with the corresponding results to provide insight into the potential factors and broader classroom-level patterns associated with changes in students' competence beliefs.

Student- and Teacher-Related Factors Explaining Changes in Competence Beliefs

To examine the extent to which student- and teacher-related factors explain changes in students' competence beliefs (perceived competence), a two-level hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) was employed using *MPlus* (Muthén & Muthén, 2011). Given the nested structure of the data, HLM was conducted to account for students (Level 1) nested within each teachers' classrooms (Level 2). This analytic approach allowed for examining variability in competence beliefs between classrooms that can be attributed to individual student characteristics (Level 1) including prior achievement and initial science interest (both assessed before the instructional unit), as well as students' perceptions of teacher competence support (assessed after the instructional unit).[1] At Level 2, teacher self-efficacy beliefs, as reported by teachers before the instructional unit, was examined as a potential predictor of changes in competence beliefs.

The multilevel analysis was guided by a three-step iterative model building framework recommended by Hox, Moerbeek, & Schoot (2018). The first step involved estimating an unconditional null model (Model 1) to determine the proportion of variance in students' competence beliefs attributable to between-classroom differences. Results indicated that the between-classroom variation was 0.09 (SD = 0.09) while within-student variation was 0.75 (SE = 0.04). The intraclass correlation coefficient (ICC) was 0.110, which indicated that approximately 11% of the variability in competence beliefs could be attributed to differences between classrooms and made it acceptable to proceed with multilevel modeling (Lüdtke et al., 2009;

[1] Teacher competence support was also tested as a Level 2 predictor using aggregated student reports. Results suggested a similar positive and significant association between teacher competence support and students' competence beliefs. However, this model was not retained due to the limited number of classrooms (n = 17), which constrained the inclusion of multiple Level 2 variables. It was instead modeled at Level 1 to reflect individual students' perceptions of their teachers' support for competence beliefs.

Raudenbush & Bryk, 2002). The second step of the model building framework introduced student-related factors in Model 2 while accounting for students' initial competence beliefs. Initial perceived competence was the strongest predictor of perceived competence at the end of the unit ($\beta = 0.469$, $SE = 0.031$, $p < 0.001$). While accounting for students' initial competence beliefs, students with higher prior achievement tended to evidence significant gains in perceived competence ($\beta = 0.132$, $SE = 0.037$, $p < 0.001$), as well as those with higher initial science interest ($\beta = 0.086$, $SE = 0.042$, $p < 0.05$). Additionally, students who perceived more competence support from their teachers were more likely to experience significant increases in competence beliefs ($\beta = 0.396$, $SE = 0.050$, $p < 0.001$). These findings suggest that students' individual characteristics and their perceptions of teachers' motivational support contributed to changes in their competence beliefs.

In the final step, Model 3 added teacher efficacy beliefs as a Level 2 predictor, along with the student-related factors from Model 2. Results revealed that teacher efficacy beliefs were *not* a significant predictor of changes in students' perceived competence ($\beta = -0.002$, $SE = 0.082$, $p < 0.983$), while all other student-related factors remained significant. This suggests that teachers' confidence in their ability to support student motivation and learning in science may not directly influence changes in students' competence beliefs across an instructional unit. A summary of the final HLM results is shown in Table 2. Together, these findings highlight the role of student-related factors associated with changes in competence beliefs while also indicating that teacher efficacy beliefs alone may not account for variations in these beliefs.

Table 2

Final HLM Model (Model 3) Predicting Changes in Students' Competence Beliefs

	Competence Beliefs	
Fixed Effects	***β***	**SE**
Level 1: Student-Related Factors		
Initial Competence Beliefs (pre-unit)	0.471***	0.032
Initial Science Interest	0.092*	0.043
Prior Achievement in Science (math scores)	0.241***	0.049
Perceived Teacher Competence Support	0.391***	0.051
Level 2: Teacher-Related Factor		
Teacher Self-Efficacy Beliefs	- 0.002	0.082

Note. β = standardized coefficient; *SE* = standard error; $*p < 0.05$, $** \ p < 0.01$, $*** \ p < 0.001$

Classroom-Level Patterns of Change in Competence Beliefs

As a next step, students' pre- and post-survey data were used to more descriptively examine classroom-level trends in students' competence beliefs. Understanding these trends was essential for situating the quantitative findings within specific classrooms to be explored in the subsequent qualitative strand. Although multilevel modeling indicated that a modest proportion of variance in students' competence beliefs was attributable to differences between classrooms (*ICC* = 0.110), such variance is considered meaningful in education research and can justify further exploration of between-classroom differences (Ludtke et al., 2009). Given the limited time points and sample size constraints, more robust statistical modeling of change trajectories were not feasible (e.g., Robinson et al., 2022). However, visual inspection of student change score distributions provided valuable means of identifying classroom-level patterns of change in students' competence beliefs and guiding case selection for the qualitative phase.

To systematically analyze classroom-level patterns of change, a series of quantitative analyses and visual inspections were conducted. First, individual student change scores were calculated as the difference between post- and pre-unit ratings of competence beliefs. Negative change scores indicated a decrease, positive scores indicated an increase, and a score of zero reflected stability (or "no change") for students' competence beliefs. Descriptive statistics (means and standard deviations) of change scores were also computed to summarize overall trends within each classroom. To explore the range of unique trends in competence beliefs, histograms were constructed to visualize the distribution of change scores by classroom. Finally, dependent samples *t*-tests were conducted for each classroom to determine whether students' competence beliefs differed meaningfully between pre- and post-unit implementation.[2]

Table 3 summarizes students' change scores across the 17 classrooms. Scores ranged from -2.75 to 1.75 (M = -0.17, SD = 0.76), which indicates a modest overall decline in competence beliefs across the sample. Although decreases in competence beliefs were more common, classrooms showed distinct patterns of change. Three classrooms (Mason, Sam, and Madison) showed modest increases ($\Delta M > 0.10$) in competence beliefs while ten classrooms showed declines. Of the ten classrooms that exhibited declines, seven classrooms, including Vivian's, showed modest declines ($-0.40 \leq \Delta M \leq -0.10$) in competence beliefs and three classrooms, including Hannah's, demonstrated relatively steeper declines ($\Delta M < -0.40$). The remaining four classrooms (Caroline, Rose, Tracy, and Joanne) showed relative stability ($-0.10 \leq \Delta M \leq 0.10$), suggesting minimal to no change in competence beliefs over the course of an instructional unit.

These classroom-level trends were further illustrated by histograms, which revealed variation in individual student changes scores within each classroom. Some classrooms showed relatively uniform trends, with most students demonstrating modest and consistent increases in competence beliefs while others showed declines that ranged from modest to substantial. A

[2] Due to small sample sizes within classrooms, Wilcoxon signed-rank tests were also conducted. Results were consistent with the dependent samples t-tests. Therefore, t-test results are reported to summarize mean differences in students' competence beliefs before and after implementation.

larger number of classrooms demonstrated modest yet variable declines where scores were somewhat negatively skewed, but still reflecting a mix of increases and decreases. A few classrooms showed minimal overall change in competence beliefs with distributions centered near zero. Several classrooms also displayed mixed patterns as evidenced by dispersed distributions that included students experiencing gains, declines, or remaining stable, which indicates substantial individual variability in how students experienced changes in their competence beliefs within the classroom. These broader patterns of change across classrooms highlight the heterogeneity in students' competence beliefs that necessitate examining both classroom-level trends and within-classroom variability.

Table 3
Classroom-Level Summary of Change in Students' Competence Beliefs

		Competence Beliefs				
		Pre-Unit	Post-Unit	Mean Δ		
Teacher [a]	*n*	*M*	*M*	Score	*SD*	*t*
Caroline	23	4.07	4.00	-0.07	0.63	0.25
Mason	31	4.03	4.20	0.17	0.45	4.28*
Shawn	21	4.10	3.64	-0.46	**0.80**	3.94
Mike [b]	11	3.09	2.71	-0.38	1.30	1.03
Valerie	18	3.95	3.53	-0.42	**0.88**	3.86
Rose	25	3.88	3.84	-0.04	0.66	0.05
Sam	19	3.86	4.00	0.14	**0.86**	0.33
Hannah	25	3.83	3.12	-0.71	0.72	14.21***
Taylor [b]	11	4.03	3.68	-0.35	0.69	2.51
Sandra [b]	10	4.33	4.03	-0.30	0.65	2.21
Madison	19	3.77	4.01	0.24	0.77	0.29
Joanne	25	4.08	4.17	0.09	0.65	0.85
Stuart	24	3.49	3.15	-0.34	**0.81**	1.80
Serena	23	4.01	3.81	-0.20	0.58	2.73
Jess	21	3.92	3.53	-0.39	**0.94**	4.00
Tracy	21	3.49	3.55	0.06	0.65	0.12
Vivian	19	3.59	3.41	-0.18	**0.94**	0.78

[a] Teacher names are pseudonyms; [b] Teachers excluded as cases due to not meeting the minimum sample size requirement (≤15); Mean Δ Score = Post – Pre competence beliefs; SD reflects standard deviation of individual student change scores within each classroom. Classrooms with SDs in moderate-high (between 0.8 -1.0) and high (≥1.0) are bolded; $*p < 0.05$, $**, p < 0.01$, $***p < 0.001$

Selection of Classroom Cases for Understanding Classroom-Level Trends

Identifying broader patterns of change in competence beliefs across classrooms was helpful in informing case selection for the qualitative strand. Specifically, classrooms exhibiting distinct trends in competence beliefs were selected as cases to further explore how teachers' competence-supportive strategies and students' daily competence perceptions may have contributed to these variations. The selection of classrooms was guided by a combination of sample size considerations as well as statistical significance and distribution of individual student change scores within classrooms. To ensure sufficient statistical power for drawing meaningful conclusions in student outcomes (Cohen, 1988; Lakens, 2022), classrooms with at least 15 students were considered for case selection. Of the 17 classrooms, 14 met this minimum sample size requirement. However, only two of these classrooms (Mason and Hannah) showed statistically significant mean differences in competence beliefs in comparisons before and after the instructional unit (see Table 3). Given their distinct, yet relatively uniform patterns of change, these two classrooms were selected as cases for further investigation.

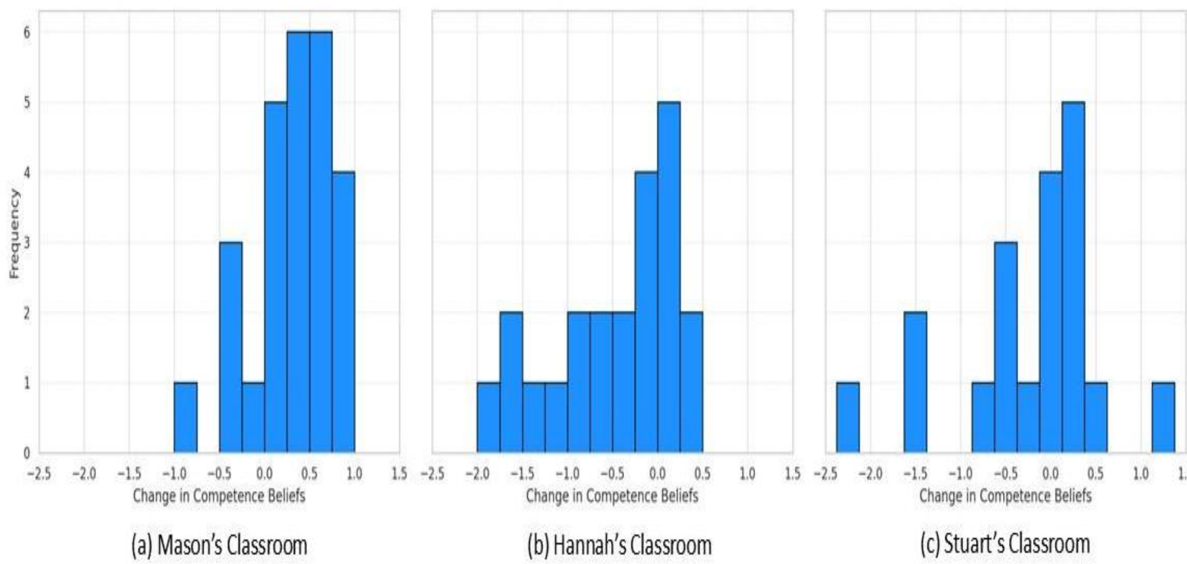
Mason's classroom demonstrated a modest and relatively uniform increase in students' competence beliefs. Although the average gain was relatively small ($\Delta M = 0.17$), it stands out in contrast to the overall trend of decline observed in most other classrooms. Notably, among the few classrooms where students showed consistent, small gains, Mason's was the only one with a statistically significant mean increase ($t = 4.28$, $p = .049$; see Table 3).[3] As shown in Figure 3a, five students evidenced decreases in competence beliefs while a majority of students ($n = 16$) showed increases with individual change scores ranging from -1.0 to 0.75. Given this distinct

[3] Although Madison's classroom had a higher average positive change score, it was excluded as a case because its mean difference was not statistically significant and a relatively small number of students (n=10) with pre- and post-competence beliefs ratings compared to Mason's classroom (n=26).

pattern, Mason's classroom was selected as a representative case to explore how his instructional approach may have contributed to a modest increase in students' competence beliefs. Hannah's classroom presented a contrasting pattern of uniform decline in students' competence beliefs. Of all classrooms with downward trends, her classroom demonstrated the steepest average decrease ($\Delta M = -0.71$) and was the only one with a statistically significant decline ($t = 14.21$, $p = .001$; see Table 3). As shown in Figure 3b, students' change scores ranged from -2.0 to 0.5. Of her students ($n = 25$), only two showed increases and five showed no change whereas the remaining students experienced declines ranging from modest to steep (approximately -0.5 to -2.0). Given the broader prevalence of declining competence beliefs, Hannah's classroom served as an illustrative case for examining how her instructional approach may have contributed to this consistent downward trend.

Unlike the relatively uniform patterns observed in Mason's and Hannah's classrooms, the third classroom was selected for its distinct pattern of substantial individual variation in competence beliefs. This mixed pattern was prioritized over classrooms displaying relative stability as it provided an opportunity to explore the complexities of how students within the same instructional context may differently experience and respond to teachers' motivational supports (Wang et al., 2017; Wigfield & Eccles, 2000). To systematically identify such classrooms, those with higher variability in student change scores as indicated by standard deviations in the moderate-high (0.8-1.0) to high (≥ 1.0) range and with a minimum of 15 students were considered. Of the six classrooms that met both criteria, Stuart's classroom ($SD = .81$) was especially notable for its near-equal distribution of student change scores with seven students showing increases, eight showing decreases, and four students remaining stable (see Figure 3c), which indicated a broader range of individual experiences. With change scores ranging from -2.5 to 1.5, 14 of his students (n = 24) showed meaningful changes in their competence beliefs (absolute change scores ≥ 0.5 on a 5-point scale). Stuart's classroom was therefore selected as the third case to better understand how his instructional approach may yield within-classroom variability in students' competence beliefs.

Figure 3
Change Score Distributions in Competence Beliefs by Classroom Case



Looking across all classrooms, students' competence beliefs generally showed a modest downward trend, but notable variation existed between classrooms within this overall pattern. To capture classroom processes underlying this variability, three classrooms exhibiting distinct patterns of change in competence beliefs were selected for further investigation in the qualitative strand. Detailed case narratives of instructional and interactional patterns along with qualitative analyses of these selected classrooms is presented in Chapter 4.

Discussion of Quantitative Strand

In the present study, the quantitative strand examined sources of variability in students' competence beliefs and identified specific classrooms with unique patterns of change throughout the instructional unit. Among the potential sources of variability, all three student-related factors, including prior achievement, initial science interest, and perceived teacher competence support, explained independent variance in changes in competence beliefs even after accounting for students' initial competence beliefs. It is noteworthy that students' perceptions of teachers' competence support was more strongly related to changes in students' competence beliefs suggesting that how students experience motivational support plays a crucial role in shaping their motivational beliefs. Furthermore, the statistical significance of teacher competence support highlights that teacher's competence-supportive instruction is meaningfully reflected in students' competence beliefs. This underscores that teacher practice not only matters but can relate to how students perceive their own ability to succeed. This finding aligns with a growing body of research that highlights the importance of integrating motivational supports into instructional design and planning to enable teachers to be more intentional in implementing strategies that promote adaptive motivational beliefs in the classroom (e.g., Linnenbrink-Garcia et al., 2016; Marchand et al., 2021).

While teachers' self-efficacy beliefs were not significantly related to changes in students' competence beliefs, this finding warrants further investigation as some variability in students' competence beliefs was attributable at the teacher-level (*ICC* = 11%). This suggests a moderate degree of between-class variability in students' competence beliefs, so future work should consider examining additional proximal teacher-level factors that may contribute to these changes. One potential explanation for the non-significant finding could be the limited statistical power due to the small sample size of teacher participants ($n = 17$) in this study (Hox, 2010). However, a more likely explanation relates to the nature of the teacher participants in the study. As part of the broader study, teachers were encouraged by district-level science coordinators to volunteer for the PL, which may indicate a positive attitude and openness to professional development. Prior research suggests that a strong sense of self-efficacy beliefs is a key motivational factor influencing both participation in PL and the quality of their instruction (Geijsel et al., 2009; Gore & Rosser, 2022; Thoonen et al., 2011). In this study, teachers reported high levels of teaching efficacy beliefs ($M = 3.98$; $SD = .44$; range 1-5; $n = 17$) prior to the PL, which may reflect that they already felt confident in their instructional abilities. This baseline confidence in their teaching may have shaped their receptiveness to the PL experience and their willingness to implement novel instructional strategies during the instructional unit. Hence, these findings underscore the potential of PL not only to enhance instructional quality but also to sustain and strengthen teachers' self-efficacy beliefs over time. Future research should explore how collaborative PL structures that engage teachers in iterative cycles of planning, implementation, and reflection can support the development of teacher efficacy beliefs.

The quantitative strand also illuminated broader patterns of changes in students' competence beliefs across classrooms by analyzing individual change scores, which helped identify distinct classroom-level trends. Statistical and visual inspections of change scores revealed a range of patterns, including classrooms where most students exhibited consistent declines ranging from modest to steep, others where competence beliefs remained relatively stable, and a few where students demonstrated modest upward trends. Within classrooms, some change patterns were relatively uniform (e.g., consistent increases or decreases across students) while other classrooms displayed substantial individual variability with students exhibiting a wider range of change scores. This variation necessitates attending not only to overall classroom-level trends, but also to the distribution of individual experiences within each classroom. These variations in classroom-level trends are consistent with prior research documenting classroom-level differences in students' competence beliefs (Musu-Gillette et al., 2015; Robinson et al., 2019; 2022). Collectively, these studies emphasized that students' competence beliefs do not follow a uniform trend but instead fluctuate in response to multiple individual and contextual factors in the classrooms, including teachers' provision of motivational supports, instructional climate, and students' affective experiences (e.g., enjoyment).

Although evaluating the effectiveness of PL is beyond the scope of this study, it is noteworthy that, on average, students' competence beliefs declined during the instructional unit. This trend raises important questions about the nature and scope of the PL experience specifically designed to support student motivation. One explanation may lie in the well-documented normative decline in motivation during secondary school, particularly in domains like science (Eccles & Wigfield, 2020; Kosovich et al., 2017). Prior research suggests that even well-designed educational interventions often do not lead to increases in students' motivational beliefs, but may help mitigate expected declines (e.g., Lazowski & Hulleman, 2016; Schmidt et al., 2017; Wigfield et al., 2006). From this perspective, the relatively modest average decline observed in this study may reflect a buffering effect of motivational supports introduced through PL. It is also possible that the broader scope of the PL that addressed multiple aspects of motivation (e.g., autonomy, relevance, and belonging) in addition to competence beliefs resulted in less targeted emphasis on competence-specific instructional strategies. Additionally, because the PL materials were developed as part of an iterative design and development process, teachers may have received varying levels of instructional support, which may contribute to inconsistency in how competence-supportive strategies were enacted across classrooms. Finally, a single instructional unit may not provide sufficient time for teachers to fully integrate new instructional strategies or for students to experience meaningful motivational change. These considerations highlight the importance of sustained, targeted instructional support to promote meaningful changes in students' competence beliefs and the need to examine both short- and long-term impacts of PL on classroom instruction.

Given these considerations, it is important to move beyond normative trends and explore classroom-level processes that may explain such variations in students' competence beliefs. To extend prior work, the present study identified classrooms with distinct patterns of change for further inquiry using qualitative methods. These classroom cases were selected to explore how teachers' competence-supportive strategies and students' daily competence perceptions may have contributed to the observed variations. A fine-grained examination of these patterns can reveal systematic differences in how teachers provide competence support and how students make sense of their own competence over time. This is consistent with prior research highlighting the dynamic, reciprocal nature of teacher-student interactions in shaping students' motivational beliefs (Robinson et al., 2019; Turner & Christensen, 2020). While the quantitative strand identified sources of variability in terms of student- and teacher-related factors and broader classroom-level change patterns, it did not capture the daily classroom interactions that may explain how these changes unfold over time. The qualitative strand addressed this gap by examining how competence-supportive strategies and students' competence perceptions unfolded across lessons within selected classroom cases. This approach provided a more contextualized understanding of how or why students experience changes in competence beliefs.

CHAPTER 4: QUALITATIVE DATA STRAND

The qualitative strand aimed to deepen understanding of classroom trends in students' competence beliefs by examining how teachers' competence-related moves and students' competence beliefs co-manifest and unfold during instruction (Creswell & Plano Clark, 2018). To pursue this goal, I employed a multiple case study approach within a broader mixed methods design. This approach was particularly appropriate given the study's focused interest in a specific motivational construct, students' competence beliefs, and its aim to provide rich, contextualized accounts of how these beliefs develop in authentic classroom settings. Multiple case studies enable both detailed within-case analysis and cross-case comparison, which was well-suited for investigating a bounded phenomenon within real-world contexts (Yin, 2009).

Three classrooms that exhibited distinct patterns of change in students' competence beliefs were selected to serve as an individual "case", each with embedded units of analysis, including classroom video data of competence-supportive instruction, both global and daily perceptions of students' competence beliefs, and teacher- and student-level survey data (Stake, 2013; Yin, 2009). Integrating these multiple data sources allowed the case studies to provide explanatory insights into how students' competence beliefs developed through recurring patterns of teacher-student interactions. This approach not only extended the quantitative findings but also supported analytic generalization by refining theoretical understanding of competence-supportive instruction and illustrating how daily teacher-student interactions unfold and shape changes in students' competence beliefs in context over time (Yin, 2009).

Method

Participants

Of the 17 seventh-grade science teachers in the quantitative strand (see Chapter 3, participants), three were selected as classroom cases for qualitative analysis. Two teachers, Mason and Hannah, taught in a Southwestern state and Stuart taught in a Midwestern state. Hannah and Stuart held master's degrees and Mason held a bachelor's degree. All three teachers identified as White. Mason and Hannah taught in different schools within the same district and county. The broader student population was approximately 47% Hispanic or Latino, 21% White, and 16% Black or African American and about 59% of the students in the district qualified for free and reduced-price lunch. Stuart taught in a district where about 65% of the students identified as White and nearly 47% of students identified as low income. Student demographics for each classroom are summarized in Table 4. It is important to note that the research sample may not fully reflect the broader district populations, particularly Mason's and Hannah's classrooms that included a higher proportion of White students than is representative of their district as a whole.

Instructional Context

The three teachers in the present study used two different curricula in their science classrooms. Stuart used a NGSS-aligned curriculum *Investigation and Questioning our World through Science and Technology* (IQWST; Activate Learning, 2019) that had been formally adopted from his school district. Mason and Hannah, who both taught in the same district, used a district-generated curriculum. While both curricula emphasized NGSS disciplinary core ideas and crosscutting concepts related to energy transfer, conservation of matter (e.g., physical and chemical changes), and science and engineering practices including developing molecular models and identifying and explaining chemical reactions, the specific instructional activities and materials varied. The specific curricula will be described in greater detail in the case studies.

Despite differences in curriculum structure, pacing, and delivery, both curricula incorporated lab investigations, class discussions, and small group activities to support students' learning of science content and practices. While teachers varied in how they introduced and reinforced concepts, there was sufficient content overlap in some lessons, particularly in topics such as evidence of chemical reactions and molecular structure. This overlap provided a basis for cross-teacher comparisons of how competence-supportive strategies were enacted within different curricular contexts. See Table B1 in Appendix B for more details on lesson activities by teacher.

Table 4
Student Demographics by Classroom Case

District	District 1				District 2	
School	School A		School B		School C	
Teacher	Mason		Hannah		Stuart	
Class Size (total)[a]	42		40		32	
Research sample	n=31		n=25		n=24	
Student Demographics	n	%	n	%	n	%
Female	16	52%	12	48%	11	48%
White	16	52%	11	44%	12	52%
African American or Black	3	10%	3	12%	3	13%
Hispanic or Latino	7	23%	6	24%	4	17%
Asian	1	3%	1	4%	1	4%
Multi-racial	3	10%	4	16%	3	13%
Native Hawaiian/Pacific Islander	1	3%	0	0%	0	0%
Special Education Status	7	23%	0	0%	6	26%
English Language Learner	0	0%	0	0%	1	4%

[a] Total class size reflects the maximum number of students enrolled in the class at any point during implementation. All three classes experienced some fluctuation in student enrollment.

Data Sources

Student and Teacher Survey Measures

Student and teacher survey measures described in Chapter 3 (data sources and measures) were also used to provide descriptive summaries that contextualize each classroom case. These measures included teachers' self-reported efficacy beliefs along with students' initial science interest, competence beliefs (pre- and post-unit), and perceptions of teacher-provided competence support (post-unit).

Classroom Video

Classroom videos were used to document teachers' competence-supportive instruction across lessons. Each recorded video sample captured a 45-to-50-minute lesson and teachers were asked to record multiple lessons throughout the instructional unit. While each teacher initially had seven recorded lessons available in the data corpus, only those with corresponding End-of-Class-Reports (ECRs, described below) were included in the qualitative analysis to allow examining alignment between observed instruction and students' self-reported competence perceptions. Due to scheduling constraints, ECRs were not administered for two of Mason's lessons and one lesson each for Hannah and Stuart. This resulted in five lessons for Mason and six for both Hannah and Stuart. These selected lessons were distributed across the instructional unit and reflected a range of learning activities, including lab investigation, whole-class discussions, and small group work.

End-of-Class Reports (ECRs)

On five to six days when classroom videos were recorded, students also completed a brief survey reporting on their own motivation and engagement for that day's lesson (referred to as End-of-Class Reports or ECRs). This pairing of ECRs with the classroom videos enabled a more direct examination of students' perceptions of their own competence on specific days when class sessions were recorded. All ECR items were rated on a 0-3 Likert scale (0 = *not at all*; 3 = *very much*). Preceded by the prompt, "*Thinking about what you did in science class today*", students' perceived competence was adapted from Hektner et al. (2007) and measured using a single item: "*How skilled were you at it?*"

Data Analytic Approach

The three selected cases represented classrooms with distinct patterns of change in students' competence beliefs as identified in the quantitative strand. These multiple cases provided an opportunity to further investigate the classroom processes that may help explain these underlying patterns. Developing classroom cases followed a systematic approach that integrated multiple data sources, data visualization methods, and coding procedures. Situated within a larger mixed methods design (Morgan et al., 2017; Yin, 2009), the multiple case study approach drew on classroom video observations and student and teacher survey data to construct a detailed and contextualized narrative account of each classroom case.

Contextualizing Classroom Case. A thorough understanding of a case necessitates developing "within-case knowledge" by grounding the qualitative analysis in the unique instructional context of each classroom (Rihoux & Lobe, 2009). This approach also supports more nuanced and meaningful cross-case comparisons by ensuring that interpretations remain rooted in the realities of each case. To contextualize each classroom, each case began with a descriptive quantitative summary that included survey measures of students' initial interest, competence belief (pre- and post-unit), perceptions of teacher competence support, prior achievement (MAP Growth Math scores) as well as teachers' self-efficacy beliefs. Descriptive statistics (means and standard deviations) were calculated for the study measures by classroom.

These quantitative summaries offered a contextual overview of how students' prior academic histories and motivational orientations may have shaped the instructional context in which teachers' competence-supportive instruction co-occurred with students' competence perceptions.

Coding Scheme for Competence Support Dimensions. To systematically identify teachers' competence-supportive instruction, classroom videos were analyzed using *a priori* coding scheme developed as part of the broader project. Informed by empirical work grounded in multiple theoretical perspectives on competence beliefs and relevant instructional strategies, Table 5 presents the coding scheme broadly categorized instructional strategies into four competence support dimensions: (1) *Clear Expectations, Goals, and Norms* (or "Clear Expectations"), (2) *Academic Challenge*, (3) *Guiding and Supporting Students* (or "Guidance and Support"), and (4) *Informational and Encouraging Feedback* (or "Feedback"). Notably, during the PL, teachers were introduced to these instructional dimensions of competence support and their corresponding instructional strategies, which served as a framework for understanding and implementing competence-supportive instruction. Each dimension was further specified through concrete examples of instructional strategies that aligned with competence support as well as nonexamples that reflected missed opportunities to support students' competence beliefs. For instance, within the "Guidance and Support" dimension, an example of a competence-supportive strategy might involve asking probing questions to guide students' thinking to promote deeper understanding of science concepts. Conversely, a nonexample might involve a teacher being indifferent or negligent in offering adequate guidance when students struggle with a task. By distinguishing between examples and nonexamples, the coding scheme captured variation in how teachers enacted specific strategies and the extent to which those strategies aligned with competence support.

Table 5
Coding Scheme: Competence Support Dimensions with Example and Non-Example Instructional Strategies

Competence Support Dimension	**Examples** (competence-supportive strategies)	**Non-Examples** (missed opportunities)
Clear Expectations, Goals, and Norms	Explaining and clarifying procedures and/or learning goal for task; communicating flow and timing of lesson; communicating positive classroom norms	Providing confusing directions or expectations; Not being consistent with verbalized/written directions or expectations
Academic Challenge	Explicit messaging related to persisting through difficulty and pursuing further challenges	Providing work below student's ability
Guiding and Supporting Students	Encouraging peer collaboration; activating prior knowledge; Using tangible aids or hints, cues; Asking probing questions to guide student thinking; Modeling effective strategy use; Responding to social-emotional needs of students	Being demanding/insistent with directions; Telling a student they won't help them because she already gave the directions
Informational and Encouraging Feedback	Positively responding to student work through praising their effort, progress towards the goal, and strategy use	Providing negative or person-centered feedback

Deductive Coding. A coding template was used to document evidence of teachers' enactment of competence support dimensions aligned with existing theoretical frameworks. This template ensured a consistent structure for coders to systematically document both examples and nonexamples of strategy use within each of the four competence support dimensions for every lesson. Although the format of the coding template did not support calculating an agreement statistic, it facilitated direct comparison and discussion of alignment and discrepancies of documented evidence. Each teacher's classroom videos (five or six per case) were double coded by two coders (myself and another trained coder) through a deductive and recursive coding process (Bingham, 2023; Braun & Clarke, 2006). Coders first reviewed a detailed lesson timeline outlining discrete instructional activities and then independently documented instructional moves using the coding template. Following each double-coded classroom video, the coders met frequently to reconcile any discrepancies that emerged from the coding templates and ensure consistency in identifying how teachers enacted competence-supportive strategies across lessons. The documented evidence generated through this coding process was subsequently used to quantify each teachers' enactment of competence support dimensions at the lesson-level, which informed the construction of state-space grids (SSGs; Hollenstein, 2013) linking teacher competence support with students' daily competence perceptions.

Quantizing Teacher Supports and Linking to Student Perceptions. Two SSGs were embedded within each classroom case using Gridware (Hollenstein, 2013) to visualize the relation between teachers' observed competence-supportive instruction and students' daily competence perceptions across an instructional unit. In each SSG, the x-axis represents observed teacher competence support (quantized at the lesson-level) and the y-axis represents students' daily competence perceptions (as reported on the ECRs). Each dot on a grid represents the co-occurrence of observed teacher competence support and students' competence perceptions for a lesson with the numbers inside the dots indicating lesson sequence. Lines connecting the dots illustrate how observed teacher competence support and students' daily competence perceptions unfolded across multiple lessons.

Teacher competence support was rated at the lesson-level by quantizing the documented evidence from the coding templates, which were synthesized into teacher-specific pattern matrices. These matrices compiled instructional strategies within four competence support dimensions (see Table 5) and captured how consistently each teacher enacted those dimensions across lessons to help identify broader instructional patterns across the unit (Miles et al., 2019). For each lesson, a binary value (1 = present, 0 = absent) was assigned to each competence support dimension if at least one related strategy was observed within that dimension. For example, if a teacher communicates learning goals, the "Clear Expectations" dimension was coded as "1". These binary values were then summed across the four dimensions to yield a lesson-level competence support score ranging from 0 (no related strategies observed) to 4 (related strategy observed across all four dimensions), which reflected the breadth of competence-supportive instruction for a given lesson. Students' daily competence perceptions were examined at both the classroom and individual levels. Classroom-level scores were calculated as the means of students' perceived competence ratings for a given lesson while individual-level scores captured each student's competence rating for that lesson. These ratings were based on a single ECR item rated from 0 (*not at all*) to 3 (*very much*). Together, the SSGs offered complementary perspectives on how observed teacher competence support co-occurred with both global and individual experiences of competence across the instructional unit.

From Thematic Analysis to Descriptive Case Narratives. Following Braun and Clarke's (2006, 2021) guidelines for thematic analysis, the pattern matrices served as an organizing framework for constructing descriptive narrative accounts of each teacher. These matrices were grounded in an a priori coding scheme developed for the broader study, which categorized observed instructional strategies across four competence support dimensions: clear expectations, academic challenge, guidance and support, and feedback. Competence-supportive strategies were compiled by lesson (rows) and competence support dimension (columns), allowing for mapping strategy use across lessons. To identify recurring patterns, the matrices were further condensed to identify recurring patterns both within individual dimensions and across multiple dimensions. This process enabled the development of case-specific themes that were generated by using the a priori coding scheme to characterize each teacher's approach to competence-supportive instruction. Aligned with the third research question, the final set of themes reflected central ideas about how teachers enacted competence-supportive strategies across the instructional unit. Each set of themes was bound to the unique instructional context of the individual case to ensure interpretations remained grounded in observed instructional patterns (Yin, 2009).

Themes were then reviewed and refined through an iterative and recursive process. First, themes were examined in relation to the documented evidence from pattern matrices to ensure they were grounded in the data and reflect recurring instructional patterns. Overlapping themes were merged, broad themes were narrowed, and theme names were revised to clearly capture the central idea they represented. Themes were also compared across teachers to support cross-case analysis of how competence support was differentially emphasized, enacted, or sustained competence-supportive strategies across teachers (Carden, 2009). This process allowed for identifying broader instructional patterns across teachers while enabling an in-depth examination of each teacher's unique approach to competence support (Stake, 2013). The finalized set of themes guided the development of descriptive narrative accounts and provided fine-grained insight into how teachers' competence-supportive strategies unfolded alongside students' competence perceptions as visualized through the SSGs.

Together, the multiple case studies offered rich, complementary insights into how competence-supportive instruction unfolded alongside students' competence perceptions across lessons. Following Yin's (2009) recommendations for case study research, triangulation strengthened the credibility of findings by integrating multiple data sources, including classroom videos, daily ECRs, and aggregated survey data on students' individual characteristics, within each case. Recurring instructional patterns observed in classroom video data were examined alongside SSGs to identify key instructional moments in which teachers' strategy use aligned or diverged from students' daily competence perceptions. Survey data on students' prior achievement, initial science interest, and global perceptions of teacher competence support were used to contextualize patterns in teacher-student interactions and supported cross-case comparisons. This triangulated approach helped ensure that thematic narratives within each case were grounded in both observational and student-reported data, offering a rich, nuanced understanding of how competence beliefs develop in context.

Results

The qualitative findings are presented as three different classroom cases aimed at addressing this study's third research question. This question explores instructional and interactional patterns within classrooms that are characterized by distinct patterns of change in students' competence beliefs. In each classroom case, the identified patterns and themes for each teacher illustrate how existing theories and prior research on supporting students' competence beliefs can advance our understanding of their unique classroom dynamics. These rich, detailed portrayals of classroom dynamics highlight how teachers' instruction and their students' motivational experiences can inform future theoretical and empirical work on students' competence beliefs.

Each classroom case follows a consistent structure that begins with a brief descriptive summary of teacher and students' characteristics examined in quantitative strand (see Table 6) and an overview of the curriculum implemented in the classroom. Together, the descriptive summary and curricular information provide additional context for interpreting the instructional and interactional patterns observed in each case. Next, using a series of SSGs, each case examined classroom trends in observed teacher competence support and students' daily competence perceptions using a series of SSGs. These visualizations captured patterns across the four competence support dimensions (see Table 5) alongside students' daily competence perceptions at both the classroom (aggregate) and individual-student levels throughout the instructional unit. To examine these interactional patterns in greater depth, each case also includes a descriptive narrative account organized around recurrent themes that showcased each teacher's unique strengths and challenges in implementing competence-supportive strategies across multiple lessons (see Table 7). The SSGs complemented these descriptive narratives by identifying key instructional moments where teachers' strategies may have aligned with or diverged from students' competence perceptions within specific lessons. Following the presentation of the three classroom cases, I conclude the chapter with a brief discussion synthesizing key insights across cases. A more substantial discussion integrating findings from the quantitative and qualitative strands is presented in Chapter 5.

Table 6

Means and Standard Deviations of Study Measures by Classroom Case

	Mason (n=31)		**Hannah** (n=25)		**Stuart** (n=24)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Teacher self-efficacy beliefs	4.00	---	4.50	---	4.30	---
Competence beliefs (pre-unit)	4.03	0.80	3.83	0.88	3.49	1.06
Competence beliefs (post-unit)	4.20	0.72	3.12	0.98	3.15	0.91
Initial science interest	4.01	0.96	3.96	0.78	3.32	1.40
Prior achievement (RIT math scores) [a]	214.52	15.41	213.68	15.13	217.88	13.49
Perceived teacher competence support	4.28	0.65	3.06	0.90	3.49	0.65

Note. [a] MAP Growth Math RIT scores ranged from 167 to 243 among student participants and scores of 228 or higher indicate sixth-grade proficiency based on state benchmarks; All other values reflect responses on a 1–5 scale from student and teacher surveys.

Table 7
Themes and Descriptions by Classroom Case

Teacher	Theme	Description
Mason	Relational approaches to academic tasks and social interaction	Clear expectations and guidance framed through inclusion, emotional support, and peer collaboration
	Leveraging challenges and feedback as growth opportunities	Positioned challenge as part of learning and used feedback to affirm effort, progress, and improvement
	Occasional slips but recovering through consistency	Inconsistent framing of academic challenges and classroom expectations and norms
Hannah	Emphasis on purpose	Regularly clarified why learning activities matter and framed tasks around real-world relevance through expectations
	Teacher-directed approaches to learning science	Used teacher-led explanations or examples to scaffold student thinking that often guided students toward intended ideas or responses
	Prioritizing correctness in feedback	Feedback primarily focused on validating correct answers with limited follow-up
Stuart	Task-oriented support within a structured environment	Emphasized procedural clarity and behavioral norms or routines to guide task completion
	Pressing for scientific understanding	Regularly used probing questions and clear explanations to reinforce content knowledge and encourage precise scientific understanding
	Mixed approach to feedback	Inconsistent messaging in performance feedback including encouragement, correction, and occasional sarcasm

Classroom Case 1: Mason

Mason is a first-year teacher who identifies as a White male and holds a bachelor's degree in human biology. He reported relatively high levels of perceived efficacy (*M* = 4.00 on a 5-point scale), indicating that he felt fairly confident in his ability to teach and support students' motivation in science effectively. Of the 42 students in the classroom he identified for data collection, 31 were included in the research sample. Mason's students, on average, reported fairly high interest in science (*M* = 4.01, *SD* = .96) at the start of the instructional unit and felt that Mason provided strong support for their own competence beliefs (*M* = 4.28, *SD* = .65). On average, students' prior achievement scores were just below the state proficiency benchmark of 228. His classroom was selected as a case due to an overall trend of increased competence beliefs among students over the course of the instructional unit. Students, on average, reported feeling highly competent in science as shown from ratings that consistently exceeded the midpoint of the 1-5 Likert scale, both before (*M* = 4.03, *SD* = .80) and after (*M* = 4.20, *SD* = .72) the instructional unit.

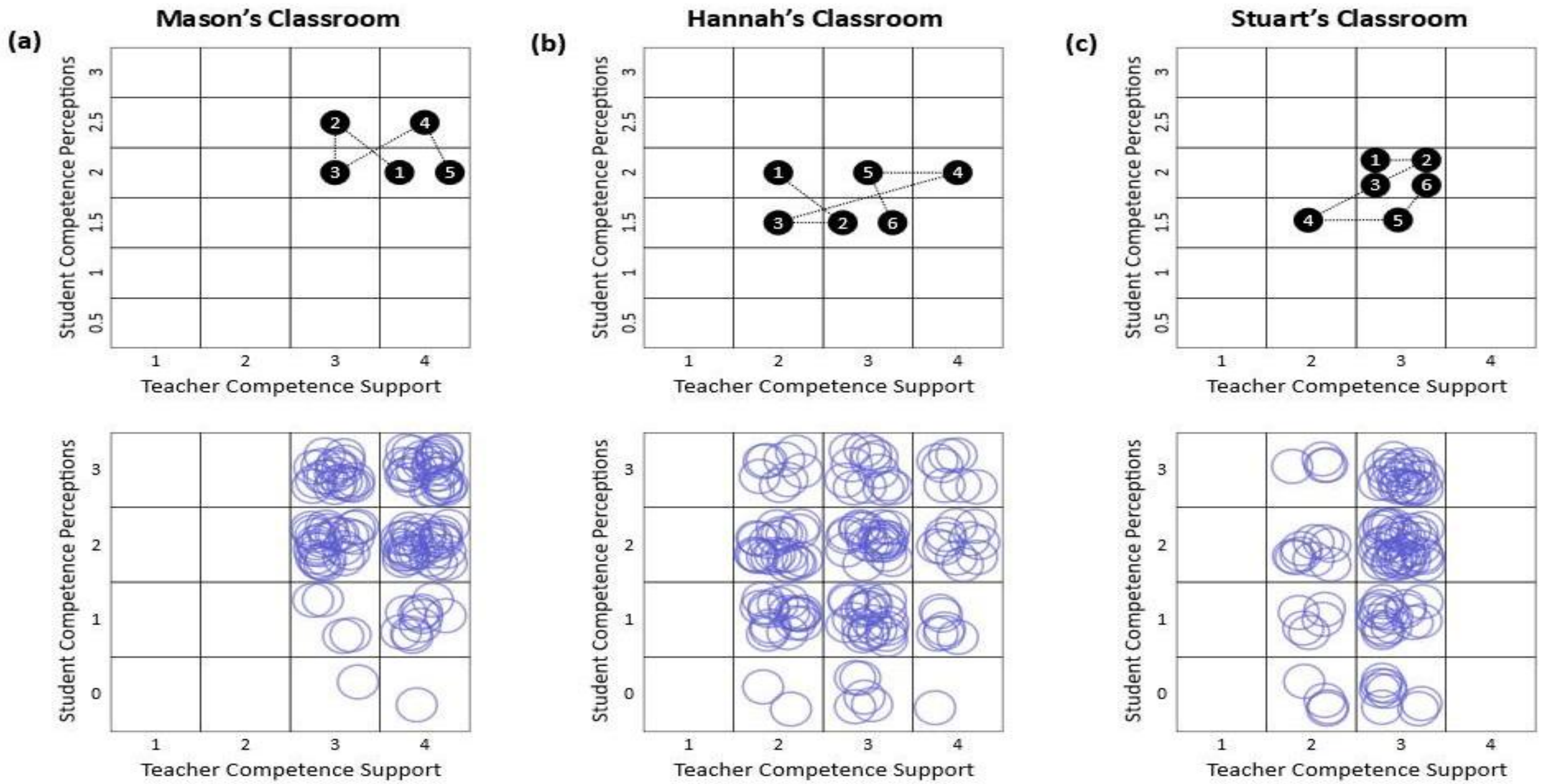
Mason's classroom implemented a district-generated chemistry unit that emphasized both content delivery and student-centered learning experiences. While direct instruction and class discussions were still present, many lessons involved students regularly engaged in partner and small-group activities to conduct hands-on investigations and structured opportunities to apply scientific understanding, such as identifying unknown substances in the mystery substance lab or examining molecular properties through collaborative research projects. Lab investigations in this curriculum tended to be more inquiry-driven that allowed students to explore concepts and make connections between concepts rather than simply following step-by-step instructions.

Patterns of Competence Support and Student Competence Beliefs

Figure 4 presents a set of SSGs for each of the three classrooms that depict patterns of teacher competence support in relation to students' competence perceptions. For each classroom, SSGs on the top row illustrate the combination of observed teacher competence support and the classroom-level aggregate of students' daily competence perceptions across lessons. The grids on the bottom row depict a more fine-grained view by mapping the same observed teacher competence support in relation to individual students' daily competence perceptions. While these individual-level grids do not directly link each students' competence perceptions to specific instructional moments or distinct competence-supportive strategies used in particular lessons, they remain useful for illustrating potential variation in students' daily experiences of feeling competent. Specifically, they show whether students' reported competence perceptions tended to cluster at similar levels or diverge from one another across different levels of observed teacher competence support (scores from 0 to 4 based on number of competence support dimensions observed per lesson). In doing so, the individual-level SSGs reveal nuances in students' competence perceptions that may otherwise be obscured in classroom-level aggregates and offer insight into how students may respond to teachers' competence support in varied ways.

Figure 4

State Space Grids (SSGs) for Teacher Competence Support and Student Competence Perceptions by Classroom Case



Note. State space grids (SSGs) illustrate relations between observed teacher competence support and students' daily competence perceptions across three classroom cases. Each subfigure presents two grids: the top panel shows classroom-aggregate competence perceptions (0-3 scale, rounded to the nearest 0.5) and the bottom panel shows individual student competence perceptions (0-3 scale in 1-point increments).

In Mason's classroom (Figure 4a), the alignment across both classroom-level (top panel) and individual-level (bottom panel) grids suggests that his competence-related moves were both consistent and varied, meaning that he regularly enacted nearly all competence support dimensions. Across nearly all lessons, coders recognized Mason's use of clear expectations, academic challenge, guidance and support, and informational, encouraging feedback, which reflects a multifaceted approach to supporting students' competence beliefs across lessons. As suggested in the top panel of Figure 4a, the steady and multifaceted provision of competence support, evident as early as Lesson 1, likely set the stage for maintaining moderate to high levels of perceived competence (with average classroom typically ratings around 2 or 2.5 on the 0-3 scale) in the lessons that followed. The bottom panel of Figure 4a reinforces this steady interaction pattern at the individual level. The dense cluster of overlapping points in the upper half of the grid with relatively few outliers indicate that most students consistently experienced moderate to high competence perceptions (ratings of 2 or 3) alongside Mason's steady competence supports. These interactional patterns suggest an overall strong alignment between Mason's competence-related strategies and students' daily competence perceptions. I turn now to a closer examination of the concrete ways in which Mason enacted these strategies to understand how his instruction may have shaped students' daily experiences of feeling competent.

Instructional Patterns in Supporting Competence Beliefs

Looking across Mason's lessons, the nature of his competence-supportive instruction was characterized by three interrelated themes. First, his strategies reflected *relational approaches* to both academic tasks and social interactions as he regularly sought inclusive participation, minimized negative emotions, and framed learning as a shared, collaborative endeavor. Second, he consistently *leveraged academic challenges and feedback as opportunities for growth* by helping students interpret struggles as part of learning while reinforcing their capability to succeed or improve. Third, the theme of *occasional slips but recovering through consistency* reflected brief deviations from Mason's typical approach such as framing challenges without pressing for student understanding or adopting a more controlling tone to communicate expectations and deliver feedback. However, these moments appeared to be followed by his overall consistency in using challenge-related and relationally grounded strategies. Together, these instructional patterns provide a nuanced understanding of how Mason cultivated a classroom environment that supported students' competence beliefs across the instructional unit.

Relational Approaches to Academic Tasks and Social Interaction. One of the most prominent themes identified in Mason's approach to supporting students' competence beliefs was the relational nature of his instructional strategies, particularly in how he applied the four competence support dimensions to prioritize inclusion, emotional support, and collaboration.[4] Rather than focusing solely on task completion or content delivery, Mason's strategies, especially related to clear expectations and guidance and support, often reflected a broader emphasis on building an instructional climate grounded in mutual respect and collective effort. This relational approach encompassed both teacher-student interactions and peer collaboration that fostered a classroom environment where students felt supported academically and socio-emotionally. For instance, when establishing clear expectations, Mason tended to reiterate expectations and norms of inclusive and equitable participation, particularly during lab activities. In Lesson 4, while students recorded observations during a lab experiment about chemical changes, he encouraged, "Make sure everyone is participating and has a chance to do their observations. Let's work as a group." Similarly, in Lesson 2 involving lab activity where

[4] None of the four competence support dimensions are inherently relational. Rather, what distinguished Mason's instruction was the relational ways in which he enacted them.

students were identifying an unknown white power in their groups, he asked, “Are we making sure that everyone is involved?”, which promoted shared engagement as part of the learning process. These moments illustrate how his expectations and norms were framed not just around academic tasks but around building inclusive and respectful classroom interactions.

Mason’s relational approach also extended to guiding and supporting students during task completion. Across multiple lessons, including Lessons 1, 2, and 5, he consistently circulated the classroom while students worked individually or in small groups, checking for understanding and offering help or clarification as needed. He also provided emotional reassurance in response to students’ distress or anxiety. For instance, in Lesson 5, to a student who was overwhelmed about completing the research project on time, Mason encouraged them to take it “piece by piece” and reassured them that there was no need to rush to complete everything on the same day. This strategy reflected flexibility in adjusting expectations around pacing to reduce time pressure, which may have supported students’ competence beliefs by reinforcing a sense of control over the task at hand. In addition to one-on-one support, Mason also encouraged peer collaboration as a means of academic guidance that reinforced a shared responsibility for learning. In Lesson 1, he ensured students used the provided rubric correctly while evaluating their peers’ research projects, and in Lesson 2, he encouraged students to check in with one another about their progress during a lab activity. Together, these examples illustrate how Mason’s competence-supportive strategies were enacted in relational ways that integrated academic guidance with socio-emotional support. By fostering inclusive participation, encouraging peer collaboration, and providing emotional reassurance, Mason cultivated a classroom environment where students’ competence beliefs were supported through a broader sense of community.

Leveraging Challenges and Feedback as Growth Opportunities. Mason engaged in competence-supportive strategies that involved framing challenges as integral to the learning process and providing informational feedback that emphasized improvement and effort. Whereas the Academic Challenge dimension was often missed across classrooms, Mason consistently integrated challenge-related strategies into his instruction that stood as distinct among the cases. Lessons 1, 4, and 5 evidenced Mason implementing challenge-related strategies that positioned students' struggles as natural and meaningful opportunities for growth to reinforce how competence beliefs develop through ongoing effort and persistence. For instance, in Lesson 5, he acknowledged the difficulty of identifying credible sources and reassured them by stating, "Part of research is finding things that's better." This framing normalized the challenge as an expected part of learning and encouraged effort and persistence. He further connected their current learning experiences to future academic demands by explaining that in high school they would likely encounter situations where things may not work as expected, which highlighted the importance of resilience in navigating academic obstacles.

A similar approach was evident in Lesson 4 where Mason used academic challenges to press for student thinking. During a class discussion about why the Ziploc bag should remain sealed when mixing reactants, a student responded that a bag should stay closed to contain the reactants. Mason affirmed the response and encouraged students to "think more scientifically," which prompted them to connect their ideas to broader concepts of chemical reactions. He guided student thinking by introducing the idea of open systems and used an analogy to explain how external substances can enter and alter the reactions and linking this concept back to the unsealed bag. Through this exchange, Mason challenged students to refine their thinking and engage in more complex reasoning by framing academic challenges as a meaningful opportunity to extend their learning.

In addition to framing challenges as a natural part of the learning process, Mason regularly provided informational and encouraging feedback that reinforced effort and growth. While more structured around a quiz game, Lesson 3 offered insight into how he framed mistakes as part of learning. When students answered questions incorrectly, Mason reassured students not to be discouraged and emphasized that making mistakes are opportunities that contribute to improvement over time. Relatedly, Lesson 4 further exemplified how Mason paired clear expectations with informational feedback focused on student effort and progress. In this lesson, students were expected to record observations based on color, gas formation, and temperature, which were written on the board and clearly communicated throughout the lesson. Mason reinforced these expectations with comments such as, “I like this. I like how you’re including all things on the board,” which highlighted what students were doing well in relation to the clearly defined expectations. This approach likely supported students’ competence beliefs by making expectations transparent and affirming progress through specific, task-related feedback. Notably, Lesson 4 also evidenced a strong alignment between observed competence support (rating of 4 on a 0-4 scale) and relatively high classroom-level competence perceptions as visualized in the SSGs (Figure 4a, top panel), which highlights the potential value of integrating multiple dimensions of competence support.

Similar feedback practices were also evident in other lessons where Mason balanced affirmation with suggestions for improvement. In Lesson 5, as students shared their progress on their research projects, he offered encouraging praise such as, “I like that. That’s good stuff” or “That’s awesome,” to acknowledge their efforts. At the same time, he further challenged students to explore their research topics more deeply by providing targeted suggestions, such as using more reliable scientific sources, to strengthen their work. On another occasion, he provided corrective feedback to a student searching for information on a shopping website and noting that search engines can often lead to misleading information when researching academic topics. Across these examples, Mason's approach to academic challenge and feedback dimensions reflected a consistent emphasis on effort, improvement, and incremental progress toward mastery, which likely supported students' competence beliefs across an instructional unit.

Occasional Slips but Recovering through Consistency. While Mason's classroom was generally characterized by consistent competence-supportive instruction, there were occasional contrasts in how instructional strategies were enacted. This theme highlights moments when Mason's instructional strategies momentarily diverged from his usual approach or brief "slips" in his provision of competence support. Notably, these slips often coincided with small dips in students' classroom-level competence perceptions as observed in Lessons 3 and 5 (see Figure 4a). However, his overall consistency in implementing a range of competence-supportive strategies appeared to reliably sustain students' competence beliefs, which suggest that consistency in competence support may likely buffer the impact of occasional lapses.

One pattern of his instructional lapses related to how Mason framed academic challenges. Although he explicitly framed challenge as a valued part of learning, his instruction at times missed opportunities to incorporate challenges by engaging students in deeper thinking. For example, in Lesson 3, where a slight dip in students' classroom-level competence perceptions (average rating of 2) was observed, Mason facilitated a quiz game that included a question about burned toast, which many students had answered incorrectly. Rather than prompting students to share their reasoning, he stated, "If anything burns, it is a chemical change." By providing the correct answer without inviting student input, he may have unintentionally limited opportunities for students to critically engage with the concept. A similar pattern was observed in Lesson 5 when Mason remarked to a student who was off task that they were expected to answer “simple questions.” This framing of tasks may have conveyed low expectations on students’ abilities and inadvertently suggest that the task was not intended to meaningfully challenge students’ thinking. Notably, this lesson also showed a small dip in students’ competence perceptions (Figure 4a, top panel).

Mason also occasionally shifted away from his typically relational and encouraging tone when establishing classroom norms. In Lesson 2, alongside the absence of challenge-related strategies, Mason expressed frustration by stating, “I am tired of being disrespected, I am tired of fighting control of my classroom.” This more controlling tone contrasted with his usual emphasis on shared norms and inclusive participation and may have potentially reduced students’ sense of psychological safety, which is important for sustaining competence beliefs. Similarly, in Lesson 4, Mason adhered to a “no talking” policy during a lab activity that may have limited opportunities for students to confer with peers while recording observations. Moreover, when some students fell behind, his feedback took on a more pressuring tone including comments such as, “You’ve done nothing,” and “Five of you have nothing written down.” These moments appeared to impose time constraints and prioritize task completion over effortful progress, which may have left students to feel rushed or uncertain about how to improve.

Overall, Mason’s case illustrates how a reliably consistent and relationally grounded approach to competence support can create a stable classroom environment that helps sustain students’ competence beliefs, even when occasional contrasts occur. While these moments of contrast were accompanied by small, momentary dips in students’ competence perceptions, Mason's broader pattern of consistent competence support may have enabled students to recover from less supportive moments. In contrast to classrooms marked by less reliable and narrower competence support, Mason's overall steady and multifaceted approach may have afforded students to persist through brief lapses and maintain their competence beliefs over time.

Classroom Case 2: Hannah

Hannah identifies as a White female with 12 years of teaching experience. She holds a bachelor's degree in environmental science and a master's degree in teaching. Among the three teachers, Hannah reported the highest efficacy beliefs ($M = 4.50$), which reflects strong confidence in her ability to teach science and support students' motivation effectively. Her class consisted of 40 students, 25 of whom were included in the research sample. Hannah's classroom was selected as a case that exhibited an overall decline in students' competence beliefs across an instructional unit as reflected in pre- and post-unit survey responses. Students began the unit with moderately high levels of perceived competence ($M = 3.83$, $SD = .88$), but this declined by the end of the unit ($M = 3.12$, $SD = .98$). On average, their average prior achievement score was slightly below the state proficiency benchmark of 228, similar to students in Mason's classroom. Although her students reported high initial interest in science ($M = 3.96$, $SD = 0.78$), comparable to those in Mason's classroom ($M = 4.01$), they also reported the lowest level of teacher competence support across the three classrooms ($M = 3.06$, $SD = .90$). While both Hannah's and Mason's students began the unit with relatively strong competence beliefs and similarly high levels of initial interest in science, Hannah's students showed a downward trend in competence beliefs over time compared to the modest increase observed in Mason's class. This contrasting pattern combined with lower perceptions of teacher competence support makes Hannah's classroom particularly useful for examining specific instructional patterns that may be linked to overall declines in students' competence beliefs.

Hannah implemented the same district-generated chemistry unit as Mason, which combined direct instruction and class discussions with inquiry-based labs and collaborative projects. One key component of the unit was the Marvelous Molecules project in which students selected a molecule of interest, researched its environmental impact, and presented their findings to the class. Her instruction also placed greater emphasis on developing students' scientific argumentation through structured discussions, guided practice, and teacher-led demonstrations (e.g., Lessons 3, 4, and 6; see Appendix B).

Patterns of Competence Support and Student Competence Beliefs

In Hannah's classroom (Figure 4b), the patterns across classroom-level grids (top panel) indicate some fluctuation in the breadth of competence support dimensions addressed across lessons. Early in the instructional unit, her strategies typically drew from only two or three dimensions. The most consistently observed strategies related to clear expectations, followed by those related to providing guidance and support and feedback. This trend shifted in Lesson 4, where her instruction drew from all four competence support dimensions, including academic challenge, which was a competence supportive dimension that was absent from all her other lessons. Notably, students' perceived competence also increased during Lesson 4 (average rating of 2), which may suggest a possible relation between the breadth of competence-supportive strategies and students' competence perceptions. In Lessons 5 and 6, Hannah's strategies returned to spanning three dimensions with challenge-related strategies no longer present. A small dip in students' competence perceptions observed in Lesson 6 may point to the importance of consistently integrating academic challenges as part of competence support. Overall, students' average daily competence perceptions remained relatively stable at moderate levels, with average ratings ranging from 1.5 to 2 across the lessons. While Hannah regularly employed strategies especially those related to clear expectations, guidance and support and feedback (each observed in five out of six lessons), her overall instructional approach was narrower in scope and less balanced across the four dimensions compared to the other classroom cases in this study.

The individual-student grids (Figure 4b, bottom panel) further illustrate students' daily competence perceptions across lessons. In Hannah's classroom, student ratings showed a wider dispersion with most responses (as indicated by the overlapping dots forming concentrated clusters) falling in the low to moderate range (ratings of 1 or 2). This wider dispersion of ratings appeared across different levels of observed teacher competence support, which indicated that students, on average, may have experienced more variation in their competence perceptions regardless of the range of competence support dimensions used in a given lesson. This stands in contrast to Mason's classroom where students' competence perceptions were generally higher (ratings of 2 or 3) and more tightly clustered at the upper end of the scale (Figure 4a, bottom panel). A closer examination of how Hannah employed competence-supportive strategies across lessons illuminates key patterns in her unique instructional approach, which are presented in the following section.

Instructional Patterns in Supporting Competence Beliefs

Hannah's instructional approach to supporting students' competence beliefs revealed three key themes across lessons. First, she consistently *emphasized the purpose* behind learning activities by often framing tasks with a clear rationale to help students understand the relevance of tasks at hand. Second, her instruction reflected *teacher-directed approaches* in which her guidance and support were delivered primarily through teacher-generated explanations and examples. Finally, her use of feedback often *prioritized correctness* that focused on confirming right answers. Together, these themes illustrate how aspects of Hannah's competence-supportive strategies tended to align with a more structured, teacher-centered model of instruction.

An Emphasis on Purpose. Across multiple lessons, Hannah consistently framed her expectations in ways that clarified the purpose of learning activities and their connection to prior knowledge or specific learning goals or outcomes. In Lesson 1, during a warm-up activity, she engaged students in a discussion of why it was important to learn about scientific models by linking the current lesson to their prior learning about atoms and molecules and explaining how models help make sense of invisible phenomena. Later in the same lesson, before students engaged in a card-sorting activity, she emphasized the purpose of group work by emphasizing the collaborative nature of scientific inquiry in which students can learn to support one another through questioning and shared thinking. She reinforced this idea by referring to scientists: "This is what scientists do. There are no successful scientists who work by themselves…they help each other out and learn from each other." Similarly, in Lesson 2, she introduced the purpose of the Marvelous Molecules project by highlighting its relevance in real-world contexts by explaining that students would investigate how molecules "affect everyday lives." This pattern of emphasizing purpose continued in Lesson 4 as students worked on the presentation portion of the project. Hannah clarified that the expected outcome was to finish filming and decide how to present their findings to the class, so that students could learn from one another. These examples demonstrate her efforts to establish clear expectations by articulating the purpose of the activity, which can help students understand not only what was expected of them, but also why their learning was meaningful and relevant.

On other occasions, Hannah regularly reinforced the purpose of her lessons by explicitly articulating the learning goals. In Lesson 6, which involved a lab activity, she framed the lesson around the learning goal of understanding the law of conservation of mass. By anchoring the activity in a key scientific principle, Hannah helped connect abstract concepts to hands-on experiments that enable students to explore and apply their knowledge. In Lesson 3, as students reviewed components of scientific argumentation, she began by inviting them to reflect on why learning about argumentation matters. During the discussion, she pointed out that doing science involves asking and answering questions about natural phenomena, which mirrored what scientists do in the real-world. She then linked this idea to their recent lab activity and explicitly stated the learning goal was for students to construct a Claim-Evidence-Reasoning (C-E-R) response. Although the emphasis on learning goals was clearly communicated in Lesson 3, the broader competence support available to help students reach those goals appeared limited. This observation aligns with the classroom-level patterns captured in the SSGs for Lesson 3 (Figure 4b, top panel), which showed that Hannah's strategy use focused on the clear expectations and feedback dimensions and no strategies related to guidance and support or academic challenge. Correspondingly, students' daily competence perceptions for this lesson were lower (rating of 1.5) compared to most other lessons, except for Lessons 2 and 6. This moment may suggest that while Hannah consistently emphasized the purpose of learning, these efforts were not always paired by other forms of competence support that may be necessary to reinforce students' confidence in their ability to meet learning goals.

Teacher-Directed Approaches to Learning Science. Hannah's instructional approach tended to be teacher-directed, particularly when providing guidance and support. Her efforts to make complex scientific concepts accessible were often shown through teacher-generated examples and scaffolding students' understanding of the content. For example, in Lesson 6, she referenced astronauts to explain the difference between weight and mass and a cake-baking analogy to emphasize the importance of recording measurements with proper units. Similarly, in Lesson 4, Hannah interacted with a group of students falling behind on the Marvelous Molecules project by encouraging their choice of rubber and providing her own examples of its everyday uses, such as tires, erasers, and other familiar objects. Although these examples aimed to make concepts relatable, they were largely teacher-driven and did not enable students to contribute their own perspectives, draw upon their own experiences, or make personal connections. Moreover, at times, some examples remained somewhat distal or abstract. For instance, while discussing chemical reactions in Lesson 6, Hannah attempted to make the concept relatable to students' daily lives by stating, "They're happening all the time. To digest whatever you eat and drink." This broad comment lacked specificity or follow-up needed to prompt students to engage more deeply with the idea through discussion.

Hannah's teacher-directed approach to guidance and support also shaped how she scaffolded students' understanding, particularly in Lesson 6. During a journal activity on chemical reactions, she offered highly prescriptive guidance by telling students, "Here's what I want you to put for this one," in response to the question, "What happens to atoms in a chemical reaction?" Although she pressed for students to share their ideas and evidence, she often ended up providing the intended explanations herself. Lesson 6 may have been one of the lessons where student competence perceptions appeared more widely dispersed (Figure 4b, bottom panel) which may suggest individual variation in how students experienced Hannah's instruction, particularly the teacher-directed approach to support student understanding along with the limited presence of challenge-related strategies. While this approach may have helped some students feel more confident by making content clear and accessible, it may have left others without sufficient opportunities to explore complex ideas or extend their thinking and potentially contributing to differences in how confident students felt during the lesson.

Prioritizing Correctness in Feedback. Alongside her directive approach to classroom discourse, Hannah's feedback practices often functioned to confirm correct responses rather than promote exploration or reasoning. For instance, in Lesson 6, when a student explained that "conservation" means to "save," Hannah positively responded, "That's the word I was looking for. That's good." While her positive affirmations signaled that the student's response met what she intended, she did not invite further elaboration. Later in the same lesson, she reiterated a student's explanation of atomic mass and number related to Niobium to the whole class to validate the accuracy of the student's response by adding her own elaboration. These moments highlight how Hannah's feedback often affirmed correct or expected responses rather than offering informational feedback that supports students' competence beliefs by clarifying why a response is meaningful or how it connects to broader ideas.

Relatedly, a notable example occurred in Lesson 5 during a discussion on the properties of water as a polar molecule. After reviewing the composition of water molecules and conducting a demonstration of comparing the evaporation of alcohol and water, Hannah asked students to explain why alcohol evaporates more quickly. When some students shared incorrect or unrelated responses such as "boiling", Hannah moved on with a more targeted prompt, "What are the molecules in the water and alcohol doing that cause one to evaporate faster?" Her feedback became noticeably more responsive when another student shared a partially correct answer as she commented, "Okay, close. Can you expand on that?", which contrasted with how she addressed earlier responses. Although she briefly invited the student to elaborate, her feedback remained on confirming correctness. When the student struggled to respond, she eventually provided the explanation herself, which also reflects her teacher-directed approach to offering guidance and support. These examples suggest that Hannah's feedback, while generally affirming, tended to signal whether students' responses aligned with her intended answers or explanations rather than leveraging students' ideas as opportunities for extended discussion.

In contrast, Lesson 4 marked a shift in Hannah's usual feedback practices of confirming correctness. As students worked on the presentation portion of their Marvelous Molecules project, she reassured a student who expressed confusion about hydrogen atoms by saying, "You were doing a great job yesterday. Let's pick up on that." She also offered constructive suggestions for improvement such as advising students to include arrows in their molecular diagrams to label the leaking gas. These instances differed in that she offered encouraging, informational feedback that supported student progress, effort, and improvement. As reflected in the classroom-level SSGs (Figure 4b, top panel), Lesson 4 was the only lesson in which Hannah demonstrated strategies across all four competence support dimensions, including strategies related to academic challenges. A closer look at her instructional patterns during this lesson revealed that she also framed challenges as meaningful opportunities for learning. While offering feedback on their presentations for the project, Hannah encouraged students to persist through difficulties and work collaboratively by commenting, "You gotta work through it. You gotta figure it out together to make it work," and "You know more about this than I do." These illustrative moments demonstrated how her feedback not only conveyed high expectations and reinforced students' abilities to navigate struggles through collaborative effort. In this context, her feedback likely played a role in supporting students' competence beliefs, which may have contributed to the observed increase in students' competence perceptions during this lesson.

Hannah's case highlighted how a strong reliance on certain competence-supportive strategies, such as teacher-generated examples and explanations, combined with less consistent use of others, particularly those related to academic challenge, may be associated with observed declines in students' competence beliefs over time. Although she regularly employed strategies related to clear expectations, guidance and support, and feedback, her instruction rarely drew on all four dimensions simultaneously. The one lesson (Lesson 4) in which she integrated academic challenge coincided with a slight increase in students' competence perceptions suggests the importance of breadth and consistency in competence support. In contrast, Stuart's classroom presented a similar but distinct instructional pattern characterized by a narrower yet predictable use of competence-supportive strategies. The following case explores how these mixed instructional patterns unfolded in Stuart's instruction and how they may relate to distinct patterns of change in students' competence beliefs.

Classroom Case 3: Stuart

Stuart, a White male, holds a bachelor's degree in chemical engineering and a master's degree in education and has 24 years of teaching experience. Like the other two teachers, he expressed high confidence in his ability to teach and support student motivation in science (M = 4.30). Of the 32 students in his class, 24 were included in the research sample. In his classroom, a teaching aide also provided inclusion support for six students in the sample who had special education status. Among the three classrooms, Stuart's students reported the lowest initial interest in learning science (M = 3.32, SD = 1.40). They also perceived Stuart as providing a moderate level of competence support (M = 3.49, SD = .65), a rating which is higher than that provided by students in Hannah's classroom (M = 3.06), but lower than the student ratings in Mason's classroom (M = 4.28). Their average prior achievement score was slightly below the state proficiency benchmark of 228, but slightly higher than the average scores of students in Mason's and Hannah's classrooms. Similarly, Stuart's students also had moderate levels of perceived competence in science, with average ratings near or slightly above the midpoint of the 1-5 Likert scale, both before (*M* = 3.49, *SD* = 1.06) and after (*M* = 3.15, *SD* = .91) the instructional unit. Compared to Mason's (*M* = 4.03) and Hannah's (*M* = 3.83) classrooms, Stuart's students began the unit with the lowest perceived competence in science.

Stuart's classroom was selected as a distinct case due to exhibiting substantial individual variability in students' competence beliefs over the course of the instructional unit. His classroom revealed a unique trend where some students experienced increases over the instructional unit, others showed declines or no change. This pattern of individual variability contrasts with the modest, but uniform upward trend in Mason's classroom, a notable case as no other classroom showed this pattern, and with the overall decline observed in Hannah's classroom. more uniform upward trend in Mason's classroom and the general decline observed in Hannah's classroom. As shown in Table 3, this variability is also reflected in the standard deviation of students' change scores in perceived competence, which was highest for Stuart's classroom (*SD* = 0.81) and substantially higher than Mason's (*SD* = 0.45) and slightly higher than Hannah's (*SD* = 0.72). To better understand this pattern of variability, I examined how Stuart's provision of competence support and student's daily competence perceptions co-occurred and unfolded throughout the instructional unit.

Stuart implemented an NGSS-aligned IQWST curriculum that was centered around the question, "How can I make new stuff from old stuff?" (Activate Learning, 2019; Krajcik et al., 2014). While the IQWST curriculum also addressed similar disciplinary core ideas (e.g., chemical reactions, molecular structures) as Mason and Hannah's district-generated curriculum, the unit followed a more structured and conceptually coherent sequence. Stuart first began by introducing foundational concepts such as mass, density, and solubility primarily through direct instruction and teacher-facilitated discussions, which prepared students for subsequent lessons on chemical reactions and conservation of matter. These concepts were reinforced through facilitating guided lab activities with clear procedural steps, including testing solubility of different liquids, constructing density columns, and investigating chemical changes through electrolysis (see Appendix B). Overall, the curriculum placed a strong emphasis on content mastery by integrating structured review activities and assessments that provided opportunities to help students refine their understanding through inquiry and reflection.

Patterns of Competence Support and Student Competence Beliefs

Stuart's instruction consistently drew from three competence support dimensions, including clear expectations, guidance and support, and feedback (Figure 4c, top panel). Compared to Hannah, who showed more fluctuation in the dimensions addressed across lessons, Stuart maintained a more stable pattern in terms of breadth of strategies used. However, strategies related to academic challenges, particularly those encouraging persistence through difficulty, were notably absent across all six lessons. In the earlier phase of the instructional unit (Lessons 1 to 3), Stuart frequently implemented strategies spanning three dimensions and students' competence perceptions during this phase remained moderate (average rating of 2). A shift in this pattern occurred in Lesson 4 where he used a narrower range of strategies across two dimensions (clear expectations and guidance and support), which corresponded with a slight dip in students' competence perceptions (rating of 1.5) and persisted into Lesson 5. By Lesson 6, the introduction of feedback dimension aligned with an increase in students' competence perceptions (average rating of 2). Overall, students' daily competence perceptions remained within the moderate range (average rating of 1.5 or 2), which approximated the same general range of students' competence perceptions observed in Hannah's classroom (Figure 4b, top panel).

The individual-student grids (Figure 4c, bottom panel) offer a more nuanced picture of students' daily competence perceptions by uncovering patterns that are masked in the classroom-level grids. While the classroom-level grids suggest a relatively stable trend at the moderate level, the individual-level grids show greater individual variation in students' competence perceptions across lessons, which results in the appearance of a stable average. Similar to Mason's students, many of Stuart's students reported moderate to high levels of perceived competence (ratings of 2 or 3). However, their responses showed more variability across lessons as indicated by the broader spread of overlapping dots. In contrast, Mason's students showed less dispersion with individual ratings more tightly clustered toward the upper end of the scale. Further, compared to Hannah's classroom (Figure 4b, bottom panel), where individual ratings of competence perceptions were also widely dispersed, but generally ranged from low to moderate (ratings of 1 or 2), Stuart's students exhibited moderate to high ratings and notable individual variation. Together, these patterns underscore the need for a closer examination of Stuart's instruction to better understand how his competence-supportive strategies may differentially relate to students' daily competence perceptions.

Instructional Patterns in Supporting Competence Beliefs

Stuart's instructional approach to supporting students' competence beliefs, particularly within the clear expectations and guidance and support dimensions, revealed three key patterns across lessons. First, he emphasized *task-oriented support within a structured environment* by providing clear procedures, explicit modeling, and firm behavioral expectations to guide students through academic tasks. Second, his instruction consistently focused on *pressing for scientific* *understanding* primarily through probing questions and clear explanations to reinforce content knowledge and encourage precise reasoning. Finally, his *mixed approaches to feedback*, ranging from encouragement and affirmations to precision, to sarcasm, may have conveyed inconsistent messages about performance. These instructional patterns may offer insight into how Stuart's instructional strategies shaped students' competence perceptions across lessons.

Task-Oriented Support within a Structured Environment. Stuart's instructional approach emphasized task-oriented support within a structured and orderly classroom environment to help guide students toward successful task completion. Through modeling explicit, step-by-step procedures, offering verbal cues, and reinforcing clear behavioral norms, he provided students with a clear roadmap to engage in tasks with clarity and precision. For example, during a lab investigation on density in Lesson 2, he modeled how to pour liquids into graduated cylinders and repeatedly reminded students, "Be very, very careful… pour it very slowly." A similar approach was evident in Lesson 6 when students investigated whether mixing water with sulfuric acid and applying electricity would produce a new substance. Stuart supplemented a video demonstration with verbal instructions and paused throughout to explain key procedural steps, such as connecting wires to batteries, prompting students to record their observations, and requiring approval before moving forward. This pattern of procedural clarity and task-oriented scaffolding, aligned with the clear expectations and guidance and support dimensions, appeared consistently across multiple lessons, including Lessons 2 and 6. Although individual student competence ratings do not track same students across lessons, the broader dispersion of competence perceptions observed in individual-level SSGs (Figure 4c, bottom panel) may reflect greater individual variability during lessons such as 2 and 6 when these structured, task-oriented supports were employed. This pattern suggests that students may have engaged in competence-supportive strategies, including Stuart's structured, task-oriented strategies, in varied ways as reflected in the dispersion of individual competence perceptions during those lessons.

This duality was also evident in how Stuart relied on classroom management strategies to maintain a structured environment for student learning. While time estimates or countdowns helped students pace their work, other moments conveyed a more controlling tone. In Lesson 4, for instance, he stated, "You have about 3 minutes left or else it is homework," and during a quiz retake in Lesson 5, he reinforced silence by stating, "This is a quiz. I shouldn't hear people talking." Although these strategies contributed to a predictable classroom environment, they may have also emphasized task compliance and pressure to complete tasks. Notably, classroom-level SSGs (Figure 4c, top panel) show a dip in average competence perceptions during Lessons 4 and 5 (ratings of 1.5) compared to other lessons (ratings of 2), even though multiple competence support dimensions (excluding academic challenge) were present.

Pressing for Scientific Understanding. Stuart consistently employed a range of strategies that pressed for scientific understanding during classroom discourse. His instruction often featured strategies that reflected the guidance and support dimension such as revisiting and clarifying key scientific concepts, connecting content to prior knowledge, and using probing questions to deepen students' thinking. These instructional strategies also appeared to reflect his high expectations in the depth or completeness in students' explanations and an ongoing effort to scaffold student thinking and reasoning. Across several lessons, Stuart employed strategies that activated students' prior knowledge to scaffold new learning. For example, in Lesson 1, he reviewed the properties of matter and asked students to recall the difference between substances and mixtures from previous lessons before introducing the concept of solubility. In Lesson 3, while reading aloud a passage about density to the class, he reinforced the density of density by stating, "I wanted you to know what density means," and provided the definition of the term before continuing. These moments illustrate his consistent use of clarification and scaffolding to ensure students had a firm understanding before moving forward in the lesson. Likewise, Stuart also regularly used probing questions to scaffold student understanding. In Lesson 6, as students conducted a lab activity investigating chemical reactions, Stuart referred to a previous lab investigation involving marshmallows and asked a series of guiding questions including, "Is water a gas at room temperature? Is water a new substance? Is there a chemical reaction going on?" These questions prompted students to connect their current observations, such as the bubbling from electrolysis to prior lessons about chemical reactions, which demonstrated how he used classroom discourse to support student understanding over time.

At times, Stuart combined strategies from the clear expectations dimension with those related to guidance and support, such as in Lesson 5, where he pressed for student understanding by making grading and performance criteria explicit. Before a quiz retake, he reminded students to use scientific vocabulary and noted that the level of detail in their explanations would relate to point values on the quiz. However, the rapid-fire questioning activity that followed revealed inconsistencies in how he provided guidance and support in student understanding. Using name sticks, Stuart called on students to identify whether characteristics, such as color, mass, and solubility, were properties. While some students were asked to justify or expand on their answers, others received little or no follow-up. This uneven distribution of scaffolding reflected inconsistencies in how the guidance and support dimension was enacted as not all students were given opportunities to build on their understanding. In result, this selective approach likely benefited students who were already confident or able to respond correctly, while others may have been left without the instructional scaffolding needed to extend their thinking, which can contribute to divergent student experiences of feeling competent. This aligns with the slight dip in students' classroom-level competence perceptions observed during Lesson 5 (Figure 4c, top panel) and may also be reflected in the broader dispersion of individual student ratings in competence perceptions (Figure 4c, bottom panel). These moments suggest that inconsistencies in how instructional guidance is provided, particularly when pressing and scaffolding for deeper understanding, may relate to variation in how competent students feel over time.

Mixed Approach to Feedback. Combined with his press for scientific understanding, Stuart's feedback featured a blend of encouragement, precision, and occasional sarcasm that revealed moments of inconsistent messaging about student performance. His feedback often alternated between generic praise or encouragement and more targeted, informational guidance. For instance, in Lesson 1, he encouraged students to persist with affirmations such as, "You are on the right track," and in Lesson 5, he acknowledged a student's strategy for using the textbook as a resource for an open-book quiz by saying, "I like how you used your resources there. It's an open book quiz. Let's make sure you use them today." When other students appeared uncertain of the sincerity of his praise, he clarified, "I'm real. I appreciate that the student looked at the textbook." Similarly, during a lab activity in Lesson 6, Stuart often combined generic praise with specific suggestions for improvement to guide student performance by stating, "You can bring this a little lower," and affirming progress with comments such as, "Yes, that's how I want it exactly," or "Nice job." He also commented enthusiastically, "You guys are having some good bubbling there," in response to student observations during the lab experiment.

However, when students provided incomplete or incorrect responses, Stuart's feedback often leaned toward correction and confirmation of accuracy. These moments of corrective feedback were sometimes paired with inconsistencies in his instructional guidance as only some students were prompted to elaborate on or extend their thinking. For example, during a discussion about the properties of materials in Lesson 5, Stuart presented a scenario involving a silver necklace and bracelet and asked students to identify their properties. When one student gave an inaccurate answer, he responded, “That’s not a property. That’s telling me what it is. That’s telling me what a substance is.” In contrast, when another student named melting point, a response that was closer to Stuart’s intended answer, he followed up with probing questions, “Yes, that is a property but tell me about the melting point for those two things. For the necklace and the bracelet.” As the student explained that melting point is determined by the temperature rather than time, Stuart affirmed the response by reiterating the student’s explanation to the class. He then extended the discussion to the class by asking, “So is it (melting point) going to be the same for the necklace and bracelet or is it going to be different?” When the class provided mixed answers, he concluded the discussion by clarifying, “It's going be the same, right? Because it's not the time, it's about the temperature and it always starts at the temperature. So the properties will always be the same.” This exchange reflects Stuart’s pattern of confirming correctness through his feedback while selectively scaffolding student thinking, an approach that closely resembled Hannah’s emphasis on reinforcing accurate responses. In both cases, feedback tended to validate students’ responses when they aligned to what the teachers intended, which may have constrained opportunities for sense making or deeper exploration of concepts.

Stuart’s feedback also occasionally included sarcastic or compliance-driven remarks, particularly in Lessons 2 and 5, which somewhat differed from the other teachers. For example, in Lesson 2, he remarked, “It shouldn’t be that hard,” and in Lesson 5, he commented to some students who were off-task or are falling behind by saying, “We talked about this for like a week," and "You should know how to answer the questions if you had been listening." While intended to redirect students' attention or reinforce accountability, they contrasted with his otherwise encouraging tone and may have conveyed low expectations on students' abilities.

Overall, Stuart's mixed approach to feedback ranged from affirming and encouraging to sarcastic or selectively validating only correct responses. During lessons when he drew on the feedback dimension, such as Lessons 2 and 5, the individual SSGs revealed a wider dispersion of competence ratings (Figure 4c, bottom panel), which suggests greater variability in how students felt competent on those days. The broader variation in competence perceptions may in part reflect differences in how they experienced the selective nature and tone of his feedback. In contrast, Mason's showed more uniform perceptions of competence as indicated by individual competence ratings that were more tightly clustered at the higher end of the scale (Figure 4a, bottom panel), particularly during lessons where both teachers drew on three competence support dimensions, including feedback. While students in both classrooms generally reported moderate to high competence perceptions (ratings of 2 or 3), the broader spread of individual ratings in Stuart's classroom suggest that consistency in strategy use, including how feedback is framed or delivered, may shape students' experiences of feeling competent across lessons.

Summary and Discussion of Qualitative Strand

The qualitative strand of this study examined how teachers' provision of competence supports unfolded alongside students' competence beliefs during the course of instruction. Drawing on three distinct classroom cases, the qualitative findings provided rich, contextualized accounts that revealed both similarities and notable differences in how each teacher implemented competence-supportive strategies across multiple lessons. While all three teachers employed strategies aligned with theoretical frameworks of competence support, they differed notably in how those strategies were enacted in practice. These variations begin to suggest how particular instructional patterns may serve to support or hinder the development of students' competence beliefs. Attending these qualitative distinctions is important for advancing both theoretical understanding and instructional design aimed at promoting students' competence beliefs. In the sections that follow, key findings across the classroom cases are highlighted with particular attention to the instructional and interactional patterns constructed through analysis of classroom videos and SSGs. These patterns are then further interpreted in light of existing theory and research on competence beliefs. An integrative discussion that synthesizes insights from the quantitative and qualitative strands is provided in Chapter 5.

Nuances in Competence-Supportive Instruction

A key finding across all three classroom cases highlights a nuanced understanding of teachers' competence-supportive instruction (see Table C1 in Appendix C for a summary). While all three teachers employed instructional strategies aligned with the four theoretical dimensions of competence support, including clear expectations, guidance and support, feedback and, to a lesser extent, academic challenges (Linnenbrink-Garcia et al., 2016; Ryan & Deci, 2020), there were qualitative differences in the specific ways in which these strategies were enacted, which together result in notable differences in the nature of teachers' instruction. These distinctions were evident not only in the types of strategies used, but also in how they were framed and integrated into classroom discourse. Across cases, teachers varied to the extent to which their instructional approaches likely created classroom environments that supported the development of students' competence beliefs.

Of the four competence support dimensions, clear expectations was the most consistently enacted across classrooms. Prior research suggests that establishing clarity around expectations, classroom norms, and goals provide a clear pathway for students to understand how to engage effectively with tasks and navigate their classroom environment (Aelterman et al., 2019; Jang et al., 2010). In this study, all three teachers regularly communicated expectations and norms, but with different emphases. Mason framed expectations and norms through emphasizing collaborative effort by encouraging inclusive participation and mutual support. Stuart emphasized procedural clarity by modeling steps with visual demonstrations and verbal cues. Hannah consistently related expectations to scientific practices by situating tasks within broader learning goals. These variations suggest that while clear expectations are foundational to competence support, their impact may depend on how they are embedded within instruction and whether they are supported by additional strategies that enable students to meaningfully meet those communicated expectations.

The guidance and support dimension was also enacted with relative consistency, but teachers varied in its form and function. Consistent with existing research, instructional support that is responsive to students' emerging motivational needs, including autonomy, can promote students' competence beliefs (Aelterman et al., 2019; Chin, 2007). Stuart frequently drew on this dimension, particularly during lab investigations, by scaffolding through probing questions, revisiting prior lessons, and clarifying scientific concepts. Mason provided guidance and support that was more affective in nature, as evidenced by how he reassured students when students felt overwhelmed during tasks. Hannah, in contrast, often relied on prescriptive support by frequently relying on teacher-generated examples and explanations that provided scaffolding but may have constrained opportunities for students to actively contribute or extend their thinking. These variations suggest that guidance and support strategies serve both cognitive and affective functions, and their effectiveness may depend on the degree to which they are attuned to students' motivational needs.

Feedback dimension was evident across all classrooms but often centered more on confirming correctness than on supporting effort or incremental progress toward mastery. While encouraging affirmations were present, process-oriented and effort-based feedback that are supportive of students' competence beliefs was less frequently observed (Adams et al., 2020; Mandouit & Hattie, 2023). Mason's feedback was typically more affirming while acknowledging effort and providing suggestions for improvement. Hannah and Stuart, however, tended to emphasize correct answers that may have occasionally missed opportunities to use feedback as a strategy for extending students' understanding. In some instances, Stuart feedback, at times, shifted toward sarcasm or compliance-driven remarks, which may have undermined students' competence beliefs (Fong et al., 2018; Rubie-Davies et al., 2020). These findings point to the importance of the quality of feedback, not merely its presence, in shaping how students develop their competence beliefs (Brooks et al., 2019; Mandouit & Hattie, 2023).

Finally, academic challenge was the least observed dimension and was implemented inconsistently across classrooms. Theoretically, appropriately challenging tasks convey to students that they are capable of engaging in cognitively complex tasks, especially when paired with adequate support and guidance (Butz & Usher, 2015; Rogat & Linnenbrink-Garcia, 2011; Schmidt et al., 2015). Across cases, limited use of this dimension represents a potential missed opportunity to promote academic press, which reflect strategies teachers use to ensure that students engage deeply with content and persist through cognitive difficulty (Blumenfeld, 1992; Middleton & Midgley, 2002). While Mason and Hannah occasionally framed academic challenges as a meaningful part of learning, such as when Hannah encouraged students to collaborate in navigating challenges during a research project in Lesson 4, these moments were infrequent and not always paired with cognitive scaffolds needed to help students navigate the challenge. In Stuart's classroom, academic press was evident through high cognitive demands, such as the rapid-fire questioning in Lesson 5. However, these demands were not consistently framed as opportunities for growth and often lacked emotional support. Without such framing, students may have hindered students' ability to interpret challenges as a growth opportunity. Overall, the limited and inconsistent enactment of challenge across classrooms constrained the development of competence beliefs through effort and persistence, which are central to competence-supportive instruction.

Findings underscore that while all four competence-support dimensions were observed, their implementation varied both across and within classrooms. These patterns align with prior research showing that teachers' use of some instructional supports over others reflects their pedagogical priorities and instructional demands of their classrooms (Loughland, 2019). Importantly, the themes characterizing teachers' competence-supportive instruction, developed through careful observation of classroom videos, triangulate in meaningful ways with students' competence perceptions represented in the SSGs (Figure 4). For example, in Hannah's classroom, even when multiple competence support dimensions were enacted such as in Lesson 4, students' competence perceptions showed a modest increase compared to other lessons but overall remained relatively low to moderate across lessons. An important implication of this finding is the need to understand the nuances of how competence-supportive strategies are enacted and interpreted by students as these aspects of strategy use can meaningfully enhance students' motivational experiences. Consequently, PL opportunities should help teachers develop a deeper, more flexible understanding of how to adapt and enact these strategies responsively.

Supporting teachers in this way may be especially critical for promoting competence beliefs among diverse learners across varied instructional contexts.

Unpacking Dynamics of Teacher Competence Support and Students' Competence Beliefs

Beyond nuances in how teachers enacted competence-supportive strategies across dimensions, the qualitative classroom cases revealed that teachers' competence-supportive instruction and students' daily competence perceptions are situated within dynamic systems. Drawing on a DS perspective, classrooms function as systems that develop relatively stabilized interaction patterns, referred to in this study as *steady states*, which reflect recurring modes of motivational support and students' motivational experiences (Hollenstein, 2013; Parrisius et al., 2022). At times, deviations from these stabilized patterns, or *perturbations*, can shift the dynamics of teacher-student interactions and shape how teachers enact competence-supportive strategies and how students feel about their own competence (Perone & Simmering, 2017). The integration of classroom video observations and SSGs visualizations in this study provided insight into both steady states and perturbations in daily teacher-student interactions across lessons. Framing classroom cases through this lens highlights how stable patterns of competence-supportive instruction and momentary perturbations or inconsistencies in those patterns may coincide with changes in students' competence perceptions, which underscore the importance of teachers' responsiveness to students' daily motivational experiences.

One notable pattern across the classroom cases was the relatively consistent use of competence-supportive strategies across lessons, although the nature of this stability varied. Mason's instruction exemplified a well-balanced steady state characterized by recurring use of all four competence support dimensions. This stable instructional pattern also corresponded with relatively uniform student competence perceptions at moderate to high levels (Figure 4a, top panel). A brief perturbation was observed in Lesson 5 when a more controlling tone and emphasis on task completion to communicate expectations and deliver feedback coincided with a slight dip in average competence perceptions. However, individual student ratings generally remained consistently high across the unit (Figure 4a, bottom panel). Mason's consistent use of both relationally grounded and task-oriented strategies reflected an authoritative teaching style marked by a balance of relational support and high academic expectations (Sierens et al., 2009; Uibu & Kikas, 2014). In particular, his explicit emphasis of coping with challenge through effort and persistence along with his use of guidance and support strategies that offered emotional reassurance during moments of student distress or struggle, reflect his responsiveness to students' competence-related cues. This instructional approach may have contributed to a classroom climate of psychological safety and accountability that likely sustained students' competence perceptions and helped buffer against such momentary instructional shifts. Overall, these interactional patterns align with prior research on synergistic teacher-student interactions where consistent and responsive motivational support is linked to positive student outcomes (Gray et al., 2020; Turner & Christensen, 2020).

While Mason's classroom reflected a well-balanced and stable pattern of competence-supportive instruction, Stuart's classroom demonstrated a different type of steady state. His instructional patterns similarly involved consistent use of three competence support dimensions across lessons and employed a range of strategies within them, excluding academic challenge. This steady pattern aligned with moderate to high levels of average competence perceptions (Figure 4c, top panel) supported by his emphasis on procedural clarity and task-oriented strategies, which contributed to a predictable learning environment (Belland & Belland, 2017).

However, wider dispersion of individual competence ratings pointed to the possibility of divergent student experiences of feeling competent (Figure 4c, bottom panel).

This variability may partly relate to fluctuations in how Stuart enacted certain strategies, particularly within guidance and support and feedback dimensions. In Lesson 4, the absence of feedback coincided with a slight dip in average competence perceptions (Figure 4c, top panel), possibly signaling a perturbation. Feedback was reintroduced in Lesson 5, though delivery ranged from affirming to sarcastic and follow-up prompts were provided selectively. By Lesson 6, feedback became more consistently encouraging and informational such as highlighting specifics of what students have done well, which corresponded with a return to higher average competence perceptions. This progression in instruction suggests that refinements in feedback practices may reflect Stuart's responsive adjustments to students' competence-related cues. Overall, these patterns highlight that even when multiple competence support dimensions are consistently used, the stability of teacher-student interactions is likely shaped by how strategies are flexibly adapted across lessons in response to students' varied competence perceptions (Turner & Christensen, 2020).

In contrast to the more stable patterns observed in Mason's and Stuart's classrooms, Hannah's classroom demonstrated a more variable steady state marked by greater fluctuation in the breadth of competence-supportive strategies. While students' average competence perceptions remained moderately stable, the range of competence support dimensions varied across lessons (Figure 4b, top panel). Lesson 4 represented a potential perturbation as the inclusion of academic challenge alongside other competence dimensions coincided with a modest increase in average competence perceptions. It is also possible that this instructional shift was responsive to the lower average competence perceptions observed in prior lessons (Lessons

2 and 3). By introducing strategies related to academic challenge in Lesson 4, Hannah framed challenges as a productive struggle, which is consistent with prior research suggesting that academic challenge when paired with appropriate guidance and support may reinforce students' competence beliefs (Schmidt et al., 2015; Strati et al., 2016). However, this broader strategy-use was not sustained as subsequent lessons returned to narrower use of two or three dimensions which aligned with lower average competence perceptions. This pattern highlights the value of integrating a full range of motivational supports and attending to fluctuations in students' competence-related experiences (Linnenbrink-Garcia et al., 2016; Robinson et al., 2019).

Although Hannah consistently implemented strategies related to clear expectations, guidance and support, and feedback, her instruction was narrower in scope within these dimensions and often delivered through a teacher-directed approach that may have potentially limited opportunities for student autonomy. Research indicates that instructional guidance and feedback are more effective when supporting students' cognitive autonomy, such as encouraging reasoning, self-reflection, and personal sense-making, rather than directing toward predetermined answers (Furtak & Kunter, 2012; Orakci, 2021; Stefanou et al., 2004). These instructional tendencies were reflected in students' individual competence ratings, which clustered at the lower end of the scale and showed wider dispersion across lessons (Figure 4b, bottom panel). Hannah's case illustrates how constrained and inconsistent enactment of strategies may relate to more varied student experiences of feeling competent and necessitate competence-supportive strategies to be framed and delivered in ways that are responsive to students' motivational needs.

The qualitative classroom cases paired with SSGs illustrate how competence-supportive instruction and students' competence perception unfold within dynamic systems. Across classrooms, moments of perturbation, such as inconsistencies in strategy enactment or brief expansions in the range of competence support, did not always disrupt overall instructional patterns or global competence perceptions, but often coincided with day-to-day variation in individual students' competence perceptions. These patterns across classrooms suggest that the consistency and responsiveness with which strategies are enacted can shape how students feel about their own competence. By attending to subtle shifts in instruction and students' daily perceptions, teachers may be better positioned to support students' competence beliefs over time.

CHAPTER 5: INTEGRATED DISCUSSION

The present study employed a mixed methods approach to examine teachers' competence-supportive instruction (as defined by a theoretically integrated motivational framework) and changes in students' competence beliefs. Quantitative findings showed that students who perceived greater competence support from their teachers experienced significant gains in competence beliefs, independent of their initial levels of science interest, prior achievement, and baseline competence beliefs. Classrooms also systematically varied in their overall patterns of change, including some showing uniform modest increases, others uniform decreases, and some displaying substantial individual variation. These classroom-level patterns, identified through visualizations and statistical comparisons, informed the selection of three representative cases for qualitative strand. Each case illustrated how teachers enacted competence-supportive strategies alongside students' daily competence perceptions with embedded SSGs highlighting dynamics of teacher-student interactions across lessons. The case studies revealed both shared and distinctive features of teachers' competence-supportive instruction across classrooms. This chapter integrates insights across both strands to offer a more nuanced understanding of how competence-supportive instruction and students' competence perceptions mutually reinforce one another in shaping patterns of teacher-student interactions and changes in students' competence beliefs. The integrated discussion concludes with implications for both theory and practice along with limitations and future directions.

Teacher Competence Support in Practice: Insights from Student Perceptions and Observed Instruction

Findings from the quantitative and qualitative strands provided distinct but complementary insights into how teachers' competence-supportive instruction may shape students' competence beliefs. The quantitative strand revealed that students who reported that their teacher more consistently had clear expectations, offered useful suggestions when students struggled, and checked to see if they needed help were more likely to report significant gains in their competence beliefs over the course of an instructional unit (approximately 9 weeks). These associations remained statistically significant, even after accounting for individual student-related factors (e.g., initial science interest, prior achievement), underscoring the importance of students' perceptions of the learning environments in shaping motivational beliefs (Cheon et al., 2020; Robinson et al., 2022; Schenke et al., 2018). To understand how students' global subjective perceptions are situated in context (Eccles & Wigfield, 2020), the qualitative strand provided rich, nuanced descriptions of how competence-supportive strategies were enacted across three classrooms. Each case embedded classroom-level SSGs and students' aggregated survey responses to examine whether or how students' global perceptions of competence support aligned with or diverged from competence-supportive strategies observed by trained researchers. Drawing on multiple sources of data enabled triangulation of observed competence-supportive instruction and students' global perceptions of teacher competence support. Observations across multiple lessons also allowed for examining how patterns in teachers' strategy use, both in terms of consistency and breadth, may shape students' daily experiences of their own competence.

While all three teachers incorporated strategies theoretically aligned with competence-supportive instruction, they varied meaningfully in how strategies were framed, enacted, and sustained across lessons. These variations appeared to shape the degree of alignment between observed competence-supportive instruction and students' global perceptions of competence support. Mason's classroom exemplified strong convergence between multiple sources of competence-supportive instruction. His instruction consistently drew upon three or all competence support dimensions, including relational strategies (e.g., offering emotional reassurance), feedback affirming effort and progress, positive framing of academic challenges, and emphasis on collaborative norms (Figure 4a, top panel), which are consistent with well-established dimensions of competence support (Cheon et al., 2020; Haerens et al., 2015). His inclusion of challenge-related strategies (e.g., framing challenge through effort and persistence) stood in contrast to other teachers who were limited in drawing upon this dimension. Overall, the consistency and breadth of competence-supportive strategies observed in Mason's instruction aligned with students' high global perceptions of competence support (Table 6).

Hannah's and Stuart's classroom revealed more complex and partial patterns of alignment between observed instruction and students' global perceptions of competence support. A key finding from this study is that the degree of alignment varied by the observed breadth of instructional strategies teachers employed. Hannah consistently used strategies such as clarifying the purpose of tasks and providing structured guidance across lessons but also showed some fluctuation in the breadth of competence support used across dimensions (Figure 4b, top panel). For example, she drew on only the clear expectations and feedback dimensions in Lesson 3 whereas in Lesson 4, she incorporated all four dimensions by including the academic challenge dimension. Her strategy use within dimensions tended to be narrow with guidance and support largely delivered through teacher-led explanations and feedback focused on correctness. This combination of fluctuating breadth and narrower range of strategies within dimensions suggests a partial alignment between observed instruction and students' global perceptions of competence support, which fell within the moderate range, but were somewhat lower than those in Mason's and Stuart's classrooms (Table 6). Stuart's instruction, in contrast, reflected consistent use of three or all four competence support dimensions across lessons (Figure 4c, top panel), resembling Mason's approach on the surface. However, his strategy use within dimensions was also relatively narrow, focusing on offering task-oriented supports such as by prompting students to explain their thinking through probing questions. These strategies can strengthen students' competence beliefs by cultivating higher "conceptions of learning" in which students view science as a process of acquiring and applying knowledge rather than simply memorizing facts (Kleitman & Gibson, 2011). Nevertheless, his instruction also offered limited emotional reassurance and rarely incorporated challenge-related strategies that normalize struggle or explicitly encourage effort and persistence. Despite his consistent use of multiple dimensions of competence support, the absence of these additional forms of strategies likely limited how students experienced his instruction as competence-supportive, which suggests partial alignment with their moderate global perceptions.

Another key finding concerns the extent to which observed competence-supportive instruction aligned with students' daily competence perceptions as visualized through the classroom-level SSGs (Figure 4, top panel). Overall, Mason's students reported relatively high and stable daily competence perceptions (Figure 4a, top panel), which closely mapped onto the broad and consistently enacted competence support observed in his instruction. The overall convergence may point to a shared classroom experience in which students collectively felt their competence was well-supported (Turner & Christensen, 2020). By contrast, both Hannah's and Stuart's students reported moderate and relatively stable competence perceptions across lessons (Figures 4b and 4c, top panel) though the instructional patterns underlying these daily perceptions differed. Hannah's instruction fluctuated in breadth across competence support dimensions and relied on a narrower set of strategies within certain dimensions (e.g., guidance and support), suggesting that students may not have experienced her competence support as reliably competence-supportive, reflecting weaker alignment. Stuart's competence-supportive instruction fell in between Masons and Hannah's in terms of alignment. While his use of competence support dimensions was stable across lessons, his strategy use within dimensions was narrower, particularly in the limited emphasis on emotional reassurance and positive framing of challenge. This pattern may have corresponded to students' moderate but stable competence perceptions observed across lessons (Figure 4c, top panel), reflecting partial alignment between observed instruction students' daily competence perceptions. Overall, examining alignment between observed competence-supportive instruction and students' competence-related experiences revealed that consistency and breadth in teachers' strategy use were associated with students' global perceptions of teacher competence support and their daily competence perceptions.

The Role of Student-Related Factors in Shaping Variations in Competence Beliefs

The mixed method multiple case study approach provided converging evidence that students' individual characteristics contribute to variations in how students' competence beliefs unfold during instruction. In the quantitative strand, initial science interest and prior achievement emerged as significant predictors of change in competence beliefs, which highlight the broader relevance of students' unique preexisting motivational orientations and academic histories (Canning & Harackiewicz, 2015; Marsh et al., 2019; Ryan & Deci, 2020). These individual student characteristics may shape how receptive students are to teachers' motivational supports and help explain why students can experience the same classroom environment in divergent ways (Eccles & Wigfield, 2020; Robinson & Lee, 2025; Schenke et al., 2018). Complementary insights from the qualitative strand, which embedded individual-level SSGs into three representative classroom cases, further illuminated how individual students engaged with competence-supportive instruction across lessons. While this study did not directly examine individual differences in students' individual characteristics (e.g., science interest, prior achievement) within classrooms, classroom-level descriptive summaries offered a useful lens for interpreting how individual students may have experienced variations in their daily competence perceptions. Students in Mason's and Hannah's showed relatively higher initial science interest while those in Stuart's classroom reported the lowest among the three. The standard deviation of initial science interest was smallest in Hannah's classroom, suggesting that her students generally seemed to be in agreement, followed by Mason's, and greater variability observed in Stuart's classroom. In terms of prior achievement, all three classrooms had average scores below the state proficiency benchmark, but Stuart's students showed slightly higher levels of prior achievement compared to those in Mason's and Hannah's (see Table 6).

Looking across the cases from an integrated perspective reveals how students' daily competence perceptions may intersect with both student-related factors and teachers' competence-supportive strategies and offers a glimpse into how students may engage with instruction in context. While not definitive, the classroom cases suggest that when teachers employ competence-supportive strategies that align with students' existing motivational orientations and academic histories, students may be more likely to experience stable and positive daily competence perceptions. Mason's classroom illustrated this pattern of alignment. Students' high initial science interest and average prior achievement slightly below the proficiency benchmark may have amplified their receptiveness to Mason's relationally grounded strategies, including normalizing challenge, affirming effort and progress, and offering emotional reassurance. These consistent, relationally grounded strategies may have contributed to the stable and high competence perceptions observed among students and collectively and individually

(Figure 4a). In particular, high levels of interest have also been linked to students' willingness to engage with challenging tasks and persist through difficulty (Inoue, 2007; Tulis & Fulmer, 2013). When teachers frame challenges as meaningful and manageable, they may be more likely to interpret academic demands as manageable and motivating, rather than threatening. In Mason's classroom, relationally grounded strategies likely resonated with students' high initial science interest that helped cultivate a classroom environment where students felt capable and sustained effort and persistence over time, particularly among those who might disengage when facing academic demands (Ryan & Deci, 2017; Usher et al., 2023; Wigfield et al., 2015). Consistent with prior research, such environments appear especially important for supporting students' competence beliefs in challenging domains like science (Hellgren & Lindberg, 2017; Patall et al., 2018; Lin-Siegler et al., 2016).

Hannah's students shared similar student-related characteristics to those in Mason's classroom, including moderately high initial interest, but showed more varied and generally lower daily competence perceptions across lessons (Figure 4b, bottom panel). This contrast may reflect a misalignment between Hannah's instruction and students' individual characteristics. Her teacher-directed approach, which relied on teacher-provided examples and explanations, may have limited both cognitive autonomy and academic press, by offering few opportunities for students to extend their own thinking or connect learning to their personal interests or prior experiences (Ainley & Ainley, 2011; Furtak & Kunter, 2012; Middleton & Midgley, 2002; Patall et al., 2016). Stuart's students, who reported moderate initial science interest and slightly higher prior achievement, also exhibited greater individual variation in their daily competence perceptions (Figure 4c, bottom panel). His instruction reflected higher academic press by emphasizing conceptual rigor but was not consistently paired with strategies that framed challenge as productive struggle or accompanied by emotional support. The combination of strategies may have partially aligned with students' moderate levels of initial interest, potentially posing additional challenges for students to persist through his task-oriented instruction, especially during moments of struggle and uncertainty (Inoue, 2007; Tulis & Fulmer, 2013). This pattern suggests partial alignment between Stuart's instruction and students' individual characteristics, contributing to their varied daily experiences of feeling competent across lessons.

Beyond shaping students' competence-related experiences, students' individual characteristics alongside their daily competence perceptions may also factor into how teachers enact and adjust their competence-supportive strategies. Students' competence-related cues, such as signs of struggle, hesitation, withdrawal, or help-seeking, are shaped not only by their individual characteristics, but also by how they experience motivational support (Robinson et al., 2019). As teachers attend to these cues and respond by adjusting their strategies, recursive feedback loops emerge that reflect the co-constructed nature of teacher-student interactions (Turner & Christensen, 2020). Stuart's case illustrates potential instructional adjustments that may reflect this dynamic. Following a dip in average competence perceptions during Lesson 4, when feedback strategies were absent, he reintroduced feedback dimension in Lesson 5 (Figure 4c, top panel). His feedback during this lesson ranged from affirming to sarcastic tones and often emphasized correctness, which may be less effective for students experiencing self-doubt or uncertainty, potentially leaving some without the reassurance or scaffolding need to feel more competent (Fong et al., 2019; Patall et al., 2024; Usher et al., 2023). By Lesson 6, however, he showed signs of refinement including more encouraging and informational feedback that recognized effort, highlighted progress, and articulated what students had done well. This progression in Stuart's feedback practices, in part, may reflect an emerging awareness of students' responses to his instruction, particularly in a classroom marked by lower initial science interest and wider individual variation in students' daily competence perceptions. Feedback that emphasizes effort and improvement has been shown to support students' competence beliefs, particularly for those whose interest is still developing (Fong et al., 2019).

More subtle and potential patterns of instructional responsiveness were also observed in Mason's and Hannah's classroom, though in different forms. In Mason's case, while his strategy use appeared consistently across lessons, it also suggested attentiveness to students' competence-related cues. For instance, his use of challenge-related strategies in Lesson 4 was distinct in that it involved messaging that pressed more directly for student understanding paired with his typical relationally grounded supports. These instructional adjustments followed a prior lesson in which the academic challenge dimension was absent (Figure 4a, top panel) and may reflect an effort to re-engage students by introducing conceptual rigor. Mason's potential responsiveness in this moment may have been especially effective given students' high initial science interest, which when coupled with his relational approach, likely amplified how students engage with his instructional adjustment and may have helped maintain high competence perceptions across lessons. His case would also be consistent with the theorized importance of leveraging instructional supports synergistically to support multiple forms of motivation, including mastery goal orientation and belonging in addition to competence (Linnenbrink-Garcia et al., 2016; Marchand et al., 2021). Hannah's case also illustrates potential teacher responsiveness even within a more teacher-directed instructional approach. Following two lessons marked by lower average daily competence perceptions, Hannah expanded the breadth of competence-supportive strategies in Lesson 4 during which all competence support dimensions were evident (Figure 4b, top panel). Alongside offering more process-oriented feedback, she introduced the academic challenge dimension and included explicit, teacher-led guidance, both of which were not observed in Lesson 3. Yet, her subsequent lessons returned to her usual teacher-directed repertoire with the academic challenge dimension again absent. Given that her students began the unit with similarly high interest as Mason's, this brief instructional adjustment may also signal a moment of responsiveness to students' competence-related cues, such as the lower average daily competence perceptions observed in preceding lessons. Nonetheless, her teacher-directed approaches to competence support may reflect responsiveness in a more constrained form, particularly for students who may have benefited from opportunities to connect learning to their interests or make sense of content on their own terms (Cheon et al., 2020; Koka et al., 2021; Stefanou et al., 2004).

Together, these cases illustrate that teacher responsiveness to competence-supportive instruction can take varied forms and is shaped by students' competence-related cues, which are partly grounded in their individual characteristics and contribute to variations in daily competence perceptions (Eccles & Wigfield, 2020; Parrisius et al., 2022). These findings highlight the value of attending to how students' daily competence perceptions intersect with their individual characteristics and how teachers enact competence-supportive instruction within recurring classroom interactions.

Classroom Environments as Contexts for Change in Competence Beliefs

Competence-supportive instruction involves creating well-structured environments where students feel both capable and supported in meeting academic demands (Eccles & Wigfield, 2020; Ryan & Deci, 2017). Changes in competence beliefs unfold within these broader classroom environments shaped through ongoing interactions between teachers and students (Marchand & Hilpert, 2020; Kaplan & Patrick, 2016; Reymond et al., 2022). This dynamic interplay suggests that classroom-level patterns of change in competence beliefs are co-constructed as teachers' instructional supports and students' daily motivational experiences mutually reinforce one another to shape the overall instructional climate. Findings from this study provide support for this perspective. While quantitative analyses revealed distinct change patterns across classrooms including uniform increase, decreases, and substantial individual variation, qualitative classroom cases helped contextualize these change patterns by identifying how consistently teachers enacted and at times, adjusted, their competence-supportive strategies and how students engaged with these competence supports across the instructional unit.

The classroom environment fostered by Mason likely contributed to the uniform but "modest" increase in competence beliefs across his students. His consistent use of a range of competence-supportive strategies, including encouraging collaborative effort, reassuring students during moments of doubt and frustration, and providing effort-oriented feedback during academic challenges, appeared to contribute to a predictable and well-structured environment and positive instructional climate where students experienced reliable academic and social support (Bahena Olivares et al., 2024; Khuhro, 2024; Ryan & Deci, 2020; Stroet et al., 2013). Overall, Mason's instruction reflected a strength in leveraging multiple forms of motivation, particularly belonging and mastery goal orientation to promote students' competence beliefs. His relationally grounded competence support aligns with SCT, which highlights teachers' social support as a key source of social persuasion in shaping students' competence beliefs (i.e., self-efficacy; Bandura, 1997; Usher et al., 2023). At times, however, Mason deviated from his usual approach by providing feedback focused on task completion and employing more teacher-directed strategies that were limited in eliciting student thinking. These instances reflected a tension between his relational approaches to competence support and instructional control. Still, students' competence perceptions remained relatively high across lessons (Figure 4a, top panel), which suggests that the overall positive classroom climate helped mitigate the potential declines in students' competence beliefs (Haerens et al., 2015; Khuhro, 2024).

Hannah and Stuart also implemented a range of competence-supportive strategies, but in ways that revealed inconsistencies in strengthening students' competence beliefs over time. A pattern of declining competence beliefs emerged in Hannah's classroom, suggesting a classroom environment characterized by heavily teacher-directed and overly prescriptive guidance, may have limited opportunities to build a stronger sense of competence. Her reliance on teacher-generated explanations or examples and feedback focused on precision may have also hindered the development of other forms of motivation, particularly autonomy and mastery goal orientation, leading students to feel less ownership over their learning and to attribute success more to teacher validation than to their own capabilities (Ryan & Deci, 2020; Wang et al., 2020). In contrast to the uniform patterns observed in Mason's and Hannah's classrooms, Stuart's classroom was marked by substantial individual variation in students' competence beliefs across an instructional unit. His consistent use of competence-supportive strategies, especially around procedural clarity and structured guidance, helped maintain an orderly and predictable classroom environment. However, his instructional approach that emphasizes scientific understanding, precision, and completeness also presented a cognitively demanding environment that likely affirmed competence beliefs for some students, but others may have found it misaligned with their current level of understanding or pre-existing knowledge or experiences. Without sufficient individualized scaffolding adjusted to students' individual characteristics and motivational needs, these academic demands may have led to divergent experiences of feeling competent. Overall, these instructional patterns highlight that competence beliefs are shaped not only by teachers' instructional strategies, but also by how students respond to instruction in light of their prior motivational orientations and academic histories (Khuhro, 2024).

Overall, findings suggest that classroom-level patterns of change in competence beliefs unfold through a dynamic, co-constructed process. Day-to-day interactions among teachers' competence supportive strategies, teachers' competence-supportive strategies, individual student characteristics, and students' daily competence perceptions accumulate over time within the broader classroom environment. These ongoing exchanges gradually shape distinct classroom-level patterns of change in students' competence beliefs across classrooms (Eccles & Wigfield, 2020; Parrisius et al., 2022; Ryan & Deci, 2020). Understanding these patterns of change necessitates examining the dynamic, situated nature of classrooms where teachers and students continuously shape one another in mutually reinforcing ways.

Implications for Theory: Toward an Integrated Framework for Understanding Competence Beliefs

Findings from this study highlight the value of a theoretically integrated framework for advancing a more comprehensive understanding of competence-supportive instruction. Drawing from contemporary theories of motivation, including SEVT (Eccles & Wigfield, 2020), SDT (Ryan & Deci, 2017), and SCT (Schunk & DiBenedetto, 2020), this study offered a nuanced understanding of how varied instructional strategies can support students' competence beliefs and shape their experiences of competence in the classroom. This integrated perspective provided a more granular view for analyzing teacher practice and revealed complexities of competence-supportive instruction that may be overlooked when competence beliefs are conceptualized through a single theoretical lens. In doing so, this study contributes to theory integration around how competence beliefs develop across diverse instructional contexts.

The observed variation in how teachers enacted competence-supportive strategies also offers qualitative evidence in support of motivational design principles (MDPs) in science education (Harris et al., 2023; Marchand et al., 2022), which emphasize that high-quality instruction often involves addressing multiple forms of student motivation simultaneously. Across the three classroom cases, competence-supportive instruction frequently intersected with other motivational constructs such as belonging, autonomy, and mastery goal orientation. Mason's relationally grounded strategies that emphasized inclusion and mutual respect appeared to promote both competence and belonging while his strategies related to academic challenge and feedback further reinforced a mastery goal orientation by focusing on effort, progress, and improvement. In contrast, other classrooms revealed instances where efforts to support competence beliefs may have inadvertently constrained other motivational needs. Hannah's prescriptive scaffolding, while aimed at supporting understanding, may have limited students' cognitive autonomy by constraining opportunities for extended thinking. Similarly, Stuart's use of sarcasm in feedback may have undermined students' sense of belonging, which are crucial for promoting competence beliefs (Ruzek et al., 2016). These patterns suggest that changes in competence beliefs may be shaped by the extent to which other motivation dimensions are supported or undermined during instruction (Cheon et al., 2020; Patall et al., 2024).

By drawing upon a theoretically integrated framework and examining how multiple motivational constructs co-occur alongside competence beliefs in classrooms, this study advances theoretical understanding that conceptualizes motivation as a multidimensional and co-constructed process (Linnenbrink-Garcia et al., 2016; Martin, 2007). A theoretically integrated approach enables a more situated understanding of how changes in competence beliefs emerge through the dynamic interplay of students' daily classroom experiences and teachers' motivational supports. These daily teacher-student interactions accumulate to shape the broader classroom environment and global competence perceptions over time (Turner & Nolen, 2015). This perspective not only informs future research but also lays the groundwork for instructional design that is responsive to the complexity of students' competence beliefs.

Implications for Practice: Designing Instruction to Support Multiple Motivational Needs

By offering nuanced insights into how competence beliefs change in classrooms, this study suggests several implications for classroom instruction and professional learning. Findings illustrate that instructional strategies intended to support competence beliefs may function differently depending on how they are enacted. For example, communicating clear expectations or providing feedback appears more effective when they are relationally grounded and focus on effort, progress, and improvement, which supports not only competence but also other forms of motivation, such as belonging and mastery goal orientation. Conversely, strategies such as scaffolding delivered in ways that constrained autonomy appeared to be less supportive of competence beliefs as indicated by wider dispersion of individual competence ratings in Hannah's classroom (Figure 4b, bottom panel). These findings suggest that promoting competence beliefs depend not only on how instructional strategies are delivered, but also how they intersect with other forms of motivation. Professional learning opportunities can draw on these findings to help teachers recognize the complexity of competence-supportive instruction and adapt their instruction accordingly. This includes, but not limited to, promoting consistent use of strategies that affirm effort and growth, normalize challenge as part of earning, and promote collaborative learning that are also supportive of students' autonomy, belonging, and mastery goal orientation alongside competence beliefs (Butz & Usher, 2015; Rogat & Linnenbrink-Garcia, 2011).

Quantitative findings from this study identified student-related factors, such as prior achievement, initial science interest, and perceptions of teacher competence support, as significant predictors of change in competence beliefs over the course of the unit. These results suggest that students' responses to instruction including their experiences of feeling competent may be related to their academic histories, motivational orientations, and prior experiences (Eccles & Wigfield, 2020; Robinson et al., 2019). This points to the need for differentiated instructional approaches that attend to students' individual characteristics when supporting students' competence beliefs. Professional learning should help teachers to adapt competence-supportive strategies through implementing practices such as regular check-ins, flexible pacing, and adjustments in scaffolding (Cheon et al., 2020; Schwartz et al., 2021). Instructional tools such as video-based reflections can also support teachers in recognizing when strategies may be perceived differently across students to enable more responsive instruction to support students' competence beliefs (e.g., Kiemer et al., 2018).

Limitations and Future Directions

Although this mixed methods, multiple case study provides a nuanced account of how competence beliefs change across classrooms, it is not without limitations. First, the qualitative strand was limited to three classrooms observed across a single instructional unit which constrains the generalizability of the findings. While the classroom cases provided valuable insight into patterns of competence-supportive instruction, it may not fully capture how these processes unfold over longer timescales or across diverse instructional contexts. Relatedly, the short timeframe may have limited the ability to detect meaningful changes in students' competence beliefs. In some classrooms such as Mason's, the magnitude of change was relatively modest, which in part, may reflect a ceiling effect as students reported high competence beliefs at the start of the unit. Such cases may be more accurately described as demonstrating stable or modest increase. Still, qualitative differences suggest that even small gains in competence beliefs may reflect meaningful distinctions in who competence-supportive instruction is enacted and experienced. Future research should examine classroom-level change patterns across longer instructional periods and varied contexts to better understand how shifts in instruction and students' daily motivational perceptions correspond to classroom-level trends in competence beliefs.

Second, the small sample size of both students and teachers did not enable examining variation in competence beliefs at the individual- and classroom-levels. The narrowed focus of three classrooms constrained statistical power to investigate how students with different levels of prior achievement, interest, or initial perceptions of teacher competence support may have exhibited distinct patterns of change in their competence belief within and across classrooms. Future research can build on this work by using person-oriented approaches with a larger sample of classrooms to identify student subgroups with distinct motivational profiles and examine how these profiles may relate to changes in competence beliefs over time (Thompson-Lee et al., 2024; Vilppu et al., 2024). Similarly, the relatively small number of teachers (n = 17) further limited the ability to explore how other potential teacher-level characteristics, such as instructional goals, perceptions of supporting students' motivation and adapting instruction, or prior teaching experiences, may shape teachers' provision of competence support and students' competence perceptions (Hornstra et al., 2015). Given these constraints, the present study modeled teacher competence support at the student-level rather than as a teacher-related factor in the multilevel analysis. Consequently, future work could expand the number of teacher participants to enable a more robust examination of teacher-level factors that may influence change in students' competence beliefs across classrooms and strengthen findings by triangulating perceptions of teacher competence support with additional data sources, such as teacher interviews.

Third, several measurement limitations in the quantitative strand warrant consideration when interpreting the findings. Standardized math scores were used as an indicator for students' prior science achievement due to the lack of consistently available science-specific assessment data across districts and grade levels in which the present study was conducted. While math and science achievement are often correlated, this substitution may have limited the precision with which students' initial competence beliefs specific to science domain were represented. Additionally, the survey measure of perceived teacher competence support did not capture the academic challenge dimension emphasized in the qualitative coding. In result, key dimensions of competence-supportive instruction, particularly those related to explicit messaging about persisting through difficulty, may have been underrepresented in the quantitative analysis. A related limitation pertains to the absence of a true baseline measure of students' perceptions of teacher competence support prior to the instructional unit. Because these perceptions were only assessed after the instructional unit, pre-existing student perceptions of teacher competence support were not captured, which constrains understanding of how prior perceptions of teacher-provided support may explain changes in competence beliefs. To address these shortcomings, future research should incorporate domain-specific measures of prior achievements, ensure greater alignment between survey measures and observational frameworks to include dimensions such as academic challenge, and baseline measures of perceived teacher competence support.

Conclusion

This mixed-methods multiple case study approach examined how students' competence beliefs changed across an instructional unit and how these changes were shaped by the ongoing, situated interactions between teachers' competence-supportive strategies and students' daily competence perceptions across three classrooms. Integrating quantitative and qualitative strands was essential for capturing the broader, classroom-level patterns of change in competence beliefs while also revealing the nuances of how these patterns were shaped through daily teacher-student interactions. The findings suggest that distinct classroom-level trends were not simply a product of the presence of competence-supportive strategies but emerged through a mutually reinforcing process in which teachers' enactment of strategies and students' competence perceptions continually shaped one another within the broader classroom environment. Together, this underscores the need for competence-supportive instruction that is flexible and responsive to students' diverse characteristics, prior experiences, and day-to-day perceptions.

REFERENCES

Activate Learning. (2019). Introduction to chemistry 2: How can I make new stuff from old stuff? Chemical reactions and conservation of matter.

Aelterman, N., Vansteenkiste, M., Haerens, L., Soenens, B., Fontaine, J. R., & Reeve, J. (2019). Toward an integrative and fine-grained insight in motivating and demotivating teaching styles: The merits of a circumplex approach. *Journal of Educational Psychology*, *111*(3), 497-521.

Adams, A. M., Wilson, H., Money, J., Palmer-Conn, S., & Fearn, J. (2020). Student engagement with feedback and attainment: the role of academic self-efficacy. *Assessment & Evaluation in Higher Education*, *45*(2), 317-329.

Ahmad, A., & Safaria, T. (2013). Effects of self-efficacy on students' academic performance. *Journal of Educational, Health and Community Psychology, 2*(1), 22-29.

Ahn, H. S., Bong, M., & Kim, S. (2017). Social models in the cognitive appraisal of self-efficacy information. *Contemporary Educational Psychology, 48*, 149–166.

Ainley, M., & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology, 36*(1), 4-12.

Ainley, M., Corrigan, M., & Richardson, N. (2005). Students, tasks and emotions: Identifying the contribution of emotions to students' reading of popular culture and popular science texts. *Learning and Instruction, 15*(5), 433-447.

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of research in science teaching: The Official journal of the national association for research in science teaching*, *47*(5), 564-582.

Bahena Olivares, L. M., Rostampour, R., & Hadwin, A. F. (2024). Modelling the unique contributions of task understanding to academic challenges and performance. *Metacognition and Learning*, *19*(3), 1215-1236.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W H Freeman/Times Books/ Henry Holt & Co.

Baysal, Y. E., & Mutlu, F. (2021). The Effect of Professional Development Programs on Teachers' Self-Efficacy Beliefs in Science Teaching: A Meta-Analysis Study. *International Journal of Contemporary Educational Research, 8*(4), 1-15.

Belland, B. R., & Belland, B. R. (2017). Instructional scaffolding: Foundations and evolving definition. *Instructional Scaffolding in STEM Education: Strategies and efficacy* *evidence*, 17-53.

Belland, B. R., Kim, C., & Hannafin, M. J. (2013). A framework for designing scaffolds that improve motivation and cognition. *Educational Psychologist*, *48*(4), 243-270.

Belmont, M. J., Skinner, E., Wellborn, J., & Connell, J. (1988). *Teacher as social context: A measure of student perceptions of teacher provision of involvement, structure, and autonomy support* (Technical Report). University of Rochester.

Bingham, A. J. (2023). From data management to actionable findings: A five-phase process of qualitative data analysis. *International Journal of Qualitative Methods*, *22*, 16094069231183620.

Blumenfeld, P. C. (1992). Classroom learning and motivation: Clarifying and expanding goal theory. *Journal of Educational Psychology, 84*(3), 272-281.

Bong, M., & Skaalvik, E. M. (2003). Academic self-concept and self-efficacy: How different are they really?. *Educational Psychology Review*, *15*, 1-40.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Braun, V., & Clarke, V. (2021). Can I use TA? Should I use TA? Should I not use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Counselling and Psychotherapy Research*, *21*(1), 37-47.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching: The official journal of the national association for research in science teaching*, *43*(5), 485-499.

Brooks, C., Carroll, A., Gillies, R. M., & Hattie, J. (2019). A matrix of feedback for learning. *Australian Journal of Teacher Education (Online)*, *44*(4), 14-32.

Bru, E., Stornes, T., Munthe, E., & Thuen, E. (2010). Students' perceptions of teacher support across the transition from primary to secondary school. *Scandinavian Journal of Educational Research*, *54*(6), 519-533.

Burić, I., & Kim, L. E. (2020). Teacher self-efficacy, instructional quality, and student motivational beliefs: An analysis using multilevel structural equation modeling. *Learning and Instruction, 66*, 101302.

Butz, A. R., & Usher, E. L. (2015). Salient sources of early adolescents' self-efficacy in two domains. *Contemporary Educational Psychology*, *42*, 49-61.

Cakiroglu, J., Capa-Aydin, Y., & Hoy, A. W. (2011). Science teaching efficacy beliefs. In *Second international handbook of science education* (pp. 449-461). Springer.

Cann, R. F., Sinnema, C., Daly, A. J., Rodway, J., & Liou, Y. H. (2022). The power of school conditions: Individual, relational, and organizational influences on educator wellbeing. *Frontiers in Psychology*, *13*, 775614.

Canning, E. A., & Harackiewicz, J. M. (2015). Teach it, don't preach it: The differential effects of directly-communicated and self-generated utility–value information. *Motivation Science*, *1*(1), 47-71.

Caprara, G. V., Vecchione, M., Alessandri, G., Gerbino, M., & Barbaranelli, C. (2011). The contribution of personality traits and self-efficacy beliefs to academic achievement: A longitudinal study. *British Journal of Educational Psychology, 81*(1), 78-96.

Carden, F. (2009). Using comparative data: A systems approach to a multiple case study. *The SAGE handbook of case-based methods*, 331-344.

Cheon, S. H., Reeve, J., Marsh, H. W., & Song, Y. G. (2022). Intervention-enabled autonomy-supportive teaching improves the PE classroom climate to reduce antisocial behavior. *Psychology of Sport and Exercise, 60*, 102174.

Cheon, S. H., Reeve, J., & Song, Y. G. (2019). Recommending goals and supporting needs: An intervention to help physical education teachers communicate their expectations while supporting students' psychological needs. *Psychology of Sport and Exercise*, *41*, 107-118.

Cheon, S. H., Reeve, J., & Vansteenkiste, M. (2020). When teachers learn how to provide classroom structure in an autonomy-supportive way: Benefits to teachers and their students. *Teaching and Teacher Education*, *90*, 103004.

Chen, J. A., & Usher, E. L. (2013). Profiles of the sources of science self-efficacy. *Learning and Individual Differences, 24*, 11-21.

Chi, S., Wang, Z., & Liu, X. (2021). Moderating effects of teacher feedback on the associations among inquiry-based science practices and students' science-related attitudes and beliefs. *International Journal of Science Education*, *43*(14), 2426-2456.

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *44*(6), 815-843.

Christensen, A. A., Nielbo, K. L., & Gümüş, S. (2024). Exploring school factors related to professional learning communities: a machine learning approach using cross-national data. *Educational Studies*, 1-21.

Cohen, M. P. (1998). Determining sample sizes for surveys with data analyzed by hierarchical linear models. *Journal of Official Statistics*, *14*(3), 267-275.

Conley, A. M. (2012). Patterns of motivation beliefs: Combining achievement goal and expectancy-value perspectives. *Journal of Educational Psychology*, *104*(1), 32-47.

Cook, D. A., & Artino Jr, A. R. (2016). Motivation to learn: an overview of contemporary theories. *Medical Education, 50*(10), 997-1014.

Constantinou, C. P., Tsivitanidou, O. E., & Rybska, E. (2018). *What is inquiry-based science teaching and learning?* (pp. 1-23). Springer International Publishing.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and Conducting Mixed Methods Research* (3rd ed.). Sage Publications.

Csikszentmihályi, M. (1990). The domain of creativity. In M. A. Runco & R. S. Albert (Eds.), *Theories of Creativity* (pp. 190–212). Sage Publications.

DeCastro-Ambrosetti, D., & Cho, G. (2011). A Look at" Lookism": A Critical Analysis of Teachers' Expectations Based on Students Appearance. *Multicultural Education*, *18*(2), 51-54.

Deci, E. L., & Ryan, R. M. (2002). Self-determination research: Reflections and future directions. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 431-441). University of Rochester Press.

Dellinger, A. B., Bobbett, J. J., Olivier, D. F., & Ellett, C. D. (2008). Measuring teachers' self-efficacy beliefs: Development and use of the TEBS-Self. *Teaching and Teacher Education*, *24*(3), 751-766.

Deneroff, V. (2016). Professional development in person: Identity and the construction of teaching within a high school science department. *Cultural Studies of Science Education, 11*, 213-233.

Depaepe, F., & König, J. (2018). General pedagogical knowledge, self-efficacy and instructional practice: Disentangling their relationship in pre-service teacher education. *Teaching and Teacher Education*, *69*, 177-190.

Dietrich, J., Viljaranta, J., Moeller, J., & Kracke, B. (2017). Situational expectancies and task values: Associations with students' effort. *Learning and Instruction, 47*, 53-64.

Doğan, S., & Yurtseven, N. (2018). Professional learning as a predictor for instructional quality: a secondary analysis of TALIS. *School Effectiveness and School Improvement*, *29*(1), 64-90.

Durik, A. M., & Harackiewicz, J. M. (2007). Different strokes for different folks: How individual interest moderates the effects of situational factors on task interest. *Journal of Educational Psychology, 99*(3), 597-610.

Durik, A. M., Hulleman, C. S., & Harackiewicz, J. M. (2015). One size fits some: Instructional enhancements to promote interest. *Interest in Mathematics and Science Learning*, 49-62.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., Midgley, C. (1983). Expectancies, values, and academic behaviors. In Spence, J. T. (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75–146). Freeman.

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*, *61*, 101859.

Engels, M. C., Spilt, J., Denies, K., & Verschueren, K. (2021). The role of affective teacher-student relationships in adolescents' school engagement and achievement trajectories. *Learning and Instruction, 75*, 101485.

Fong, C. J., Patall, E. A., Vasquez, A. C., & Stautberg, S. (2019). A meta-analysis of negative feedback on intrinsic motivation. *Educational Psychology Review*, *31*, 121-162.

Fong, C. J., Schallert, D. L., Williams, K. M., Williamson, Z. H., Warner, J. R., Lin, S., & Kim, Y. W. (2018). When feedback signals failure but offers hope for improvement: A process model of constructive criticism. *Thinking Skills and Creativity*, *30*, 42-53.

Franks, A. D., & Capraro, M. M. (2019). Motivated for STEM: Developing an Understanding of Highly Motivated Students' Self-Concept in STEM Education. *Science Educator*, *27*(1), 60-69.

Fred, H., Meeuwen Pierre, V., Ellen, R., & Marjan, V. (2020). How to enhance teachers' professional learning by stimulating the development of professional learning communities: operationalizing a comprehensive PLC concept for assessing its development in everyday educational practice. *Professional Development in Education*, *46*(5), 751-769.

Freiberger, V., Steinmayr, R., & Spinath, B. (2012). Competence beliefs and perceived ability evaluations: How do they contribute to intrinsic motivation and achievement?. *Learning and Individual Differences*, *22*(4), 518-522.

Furtak, E. M., & Kunter, M. (2012). Effects of autonomy-supportive teaching on student learning and motivation. *The Journal of Experimental Education*, *80*(3), 284-316.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. *Review of Educational Research, 82*(3), 300-329.

Geijsel, F. P., Sleegers, P. J., Stoel, R. D., & Krüger, M. L. (2009). The effect of teacher psychological and school organizational and leadership factors on teachers' professional learning in Dutch schools. *The Elementary School Journal*, *109*(4), 406-427.

Ghafarpour, H., & Moinzadeh, A. (2020). A dynamic systems analysis of classrooms: teacher experience and student motivation. *Learning Environments Research*, *23*, 101-116.

Gore, J., & Rosser, B. (2022). Beyond content-focused professional development: powerful professional learning through genuine learning communities across grades and subjects. *Professional Development in Education, 48*(2), 218-232.

Gray, D. L., McElveen, T. L., Green, B. P., & Bryant, L. H. (2020). Engaging Black and Latinx students through communal learning opportunities: A relevance intervention for middle schoolers in STEM elective classrooms. *Contemporary Educational Psychology, 60*, 101833.

Green, J., Martin, A. J., & Marsh, H. W. (2007). Motivation and engagement in English, mathematics and science high school subjects: Towards an understanding of multidimensional domain specificity. *Learning and Individual Differences*, *17*(3), 269-279.

Grigg, J., Kelly, K. A., Gamoran, A., & Borman, G. D. (2013). Effects of two scientific inquiry professional development interventions on teaching practice. *Educational Evaluation and Policy Analysis, 35*(1), 38-56.

Guay, F., Marsh, H., & Boivin, M. (2003). Academic Self-Concept and Academic Achievement: Developmental Perspectives on Their Causal Ordering. *Journal of Educational Psychology, 95*, 124-136.

Guay, F., Roy, A., & Valois, P. (2017). Teacher structure as a predictor of students' perceived competence and autonomous motivation: The moderating role of differentiated instruction. *British Journal of Educational Psychology, 87*(2), 224-240.

Haerens, L., Aelterman, N., Vansteenkiste, M., Soenens, B., & Van Petegem, S. (2015). Do perceived autonomy-supportive and controlling teaching relate to physical education students' motivational experiences through unique pathways? Distinguishing between the bright and dark side of motivation. *Psychology of Sport and Exercise, 16*, 26-36.

Han, J., Perron, B. E., Yin, H., & Liu, Y. (2021). Faculty stressors and their relations to teacher efficacy, engagement and teaching satisfaction. *Higher Education Research & Development*, *40*(2), 247-262.

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences, 3*(2), 220-227.

Harris, C. J., Schmidt, J. A., Linnenbrink-Garcia, L., Marchand, G. C., Cabrera, L., McKinney, D., & Liu, P. P. (2023). Equipping Science Teachers to Support Student Motivation in NGSS Classrooms: Insights from the Development of the M-PLANS Program. *WestEd*.

Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Sage Publications.

Hellgren, J. M., & Lindberg, S. (2017). Motivating students with authentic science experiences: changes in motivation for school science. *Research in Science & Technological Education*, *35*(4), 409-426.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111-127.

Higgins, T. E., & Spitulnik, M. W. (2008). Supporting teachers' use of technology in science instruction through professional development: A literature review. *Journal of Science Education and Technology*, *17*, 511-521.

Hilpert, J. C., & Marchand, G. C. (2018). Complex systems research in educational psychology: Aligning theory and method. *Educational Psychologist, 53*(3), 185-202.

Hollenstein, T. (2013). *State space grids: Depicting dynamics across development*. Springer Science + Business Media.

Hornstra, L., Mansfield, C., Van der Veen, I., Peetsma, T., & Volman, M. (2015). Motivational teacher strategies: the role of beliefs and contextual factors. *Learning Environments Research*, *18*, 363-392.

Hornstra, L., Stroet, K., van Eijden, E., Goudsblom, J., & Roskamp, C. (2018). Teacher expectation effects on need-supportive teaching, student motivation, and engagement: A self-determination perspective. *Educational Research and Evaluation*, *24*(3-5), 324-345.

Hornstra, L., Stroet, K., & Weijers, D. (2021). Profiles of teachers' need-support: How do autonomy support, structure, and involvement cohere and predict motivation and learning outcomes?. *Teaching and Teacher Education*, *99*, 103257.

Hornstra, L., van der Veen, I., & Peetsma, T. (2016). Domain-specificity of motivation: A longitudinal study in upper primary school. *Learning and Individual Differences*, *51*, 167-178.

Hox, J. J., Moerbeek, M., Moerbeek, M., & Schoot, R. V. D. (2018). *Multilevel Analysis: Quantitative Methodology Series.*

Hwang, S., & Roth, W. M. (2011). The (embodied) performance of physics concepts in lectures. *Research in Science Education, 41*, 461-477.

Inoue, N. (2007). Why face a challenge?: The reason behind intrinsically motivated students' spontaneous choice of challenging tasks. *Learning and Individual Differences*, *17*(3), 251-259.

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *Journal of Educational Psychology, 102*(3), 588-600.

Jansen, M., Scherer, R., & Schroeders, U. (2015). Students' self-concept and self-efficacy in the sciences: Differential relations to antecedents and educational outcomes. *Contemporary Educational Psychology*, *41*, 13-24.

Kaplan, A., Garner, J. K., & Brock, B. (2019). Identity and motivation in a changing world: A complex dynamic systems perspective. In *Motivation in education at a time of global change* (Vol. 20, pp. 101-127). Emerald Publishing Limited.

Kaplan, A., & Patrick, H. (2016). Learning environments and motivation. In *Handbook of motivation at school* (pp. 251-274). Routledge.

Khuhro, N. (2024). Study of Classroom Climate, Student Engagement, Self-Efficacy and Learning Experiences: An Analyses Employing Social Cognitive Theory. *Academy of Education and Social Sciences Review, 4*(1), 118-126.

Klassen, R. M., & Usher, E. L. (2010). Self-efficacy in educational settings: Recent research and emerging directions. *The decade ahead: Theoretical perspectives on motivation and achievement, 16*, 1-33.

Kleickmann, T., Tröbst, S., Jonen, A., Vehmeyer, J., & Möller, K. (2016). The effects of expert scaffolding in elementary science professional development on teachers' beliefs and motivations, instructional practices, and student achievement. *Journal of Educational Psychology*, *108*(1), 21-42.

Kleitman, S., & Gibson, J. (2011). Metacognitive beliefs, self-confidence and primary learning environment of sixth grade students. *Learning and Individual Differences*, *21*(6), 728-735.

Koka, A., Tilga, H., Hein, V., Kalajas-Tilga, H., & Raudsepp, L. (2021). A multidimensional approach to perceived teachers' autonomy support and its relationship with intrinsic motivation of students in physical education. *International Journal of Sport Psychology*, *52*(3), 266-286.

Kosovich, J. J., Flake, J. K., & Hulleman, C. S. (2017). Short-term motivation trajectories: A parallel process model of expectancy-value. *Contemporary Educational Psychology*, *49*, 130-139.

Krajcik, J., Codere, S., Dahsah, C., Bayer, R., & Mun, K. (2014). Planning instruction to meet the intent of the Next Generation Science Standards. *Journal of Science Teacher*

Education, *25*(2), 157-175.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education, 33*(1), 27-50.

Lai, C. S. (2018). Using Inquiry-Based Strategies for Enhancing Students' STEM Education Learning. *Journal of Education in Science, Environment and Health*, *4*(1), 110-117.

Lakens, D. (2022). Sample size justification*. Collabra: psychology, 8*(1), 33267.

Lakshmanan, A., Heath, B. P., Perlmutter, A., & Elder, M. (2011). The impact of science content and professional learning communities on science teaching efficacy and standards-based instruction. *Journal of Research in Science Teaching*, *48*(5), 534-551.

Lauermann, F., & Berger, J. L. (2021). Linking teacher self-efficacy and responsibility with teachers' self-reported and student-reported motivating styles and student engagement. *Learning and Instruction, 76*, 101441.

Lauermann, F., & Karabenick, S. A. (2013). The meaning and measure of teachers' sense of responsibility for educational outcomes. *Teaching and Teacher Education*, *30*, 13-26.

Lauermann, F., Tsai, Y. M., & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.'s expectancy–value theory of achievement-related behaviors. *Developmental Psychology*, *53*(8), 1540-1559.

Lazarides, R., & Watt, H. M. (2015). Girls' and boys' perceived mathematics teacher beliefs, classroom learning environments and mathematical career intentions. Contemporary Educational Psychology, 41, 51-61.

Linnenbrink, E. A., & Pintrich, P. R. (2003). The role of self-efficacy beliefs in student engagement and learning in the classroom. *Reading and Writing Quarterly*, *19*(2), 119-137.

Linnenbrink-Garcia, L., Patall, E. A., & Pekrun, R. (2016). Adaptive motivation and emotion in education: Research and principles for instructional design. *Policy Insights from the Behavioral and Brain Sciences, 3*(2), 228-236.

Lin-Siegler, X., Ahn, J. N., Chen, J., Fang, F. F. A., & Luna-Lucero, M. (2016). Even Einstein struggled: Effects of learning about great scientists' struggles on high school students' motivation to learn science. *Journal of Educational Psychology*, *108*(3), 314-328.

Loughland, T. (2019). *Teacher adaptive practices: Extending teacher adaptability into classroom practice*. Springer.

Lotter, C., Harwood, W. S., & Bonner, J. J. (2007). The influence of core teaching conceptions on teachers' use of inquiry teaching practices. *Journal of Research in Science Teaching, 44*(9), 1318-1347.

Lüdtke, O., Robitzsch, A., Trautwein, U., & Kunter, M. (2009). Assessing the impact of learning environments: How to use student ratings of classroom or school characteristics in multilevel modeling. *Contemporary Educational Psychology*, *34*(2), 120-131.

Mainhard, M. T., Brekelmans, M., & Wubbels, T. (2011). Coercive and supportive teacher behaviour: Within-and across-lesson associations with the classroom social climate. *Learning and Instruction*, *21*(3), 345-354.

Malmberg, L. E., Walls, T. A., Martin, A. J., Little, T. D., & Lim, W. H. (2013). Primary school students' learning experiences of, and self-beliefs about competence, effort, and difficulty: Random effects models. *Learning and Individual Differences*, *28*, 54-65.

Mandouit, L., & Hattie, J. (2023). Revisiting "The Power of Feedback" from the perspective of the learner. *Learning and Instruction*, *84*, 101718.

Mansour, N., EL-Deghaidy, H., Alshamrani, S., & Aldahmash, A. (2014). Rethinking the theory and practice of continuing professional development: Science teachers' perspectives. *Research in Science Education, 44*, 949-973.

Marchand, G. C., & Hilpert, J. C. (2020). Complex systems approaches to educational research: Introduction to the special issue. *The Journal of Experimental Education, 88*(3), 351-357.

Marchand, G. C., Schmidt, J. A., Linnenbrink-Garcia, L., Harris, C. J., McKinney, D., & Liu, P. (2021). Lessons from a co-design team on supporting student motivation in middle school science classrooms. *Theory Into Practice, 61*(1), 113-128.

Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology, 81*(1), 59-77.

Marsh, H. W., Martin, A. J., Yeung, A. S., & Craven, R. G. (2017). Competence self-perceptions. In A. J. Elliot, C. S. Dweck, & D. S. Yeager (Eds.), *The Handbook of competence and Motivation: Theory and application* (p. 85–115). The Guilford Press.

Martin, A. J. (2007). Examining a multidimensional model of student motivation and engagement using a construct validation approach. *British Journal of Educational Psychology*, *77*(2), 413-440.

Martin, A.J., & Lazendic, G. (2018). Achievement in large-scale national numeracy assessment: An ecological study of motivation and student, home, and school predictors. *Journal of Educational Psychology. 10*(4), 465–482.

Meece, J. L., & Scantlebury, K. (2006). Science achievement and motivation: A longitudinal study of the links between achievement in science and math. *Educational Psychologist, 41*(3), 170–185.

Menninga, A., Van Geert, P., Van Vondel, S., Steenbeek, H., & Van Dijk, M. (2021). Teacher-student interaction patterns change during an early science teaching intervention. *Research in Science Education*, 1-27.

Middleton, M. J., & Midgley, C. (2002). Beyond motivation: Middle school students' perceptions of press for understanding in math. *Contemporary Educational Psychology*, *27*(3), 373-391.

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Change in teacher efficacy and student self- and task-related beliefs in mathematics during the transition to junior high school. *Journal of Educational Psychology, 81*(2), 247-258.

Midgley, C., Maehr, M. L., Hruda, L. Z., Anderman, E., Anderman, L., Freeman, K. E., & Urdan, T. (2000). Manual for the patterns of adaptive learning scales. *Ann Arbor: University of Michigan*.

Miles, M. B., Huberman, A. M., & Saldana, J. (2019). *Qualitative data analysis: A methods sourcebook* (4th edition). SAGE Publications, Inc.

Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher*, *45*(1), 18-35.

Morgan, M. V., & Gerber, M. M. (2016). Utilizing factor analysis to inform the development of institutionally contrived experiences to increase STEM engagement. *Community College Journal of Research and Practice, 40*(3), 204-218.

Morgan, S. J., Pullon, S. R. H., Macdonald, L. M., McKinlay, E. M., & Gray, B. V. (2017). Case study observational research: A framework for conducting case study research where observation data are the focus. *Qualitative Health Research, 27*, 1060–1068.

Moro, L., Mortimer, E. F., & Tiberghien, A. (2020). The use of social semiotic multimodality and joint action theory to describe teaching practices: Two cases studies with experienced teachers. *Classroom Discourse, 11*(3), 229-251.

Mouratidis, A., Vansteenkiste, M., Michou, A., & Lens, W. (2013). Perceived structure and achievement goals as predictors of students' self-regulated learning and affect and the mediating role of competence need satisfaction. *Learning and Individual Differences, 23*, 179-186.

Mouza, C. (2009). Does research-based professional development make a difference? A longitudinal investigation of teacher learning in technology integration. *Teachers College Record*, *111*(5), 1195-1241.

Muenks, K., & Miele, D. B. (2017). Students' thinking about effort and ability: The role of developmental, contextual, and individual difference factors. *Review of Educational Research*, *87*(4), 707-735.

Muenks, K., Wigfield, A., & Eccles, J. S. (2018). I can do this! The development and calibration of children's expectations for success and competence beliefs. *Developmental Review*, *48*, 24-39.

Musu-Gillette, L. E., Wigfield, A., Harring, J. R., & Eccles, J. S. (2015). Trajectories of change in students' self-concepts of ability and values in math and college major choice. *Educational Research and Evaluation*, *21*(4), 343-370.

Muthén, L. K., & Muthén, B. O. (2011). Mplus User's Guide. Sixth Edition. Los Angeles, CA: Muthén & Muthén.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press. https://doi.org/10.17226/13165

Näykki, P., Isohätälä, J., & Järvelä, S. (2021). "You really brought all your feelings out"– Scaffolding students to identify the socio-emotional and socio-cognitive challenges in collaborative learning. *Learning, Culture and Social Interaction*, *30*, 100536.

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. The National Academies Press. https://doi.org/10.17226/18290

Nichols, K., Burgh, G., & Kennedy, C. (2017). Comparing two inquiry professional development interventions in science on primary students' questioning and other inquiry behaviours. *Research in Science Education, 47*, 1-24.

Nolen, S. B. (2024). Taking a situative approach to research in educational psychology. In P. A. Schutz & K. R. Muis (Eds.), *Handbook of Educational Psychology* (4th ed., pp. 119–138). Routledge.

Northwest Evaluation Association (2022). *MAP Growth Math Fact Sheet* [Fact sheet]. https:/https://www.nwea.org/resource-center/fact-sheet/48377/map-growth-math-assessment-fact-sheet.pdf/

Odden, T. O. B., & Russ, R. S. (2019). Defining sensemaking: Bringing clarity to a fragmented theoretical construct. *Science Education, 103*(1), 187-205.

Opdenakker, M. C. (2021). Need-supportive and need-thwarting teacher behavior: Their importance to boys' and girls' academic engagement and procrastination behavior. *Frontiers in Psychology, 12*, 628064.

Orakcı, Ş. (2021). Teachers' reflection and level of reflective thinking on the different dimensions of their teaching practice. *International Journal of Modern Education Studies*, *5*(1), 118-139.

Palmer, D., Dixon, J., & Archer, J. (2015). Changes in science teaching self-efficacy among primary teacher education students. *Australian Journal of Teacher Education (Online), 40*(12), 27-40.

Parrisius, C., Gaspard, H., Zitzmann, S., Trautwein, U., & Nagengast, B. (2022). The "situative nature" of competence and value beliefs and the predictive power of autonomy support: A multilevel investigation of repeated observations. *Journal of Educational Psychology, 114*(4), 791-814.

Patall, E. A., Hooper, S., Vasquez, A. C., Pituch, K. A., & Steingut, R. R. (2018). Science class is too hard: Perceived difficulty, disengagement, and the role of teacher autonomy support from a daily diary perspective. *Learning and Instruction*, *58*, 220-231.

Patall, E. A., Pituch, K. A., Steingut, R. R., Vasquez, A. C., Yates, N., & Kennedy, A. A. (2019). Agency and high school science students' motivation, engagement, and classroom support experiences. *Journal of Applied Developmental Psychology*, *62*, 77-92.

Patall, E. A., Vasquez, A. C., Steingut, R. R., Trimble, S. S., & Pituch, K. A. (2016). Daily interest, engagement, and autonomy support in the high school science classroom. *Contemporary Educational Psychology, 46*, 180-194.

Patall, E. A., Yates, N., Lee, J., Chen, M., Bhat, B. H., Lee, K., ... & Hanson, D. J. (2024). A meta-analysis of teachers' provision of structure in the classroom and students' academic competence beliefs, engagement, and achievement. *Educational Psychologist*, *59*(1), 42-70.

Patrick, H., Ryan, A. M., & Kaplan, A. (2007). Early adolescents' perceptions of the classroom social environment, motivational beliefs, and engagement. *Journal of Educational Psychology, 99*(1), 83-98.

Pennings, H.J.M., & Hollenstein, T. (2020) Teacher-Student Interactions and Teacher Interpersonal Styles: A State Space Grid Analysis, *The Journal of Experimental Education, 88* (3), 382-406.

Pennings, H. J., & Mainhard, T. (2016). Analyzing teacher–student interactions with state space grids. *Complex dynamical systems in education: Concepts, methods and applications*, 233-271.

Perez, T., Wormington, S. V., Barger, M. M., Schwartz-Bloom, R. D., Lee, Y. K., & Linnenbrink-Garcia, L. (2019). Science expectancy, value, and cost profiles and their proximal and distal relations to undergraduate science, technology, engineering, and math persistence. *Science Education, 103*(2), 264-286.

Perone, S., & Simmering, V. R. (2017). Applications of dynamic systems theory to cognition and development: New frontiers. *Advances in Child Development and Behavior*, *52*, 43-80.

Putwain, D., Sander, P., & Larkin, D. (2013). Academic self-efficacy in study-related skills and behaviours: Relations with learning-related emotions and academic success. *British Journal of Educational Psychology*, *83*(4), 633-650.

Rathgen, E. (2006). In the voice of teachers: The promise and challenge of participating in classroom-based research for teachers' professional learning. *Teaching and Teacher Education, 22*(5), 580-591.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods.* Sage Publications.

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, *104*(3), 700-712.

Reymond, N. C., Nahrgang, R. G., Großmann, N., Wilde, M., & Fries, S. (2022). Why students feel competent in the classroom: A qualitative content analysis of students' views. *Frontiers in Psychology, 13*, 928801.

Rittmayer, M.A. & Beier, M.E. (2009). Self-Efficacy in STEM. In B. Bogue & E. Cady (Eds.). *Applying Research to Practice (ARP) Resources*. Retrieved <Mar 3,2017> from http://www.engr.psu.edu/AWE/ARPresources.aspx

Rihoux, B., & Lobe, B. (2009). The case for qualitative comparative analysis (QCA): Adding leverage for thick cross-case comparison. *The Sage Handbook of Case-Based Methods*, 222-242.

Robertson, D. A., Padesky, L. B., & Brock, C. H. (2020). Cultivating student agency through teachers' professional learning. *Theory Into Practice*, *59*(2), 192-201.

Robinson, K. A., & Lee, S. Y. (2025). Same classroom, different affordances? Demographic differences in perceptions of motivational climate in five STEM courses. *The Journal of Experimental Education*, *93*(1), 110-135.

Robinson, K. A., Lee, S. Y., Friedman, S., Christiaans, E., McKeague, M., Pavelka, L., & Sirjoosingh, P. (2022). "You know what, I can do this": Heterogeneous joint trajectories of expectancy for success and attainment value in chemistry. *Contemporary Educational Psychology*, *69*, 102055.

Robinson, K. A., Lee, Y.K., Bovee, E. A., Perez, T., Walton, S. P., Briedis, D., &

Linnenbrink-Garcia, L. (2019). Motivation in transition: Development and roles of expectancy, task values, and costs in early college engineering. *Journal of Educational Psychology, 111*(6), 1081–1102.

Rogat, T. K., & Linnenbrink-Garcia, L. (2011). Socially shared regulation in collaborative groups: An analysis of the interplay between quality of social regulation and group processes. *Cognition and Instruction*, *29*(4), 375-415.

Roof, H., & Chimuma, L. (2022). The Relationship among Reading, Math and Science Achievement: Exploring the Growth Trajectories over Three Time Points. *Educational Research: Theory and Practice, 33*(2), 32-49.

Rubie-Davies, C. M. (2006). Teacher expectations and student self-perceptions: Exploring relationships. *Psychology in the Schools, 43*(5), 537-552.

Rubie-Davies, C. M. (2010). Teacher expectations and perceptions of student attributes: Is there a relationship?. *British Journal of Educational Psychology, 80*(1), 121-135.

Rubie-Davies, C., Meissel, K., Alansari, M., Watson, P., Flint, A., & McDonald, L. (2020). Achievement and beliefs outcomes of students with high and low expectation teachers. *Social Psychology of Education*, *23*(5), 1173-1201.

Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y., & Pianta, R. C. (2016). How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence. *Learning and Instruction*, *42*, 95-103.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, *61*, 101860.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications.

Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in adolescents' motivation and engagement during middle school. *American Educational Research Journal, 38*(2), 437-460.

Sadler, P. M., Sonnert, G., Coyle, H. P., Cook-Smith, N., & Miller, J. L. (2013). The influence of teachers' knowledge on student learning in middle school physical science classrooms. *American Educational Research Journal, 50*(5), 1020-1049.

Sameroff, A. (Ed.). (2009). *The transactional model of development: How children and contexts shape each other.* American Psychological Association.

Schenke, K., Ruzek, E., Lam, A. C., Karabenick, S. A., & Eccles, J. S. (2018). To the means and beyond: Understanding variation in students' perceptions of teacher emotional support. *Learning and Instruction*, *55*, 13-21.

Schiefele, U., & Schaffner, E. (2015). Teacher interests, mastery goals, and self-efficacy as predictors of instructional practices and student motivation. *Contemporary Educational Psychology, 42*, 159-171.

Schmidt, J. A., Kackar-Cam, H. Z., Strati, A. D., & Shumow, L. (2015). The Role of Challenge in Students' Engagement and Competence in High School Science Classrooms: Hispanic and Non-Hispanic Whites Compared. *NCSSS Journal*, *20*(1), 20-26.

Schmidt, J. A., Shumow, L., & Kackar-Cam, H. Z. (2017). Does mindset intervention predict students' daily experience in classrooms? A comparison of seventh and ninth graders' trajectories. *Journal of Youth and Adolescence*, *46*, 582-602.

Shumow, L., & Schmidt, J. A. (2014). *Enhancing adolescents' motivation for science*. Corwin Press.

Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social cognitive theory. *Contemporary Educational Psychology*, *60*, 101832.

Schunk, D. H., & Hanson, A. R. (1985). Peer models: Influence on children's self-efficacy and achievement. *Journal of Educational Psychology*, *77*(3), 313-322.

Schunk, D. H., & Pajares, F. (2005). Competence Perceptions and Academic Functioning. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of Competence and Motivation* (pp. 85–104). Guilford Publications.

Schwartz, L., Adler, I., Madjar, N., & Zion, M. (2021). Rising to the challenge: The effect of individual and social metacognitive scaffolds on students' expressions of autonomy and competence throughout an inquiry process. *Journal of Science Education and Technology*, *30*, 582-593.

Siems-Muntoni, F., Dunekacke, S., Heinze, A., & Retelsdorf, J. (2024). Teacher expectation effects on the development of elementary school students' mathematics-related competence beliefs and intrinsic task values. *Contemporary Educational Psychology*, *76*, 102255.

Sierens, E., Vansteenkiste, M., Goossens, L., Soenens, B., & Dochy, F. (2009). The synergistic relationship of perceived autonomy support and structure in the prediction of self-regulated learning. *British Journal of Educational Psychology, 79*(1), 57-68.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70-83.

Soltani, A., & Askarizadeh, G. (2021). How students' conceptions of learning science are related to their motivational beliefs and self-regulation. *Learning and Motivation*, *73*, 101707.

Stake, R. E. (2013). *Multiple case study analysis*. Guilford Press.

Steenbeek, H., & van Geert, P. (2013). The emergence of learning-teaching trajectories in education: A complex dynamic systems approach. *Nonlinear Dynamics, Psychology, and Life Sciences, 17*(2), 233-267.

Stefanou, C. R., Perencevich, K. C., DiCintio, M., & Turner, J. C. (2004). Supporting autonomy in the classroom: Ways teachers encourage student decision making and ownership. *Educational Psychologist*, *39*(2), 97-110.

Strati, A. D., Schmidt, J. A., & Maier, K. S. (2017). Perceived challenge, teacher support, and teacher obstruction as predictors of student engagement. *Journal of Educational Psychology*, *109*(1), 131-147.

Stroet, K., Opdenakker, M. C., & Minnaert, A. (2013). Effects of need supportive teaching on early adolescents' motivation and engagement: A review of the literature. *Educational Research Review, 9*, 65-87.

Talsma, K., Schüz, B., Schwarzer, R., & Norris, K. (2018). I believe, therefore I achieve (and vice versa): A meta-analytic cross-lagged panel analysis of self-efficacy and academic performance. *Learning and Individual Differences, 61*, 136-150.

Teig, N., Scherer, R., & Nilsen, T. (2019). I know I can, but do I have the time? The role of teachers' self-efficacy and perceived time constraints in implementing cognitive-activation strategies in science. *Frontiers in Psychology*, *10*, 1-17.

Thoman, D. B., Smith, J. L., & Silvia, P. J. (2011). The resource replenishment function of interest. *Social Psychological and Personality Science, 2*(6), 592-599.

Thompson-Lee, S., Klassen, R. M., Wang, H., & Snell, R. J. (2024). Measuring the effects of motivation messages on STEM undergraduates' interest in teaching. *Teaching and Teacher Education*, *146*, 104639.

Thoonen, E. E., Sleegers, P. J., Oort, F. J., Peetsma, T. T., & Geijsel, F. P. (2011). How to improve teaching practices: The role of teacher motivation, organizational factors, and leadership practices. *Educational Administration Quarterly*, *47*(3), 496-536.

Tran, S. T., Majumdar, R., Hu, A. H., & Meyer, J. P. (2022). *Default cut scores for MAP Growth reading and mathematics assessments.* NWEA Research Report.

Tsai, Y.-M., Kunter, M., Lüdtke, O., & Trautwein, U. (2008). Day-to-day variation in competence beliefs: How autonomy support predicts young adolescents' felt competence. In C. G. Rhonda & H. W. Marsh (Eds.), *Self-processes, learning, and enabling human potential: Dynamic new approaches* (pp. 119–143). Information Age Publishing.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, *17*(7), 783-805.

Tulis, M., & Fulmer, S. M. (2013). Students' motivational and emotional experiences and their relationship to persistence during academic challenge in mathematics and reading. *Learning and Individual Differences*, *27*, 35-46.

Turner, J. C., & Christensen, A. L. (2020). Using state space grids to analyze teacher–student interaction over time. *Educational Psychologist*, *55*(4), 256-266.

Turner, J. C., Christensen, A., Kackar-Cam, H. Z., Trucano, M., & Fulmer, S. M. (2014). Enhancing students' engagement: Report of a 3-year intervention with middle school teachers. *American Educational Research Journal, 51*(6), 1195-1226.

Turner, J. C., & Nolen, S. B. (2015). Introduction: The relevance of the situative perspective in educational psychology. *Educational Psychologist*, *50*(3), 167-172.

Udo, M. K., Ramsey, G. P., & Mallow, J. V. (2004). Science anxiety and gender in students taking general education science courses. *Journal of Science Education and Technology*, *13*, 435-446.

Uibu, K., & Kikas, E. (2014). Authoritative and authoritarian-inconsistent teachers' preferences for teaching methods and instructional goals. *Education 3-13*, *42*(1), 5-22.

Usher, E. L. (2015). Personal capability beliefs. *Handbook of Educational Psychology, 3*, 146-159.

Usher, E. L., Butz, A. R., Chen, X. Y., Ford, C. J., Han, J., Mamaril, N. A., ... & Piercey, R. R. (2023). Supporting self-efficacy development from primary school to the professions: A guide for educators. *Theory into Practice*, *62*(3), 266-278.

Usher, E. L., & Pajares, F. (2008). Sources of self-efficacy in school: Critical review of the literature and future directions. *Review of Educational Research*, *78*(4), 751-796.

Valentine, J. C., DuBois, D. L., & Cooper, H. (2004). The relation between self-beliefs and academic achievement: A meta-analytic review. *Educational Psychologist*, *39*(2), 111-133.

van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. *Educational Psychology Review, 22*, 271-296.

Van den Berghe, L., Cardon, G., Tallir, I., Kirk, D., & Haerens, L. (2016). Dynamics of need-supportive and need-thwarting teaching behavior: The bidirectional relationship with student engagement and disengagement in the beginning of a lesson. *Physical Education and Sport Pedagogy, 21*(6), 653-670.

Vansteenkiste, M., Sierens, E., Goossens, L., Soenens, B., Dochy, F., Mouratidis, A., ... & Beyers, W. (2012). Identifying configurations of perceived teacher autonomy support and structure: Associations with self-regulated learning, motivation and problem behavior. *Learning and Instruction, 22*(6), 431-439.

Vedder-Weiss, D., & Fortus, D. (2011). Adolescents' declining motivation to learn science: Inevitable or not?. *Journal of Research in Science Teaching*, *48*(2), 199-216.

Vilppu, H., Laakkonen, E., Laine, A., Lähteenmäki, M., Metsäpelto, R. L., Mikkilä-Erdmann, M., & Warinowski, A. (2024). Learning strategies, self-efficacy beliefs and academic achievement of first-year preservice teachers: a person-centred approach. *European Journal of Psychology of Education*, *39*(2), 1161-1186.

Vincent-Ruz, P., & Schunn, C. D. (2017). The increasingly important role of science competency beliefs for science learning in girls. *Journal of Research in Science Teaching*, *54*(6), 790-822.

Vivante, I., & Vedder-Weiss, D. (2023). Examining science teachers' engagement in professional development: A multimodal situated perspective. *Journal of Research in Science Teaching, 60*(7), 1401-1430.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Wang, M. T. (2012). Educational and career interests in math: a longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Developmental Psychology, 48*(6), 1643-1657.

Wang, M.-T., Chow, A., Degol, J. L., & Eccles, J. S. (2017). Does everyone’s motivational beliefs about physical science decline in secondary school?: Heterogeneity of adolescents’ achievement motivation trajectories in physics and chemistry. *Journal of Youth and Adolescence, 46*(8), 1821–1838.

Wang, S., Rubie-Davies, C. M., & Meissel, K. (2020). The stability and trajectories of teacher expectations: Student achievement level as a moderator. *Learning and Individual Differences, 78*, 101819.

Wigfield, A., Byrnes, J. P., & Eccles, J. S. (2006). Development during early and middle adolescence.

Wigfield, A., & Cambria, J. (2010). Students’ achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review*, *30*(1), 1-35.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation.

Contemporary Educational Psychology, 25(1), 68-81.

Wigfield, A., Eccles, J. S., Fredricks, J. A., Simpkins, S., Roeser, R. W., & Schiefele, U. (2015). Development of Achievement Motivation and Engagement. In M. E. Lamb & R. M. Lerner (Eds.), *Handbook of Child Psychology and Developmental Science*: Socioemotional processes (pp. 657–700). John Wiley & Sons, Inc..

Wilmes, S. E., & Siry, C. (2021). Multimodal Interaction Analysis: a Powerful Tool for Examining Plurilingual Students' Engagement in Science Practices: Proposed Contribution to RISE Special Issue: Analyzing Science Classroom Discourse. *Research in Science Education, 51*(1), 71-91.

Wisniewski, B., Zierer, K., & Hattie, J. (2020). The power of feedback revisited: A meta-analysis of educational feedback research. *Frontiers in Psychology*, *10*, 487662.

Woodcock, S., Sharma, U., Subban, P., & Hitches, E. (2022). Teacher self-efficacy and inclusive education practices: Rethinking teachers' engagement with inclusive practices. *Teaching and Teacher Education*, *117*, 103802.

Wubbels, T., Brekelmans, J. M. G., Mainhard, M. T., den Brok, P., & van Tartwijk, J. W. F. (2017). Teacher-student relationships and interactions as a factor in learning environments. *The British Psychological Society.*

Yeager, D. S., Purdie-Vaughns, V., Garcia, J., Apfel, N., Brzustoski, P., Master, A., … Cohen, G. L. (2014). Breaking the cycle of mistrust: Wise interventions to provide critical feedback across the racial divide. *Journal of Experimental Psychology: General, 143*(2), 804–824. https://doi.org/10.1037/a0033906

Yesilyurt, E., Kaya, E., & Deniz, H. (2024). Adapting the science teaching efficacy beliefs instrument to assess engineering teaching efficacy beliefs of pre-service elementary teachers: Rasch model and confirmatory factor analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(8), 1-15.

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). Sage Publications.

Yu, M. V. B., Hsieh, T. Y., Lee, G., Jiang, S., Pantano, A., & Simpkins, S. D. (2022). Promoting Latinx adolescents' math motivation through competence support: Culturally responsive practices in an afterschool program context. *Contemporary Educational Psychology*, *68*, 102028.

Zeinstra, L., Kupers, E., Loopers, J., & de Boer, A. (2023). Real-time teacher-student interactions: The dynamic interplay between need supportive teaching and student engagement over the course of one school year. *Teaching and Teacher Education*, *121*, 103906.

APPENDIX A: SURVEY ITEMS

Table A1
Survey Items Used in the Study

Constructs	Items	Source
Student-Related Factors		
Competence Beliefs	I'm certain I can master the skills taught in science. I can do almost all the work in science if I don't give up. Even if the work in science is hard, I can learn it. I can do even the hardest work in science if I try.	Adapted from Midgley et al. (2000)
Interest	I enjoy the subject of science. I enjoy doing science. Science is exciting to me. I like science.	Adapted from Conley (2012)
Perceptions of Teacher Competence Support	My teacher's expectations in science class are clear. My teacher makes it clear how to be successful in class. My teacher lets students know if they're on the right track. My teacher knows when students are confused. My teacher checks to see if students have questions. My teacher lets students have more time if they need it. My teacher offers useful suggestions when students get stuck. My teacher helps students when they run into problems.	Developed by the Authors based on Belmont et al. (1988)
Teacher-Related Factor		
Teachers' Self-Efficacy Beliefs	I can get my students interested in science. I can get my students to like science. I can get my students to value learning science. I can teach my lessons so that they are engaging for students. I can teach my lessons so that they are effective for student learning. I can teach my lessons so that they reflect my highest ability as a teacher.	Adapted from Lauermann & Karabenick (2013)

APPENDIX B: LESSON SUMMARY BY CASE

Table B1

Instructional Activities by Lesson and Classroom Case

Lesson	Mason	Hannah	Stuart
Lesson 1	Peer feedback and completing **Marvelous Molecules project**	Card sort activity: matching **chemical formulas** to molecular models	Introduction to **solubility**: guided lab activity and demonstration with road salt in water, oil, and butter
Lesson 2	Introduction to the **Mystery Substances Lab**: identifying unknown white powder and discussing classroom norms	Introduction to **Marvelous Molecules project**: students select and research molecule in pairs	Review of **mass, volume, properties, and substance**. Density column activity with guided demonstration and discussion
Lesson 3	Quiz-based game (Kahoot) on **chemical and physical changes and reactions**	Scientific argumentation and Claim-Evidence-Reasoning (CER): comparing pros and cons of water molecules using t-charts	Direct instruction and guided practice to review concepts of density with readings, analogies, and calculations
Lesson 4	Chemical change lab: conducting 10 different experiments to explore **chemical reactions and solubility** and recording observations	Prepare for presentation portion of **Marvelous Molecules project**	Lab review and quiz preparation: filling in data table to calculate **density and mass** in groups
Lesson 5	Discussion on evaluating credible sources for group research projects and organizing research plans into graphic organizers	Evaporation demonstration and discussion of **polar molecules** (e.g., water)	Quiz review and retake: discussion of concepts such as properties, substances, mass, volume, and prior misconceptions
Lesson 6	N/A	Review of c**onservation of mass**: journal prompts and bean lab using triple beam balance	Introduction to **electrolysis lab investigation** with video demonstrations

Note. Content or activities that overlap across multiple classrooms are bolded.

APPENDIX C: SUMMARY OF COMPETENCE SUPPORT DIMENSIONS BY CASE

Table C1

Comparison of Observed Competence Support Dimensions by Classroom Case

Dimension	Mason	Hannah	Stuart
Clear Expectations, Goals, and Norms	Communicates clear task and participation norms but with occasional shifts to controlling tone Emphasis on inclusive and collaborative norms during group work	Articulates purpose behind tasks through learning goals Frames lessons around real-world relevance through discussing science	Emphasis on procedural clarity through step-by-step instructions and timing estimates Grading or evaluative criteria made explicit
Academic Challenge	Positive messaging about coping with challenges through effort and persistence Limited press for students to extend reasoning	Occasionally positions challenge as part of learning Emphasis on precision over complexity	Conveys challenges through performance expectations and outcomes Adaptive messages on challenges as productive struggle largely absent
Guiding and Supporting Students	Consistent academic and emotional support during task completion Promotes peer collaboration as a form of guidance Flexible pacing for tasks in moments of student struggle	Frequent structured, teacher-directed guidance Scaffolds student understanding through teacher-generated examples and explanations	Frequent teacher-led reviews and guided practice to revisit concepts Relies on probing questions and connections to prior knowledge to scaffold task completion and student understanding
Informational and Encouraging Feedback	Balances praise with informational feedback that affirms effort, progress, and improvement Occasional pressuring or corrective remarks	Feedback patterns may focus students on correct answers Limited use of feedback to prompt elaboration or reasoning	Mix of encouragement and correction Uneven follow-up on student thinking Occasional sarcasm and compliance-driven remarks