RECONCEPTUALIZING TEACHER ADAPTABILITY: THE TEACHER ADAPTIVE-COGNITION THEORY

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ABSTRACT

The capacity of educators to dynamically adjust their thought processes and behaviors in response to the diverse needs and characteristics of students in an unfolding teaching situation is widely acknowledged as a cornerstone of effective teaching. While teachers' instructional adaptations have been documented and studied from various angles, the field lacks a robust theoretical framework that precisely distinguishes yet cohesively integrates teachers' cognitive processes and capabilities of adaptive teaching. Addressing this gap, this dissertation presents the Teacher Adaptive-Cognition Theory (TACT), an innovative theoretical framework that aims at providing a comprehensive and much-needed perspective on the cognitive complexity inherent in adaptive teaching. Formulated through a critical and extensive review of adaptive cognition within and beyond the field of teaching, the TACT model distinguishes among behavioral performance of adaptation, cognitive performance of adaptation, and cognitive readiness for adaptation. It posits that analyses of the cognitive processes and capabilities of adaptive teaching should be systematically contextualized within each other. Furthermore, the dissertation delves into the implications of the TACT model for both research and practical application within and beyond the realm of teacher adaptability. By providing this detailed, integrative framework, this dissertation aims to enhance the conceptual clarity needed to guide research in the study of the crucial skill of teacher adaptability in particular and adaptive expertise in general, as well as to foster the development of such skill.

This dissertation is dedicated to Mom, Dad, Mark, and Aiden.
Thank you for your unconditional support.

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CHAPTER 1: INTRODUCTION AND OVERVIEW

Teaching is an *adaptive* act. Minute by minute and day by day, teachers adapt their classroom teaching to a myriad of factors in order to optimize student learning (Kiel & Weiss, 2022). As Sawyer (2011) summarized in his description of the most effective classrooms:

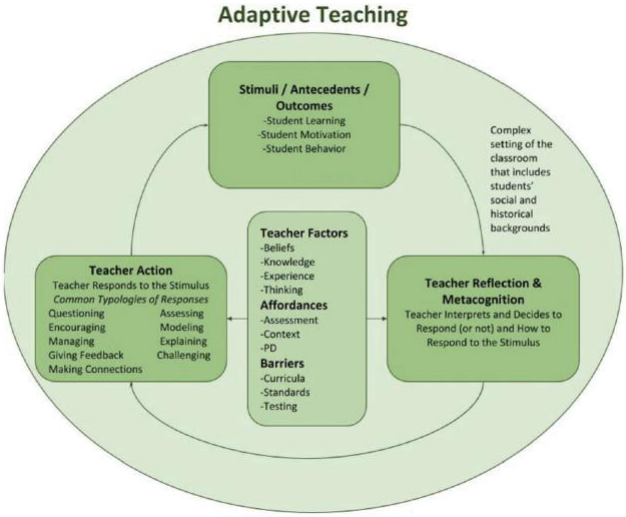
> "Teachers constantly improvise a balance between creativity and constraint, … create and adapt structures of just the right sort to scaffold students' effective learning improvisations, … adapt textbooks and develop lesson plans that enable students to participate in classroom improvisations." (p.3)

When instructional adaptation is done effectively, teaching is considered "artful" (Sawyer, 2011), "skillful" (Brookfield, 2015), and "thoughtful" (Fairbanks, et al., 2010). However, effective instructional adaptation is an inherently complex and demanding task. Even in apparently routine activities, the teaching situation itself can unfold differently and thus requires different, situated adaptations. In addition, classroom teaching is known for its dilemma-ridden qualities (Eilam & Poyas, 2006; Lampert, 2001). There is unfortunately not an optimal answer or algorithm teachers can follow to solve emerging problems in teaching. Rather, the solution to a problem often requires weighing of different options and negotiation of conflicting values (Lin et al., 2005). For teachers to navigate such complex, ill-structured, and messy real-world teaching environments, teacher adaptability – teachers' capabilities to adapt their thoughts and behaviors to student variability and individual needs in an unfolding situation, in pursuit of common and individual goals – is of critical importance and thus often regarded as the cornerstone of excellent teaching (Corno, 2008; Darling-Hammond & Bransford, 2005; Dewey, 1910; Duffy et al., 2009; Parson et al., 2018).

As instructional adaptation receives increasing recognition in educational research, teacher adaptability has been documented and studied from various angles, including but not limited to teachers' adaptive actions (Allen et al., 2013; Ankrum et al., 2020; Parsons, 2012), teachers' rationales for their adaptive responses (Athanases et al., 2015; Mannikko & Husu, 2019), and teachers' metacognitive reflection (Duffy et al., 2009; Jiang et al., 2016; Lin et al., 2005). However, it is only recently that the conceptualization and examination of teacher adaptability has been systematically reviewed. As the first of these reviews, Parsons et al. (2018) synthesized 64 studies in teachers' instructional adaptations to examine how teacher adaptability was defined and conceptualized in the education research literature. They concluded that despite a vast terminology used to describe the phenomenon of instructional adaptations, definitions of teacher adaptability have a common emphasis on a teacher's instructional responses to stimulus (or stimuli) through teacher reflection during planning or teaching. This finding has led to a model of adaptive teaching (see Figure 1a), where the feedback loop among stimulus, reflection, and response (SRR) is influenced by teacher factors as well as contextual affordances and barriers. Following Parsons and colleagues' work, Gallagher at al. (2020) conducted a subsequent review of adaptive teaching in mathematics. Compared to Parsons et al. (2018), Gallagher et al. (2020) included teacher noticing as an additional search term, and proposed a revised model of the adaptive teaching feedback loop (Figure 1b). The newer model still follows the SRR structure, but includes curricula as a potential stimulus, specifies what teachers would notice and interpret in their reflection, and adds orchestrating classroom discourse, modifying curricular materials, and selecting teaching aids to teacher responses. Collectively, the growing body of scholarship has constructed a multifaceted picture of teacher adaptability. The SRR models have also shaped the dominant discourse on teacher adaptability research.

Figure 1a.

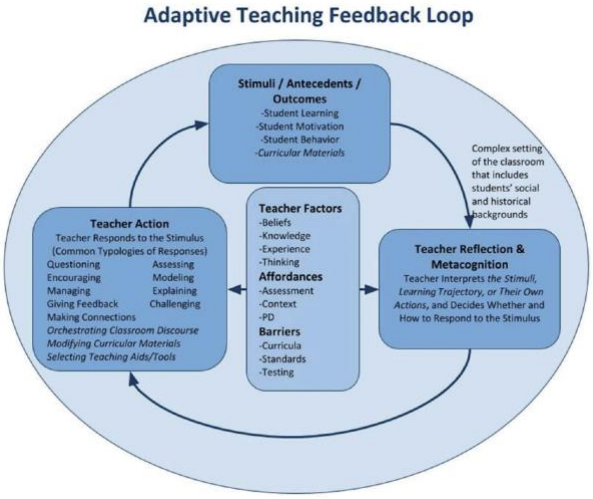
Model of Adaptive Teaching



Note. Model of adaptive teaching. Reprinted from "Teachers' Instructional Adaptations: A Research Synthesis," by S.A. Parsons et al., 2018, *Review of Educational Research*, *88,* p. 231. Copyright 2018 by American Educational Research Association. Reprinted with permission.

Figure 1b.

Revised Model of Adaptive Teaching Feedback Loop



Note. A revised model of adaptive teaching. Reprinted from "Adaptive Teaching in Mathematics: A Review of the Literature," by M.A. Gallagher et al., 2020, *Educational Review, 74*, p. 315. Copyright 2020 by Taylor & Francis. Reprinted with permission.

Nevertheless, as the literature review and conceptual discussions in Chapter 3 will further elaborate, several major gaps remain in the current body of teacher adaptability research. First, there is not yet a sufficiently comprehensive depiction of the cognitive processes and their interrelationships to capture the *dynamics* and *complexity* of teachers' mental activities during instructional adaptation. Take the aforementioned SRR models as an example. There is a heavy emphasis on the "what" questions – what student-related or curriculum-related considerations teachers reflect on and what types of instructional action teachers take to respond to such reflection. The "how" questions – how teachers selectively attend to certain aspects of the teaching situation, how teachers interpret their observations, how teachers reach a decision of particular instructional responses, and more importantly, *how such processes could interact with each other in a non-linear manner* – await further investigation and synthetization.

Related to the cognitive processes of adaptive teaching, another concern is that many studies only focus on mental processes that lead to teachers' behavior alterations in teaching (Allen et al., 2013; Hoffman & Duffy, 2016; Parsons, 2012). While adaptation, by definition, implies change and adjustment, only focusing on behavioral adjustments and cognitive processes leading to such adjustments may leave out cognitive activities that contribute to teachers' development of situation-specific understanding but are *not necessarily* or *immediately* externalized through teachers' behavior changes. A methodological implication of this bias may be the reduction of teacher adaptability measures to just teachers' reflection on their observable behavioral responses (see Allen et al., 2013 for examples of these observable responses and

rationales mentioned in teachers' reflections). In other words, by only working backwards from teachers' behaviors to their rationales, cognitive processes that are not directly related to such behavior changes may miss important research attention. So, the question becomes: What does the *total* process of adaptive teaching consist of and how shall we better represent this process?

In addition to the lack of a descriptive overview of teachers' mental processes during teaching adaptation, there is not yet a systematic explication of teachers' cognitive readiness – a construct that should not be confounded with one's cognitive performance (see Chapter 3 for more discussion on this matter) – for adaptation. More specifically, one's cognitive readiness for adaptation is a *multidimensional* concept consisting of interrelated cognitive elements such as epistemological mindsets, cognitive skills, and knowledge representations that explain the nature of the adaptive behaviors. Although researchers have examined individual teacher factors that influence teacher adaptability, including the use of prior experience and/or knowledge (Moallem, 1998), epistemological orientation (Mannikko & Husu, 2019), both conventional and adaptive metacognitive skills (Crawford et al., 2005; Eilam & Poyas, 2006; Leikin & Dinur, 2007; Lin et al., 2005), little discussion has been done on the inherent interrelationships among these cognitive capabilities (e.g., how one's epistemological orientation may influence their skill of using prior experience and knowledge to interpret and respond to novel teaching situations), let alone on how such interrelationships influence the pattern of mental processes during adaptive teaching (e.g., how the interplay between one's epistemological orientation and cognitive skills can help them with or prevent them from noticing and thus responding to hidden features of an unfolding teaching situation).

I argue that an important contributor to the gaps above is the lack of a theoretical framework of teacher adaptability that not only *differentiates* but also *integrates* cognitive

processes and the underlying cognitive capabilities of adaptative teaching. As to be further elaborated in Chapter 3, many existing theoretical models of teacher adaptability fall into one of the two oversimplifications. One oversimplification is resulted from the lack of differentiation between teachers' cognitive processes (e.g., noticing, decision-making) and the underlying cognitive capabilities (e.g., knowledge structure, metacognitive awareness, reflective skills, etc.) in adaptive teaching. For instance, in both the SRR models as referenced above, teacher thinking is listed as a factor that influences teachers' reflection and metacognition, but it is not clear how these two constructs are different from each other. Similarly, some models (Leikin & Dinur, 2007; Moallem, 1998) highlight factors (e.g., prior experiences or knowledge) that influence teachers' instructional adaptation, but in their explanation of how these factors influence teacher adaptability, cognitive processes and capabilities are mixed together and sometimes even treated as the same construct (again, see Chapter 3 for more details).

The other oversimplification is due to the insufficient integration between the cognitive processes and capabilities. For instance, models that include both cognitive factors and processes (Gallagher et al., 2020; Parsons et al., 2018) stop short at mixing process-oriented constructs (e.g., teacher thinking) and non-process-oriented constructs (e.g., experience, knowledge, belief, etc.) as bullet points of the same category, without discussing the interaction among these constructs. Some models (Shavelson & Stern, 1981) focus on possible algorithms of cognitive processes but are vague about cognitive capabilities that enable such processes.

These oversimplifications, such as failing to distinguish between teachers' actual cognitive processes and their cognitive abilities, or discussing one without the context of the other, can lead to a lack of precision in our understanding of this inherently complex and

intricate phenomenon. This may consequently result in an incomplete or insufficiently nuanced (Corno, 2008) explanatory theory for teacher adaptability.

To address the aforementioned gaps and their underlying oversimplifications, this dissertation develops a new theoretical framework – Teacher Adaptive-Cognition Theory (TACT) – that provides a comprehensive and much-needed perspective on the cognitive complexity inherent in adaptive teaching. The TACT framework includes two closely related yet distinct accounts of teacher adaptability. The first is a *descriptive* account that scrutinizes the dynamic, interactive, iterative, and integrative cognitive processes that drive adaptive teaching. The second is an *explanatory* account that investigates various dimensions of teachers' cognitive abilities that may impact their adaptive teaching processes. While each account brings in unique complexities of adaptive teaching, neither of them alone fully constitutes teacher adaptability. Therefore, the TACT model highlights the *interactions* between these two aspects and the *variability* of such interactions in different contexts (see Chapter 4 for more details).

This dissertation, with an emphasis on theory-building, enhances the theory, research, and practice in adaptive teaching in particular and adaptive cognition in general in three key ways. Firstly, it addresses substantial gaps in the prevailing conceptualization of teacher adaptability as referenced earlier and reconfigures the landscape of teacher adaptive cognition research. By distinguishing between concepts related to adaptive processes and those linked to adaptive capabilities, while explicating the variability of the interactions between these two, the TACT framework ventures into unexplored territory within teacher adaptability research. The mutual contextualization between adaptive cognitive processes and abilities, a major emphasis of the framework, has implications beyond the teaching profession, thus broadening our understanding of general adaptive responses to novel situations.

Secondly, beyond advancing our understanding of adaptive cognition, the TACT model provides new directions as well as a highly specific framework to guide future empirical investigations. While empirical research is integral to applied educational studies, the importance of conceptual exploration and theory development cannot be overstated. Simplistic or deficient theoretical frameworks may result in methodological biases. For instance, current models of teacher adaptability, as to be further elaborated in Chapter 3, concentrate predominantly on teachers' behavioral decisions in adaptive teaching, detouring empirical research away from unobservable cognitive processes, and providing a truncated view of teachers' adaptive cognition. Similarly, when theoretical frameworks fail to systematically articulate the cognitive processes, capabilities, and their interactions in adaptive teaching, empirical research, at best, will only yield fragmented and disjointed insights into teachers' cognitive activities, posing challenges to outcome prediction or causality establishment. A novel, comprehensive theoretical framework, like TACT, is needed to appropriately formulate hypotheses and foster methodological advancements for testing these hypotheses (see Chapter 4 for more details).

Finally, the TACT framework emerges at a pivotal time of societal educational reform and can inform instructional adaptation practices at various levels. As classrooms burgeon with diversity, our education system is experiencing an important and necessary shift from standardized, performance-driven teaching to individualized, inclusive approaches (Gargiulo & Metcalf, 2022; Ladson-Billings, 1992, 2014; Rose & Meyer, 2002). Teachers are exposed to numerous theories, principles, and guidelines of inclusive teaching through teacher education and professional development (Chang & Viesca, 2022). With increasing complexities in educational standards (National Research Council, 2013, 2015), the demand for teachers to cater to specific student groups intensifies. The TACT framework offers a valuable perspective on

teachers' mental processes and skills when adapting general guidelines to their specific teaching situations, informing the design of effective teacher education and training programs. Furthermore, amidst an era of rigorous accountability where policy makers and schools are inclined towards prescriptive curricula, the TACT framework uncovers the inherent complexity in adaptive teaching. This serves as a theoretical challenge to the 'teacher-proof' mentality, urging policy makers to appreciate and leverage teacher adaptive cognition in shaping educational policies.

In what follows, Chapter 2 commences with an exploration of the prevailing definitions of teacher adaptability, spawning four questions that steer an expansive scrutiny of current literature from adaptive teaching, adaptive expertise, and additional domains of education and psychological research. Subsequent to articulating my methodological approach in Chapter 3, I present the findings of my research synthesis and provide responses to the four aforementioned questions. This conceptual examination forms the groundwork for an in-depth elucidation of the TACT model in Chapter 4. Finally, The dissertation concludes in Chapter 5, discussing the implications of the TACT framework on teacher adaptability research as well as the broader psychological fields (e.g., decision-making, response to novelty, accelerated development of adaptive expertise, etc.), and offering recommendations for future research.

CHAPTER 2: CONCEPTUAL FRAMEWORK

This chapter commences with a contemplative examination of a widely-accepted definition of teacher adaptability. By presenting four hypothetical scenarios illustrating teachers' reactions to unforeseen circumstances, I aim to shed light on the limitations of the current conceptualization of teacher adaptability, particularly its inability to encapsulate the multifaceted nature, intricacies, and dynamism inherent in adaptive teaching. This introspection raises two pivotal questions: one addressing the holistic process of adaptive teaching, and the other probing the nuances of adaptability across various stages, processes, and facets of adaptive teaching. Such inquiries pave the way for a review of the broader literature on adaptive cognition, aiming to achieve a deeper understanding of cognitive processes underpinning adaptive teaching. Moreover, the Cognitive Flexibility Theory (CFT) is introduced as a rigorous and integrative framework for elucidating adaptive cognition in ill-structured domains. Informed by insights from adaptive cognition and CFT studies, the initial two questions are further refined and broadened into four at the end of this chapter, serving as guiding principles for the detailed reassessment of teacher adaptability research in Chapter 3 and paving the way to the development of a new theory in Chapter 4.

A Reflection on the Definition of Teacher Adaptability

Teacher adaptability has been described and defined under a number of terminologies, such as teacher decision-making (Perfecto, 2012; Peterson et al., 1978), instructional adaptation (Allen et al., 2013; Parsons, 2012; Parsons et al., 2018), adaptive teaching (Hoffman & Duffy, 2016), just to name a few. In their review of four decades of research on adaptive instruction, Parsons et al. (2018) concluded that despite variations in terminology, researchers operationalize

the concept of teacher adaptability similarly. For instance, Hoffman and Duffy (2016) gave the following criteria for adaptive teaching:

> "For researchers to count an observed teacher action as an adaptation, it had to be (a) nonroutine, thoughtful, proactive, and invented; (b) a change from usual practices; and (c) done in response to students and/or situations." (p.173)

Examining science teachers' instructional adaptations, Allen et al. (2013) defined teacher adaptation as:

> "... a deviation from the lesson plan associated with either the curriculum materials or the teacher's plan for instruction that demonstrated an application of professional knowledge in order to meet the needs of students or the demands of an instructional situation" (p.114).

In their review of adaptive teaching in mathematics, Gallagher et al. (2020) stated:

> "Adaptive teaching is a teacher's unplanned response (i.e., a diversion from the lesson plan) to a stimulus. … Adaptive teachers monitor classroom proceedings and student understandings and use this cognitive monitoring and their knowledge of content, pedagogy, and students to decide when and how to alter their instruction to better support students' instructional needs (Duffy, 2005)." (pp.298-299)

Two features are in common to the definitions above. First, teacher adaptability focuses on teachers' response to student and situational demands. Second, the response that indicates teacher adaptability is marked by teachers' alteration of their instructional actions and deviation from the original teaching plan or materials. However, such a definition of teacher adaptability (i.e., instructional alteration as a response to student stimuli) may fall short of capturing the

complexity of adaptive teaching. To better illustrate my point, let's consider the following scenario:

> *Mutsumi is a middle school student whose family immigrated to the U.S. from Japan recently. English is her second language. Today is her first day at the new school. In her science class, the teacher asks students to work in pairs to develop an ecosystem model of a farm. Mutsumi's partner is Jeff, who is a native English speaker. They are given a worksheet with text descriptions of the ecosystem. As Jeff reads aloud the descriptions, Mutsumi tries to draw lines between populations to denote their relationships. When Jeff reads: "Rats' natural predators are snakes." Mutsumi draws a line representing the "prey-predator" relationship between snakes and rats. Jeff then continues: "Cobras and pythons are sometimes killed by farmers." Mutsumi hesitates and seems confused. This moment is witnessed by the teacher.*

The teacher may respond in various ways. Four of the possible responses are listed below.

> *Teacher A notices Mutsumi's hesitation but does not realize that Mutsumi has encountered a problem, so he walks away without doing anything and continues his teaching as planned.*

Evidently, Teacher A is non-adaptive as he fails to respond to the student's needs and makes no adaptation at all. Then, what if the teacher notices and realizes that the student has encountered a problem? See the next two responses.

> *Teacher B notices Mutsumi's hesitation and confusion. She knows Mutsumi is an English language learner, so she immediately thinks that Mutsumi's confusion is because she does not understand what "cobra" and "python" mean. Although clarification of these*

two words is not included in her teaching plan, she elaborates to Mutsumi: "Cobra and python are types of snakes. Cobras and pythons are sometimes killed by famers. That means farmers sometimes kill snakes."

Teacher C also notices Mutsumi's hesitation and confusion. At first he thinks it may be a language issue, but he wonders if there can be another cause to Mutsumi's confusion. He recalls that when he taught this lesson in the past, some students had questions about whether a prey-predator relationship was appropriate when one species killed but did not feed on another (i.e., farmers kill snakes but do not eat them). In other words, Mutsumi's hesitation could suggest either conceptual or linguistic confusion, or both. With that in mind, he proceeds to ask Mutsumi: "Do you know what python and cobra means?" Mutsumi nods her head. "So, this may not be a language issue." Teacher C thinks to himself. Therefore, Teacher C says to Mutsumi: "What do you think? Are they in a prey-predator relationship?" Mutsumi says, "I am not sure." Like how he helped his students in the past, Teacher C then gives a few other examples in which one species kills but does not feed on another species, and explains to Mutsumi why these species are not in a prey-predator relationship.

Teacher B and C both alter their teaching plan to meet the student's needs, or more accurately, their perception and understanding of what the student needs at the moment. Nevertheless, the quality and result of their adaptations differ because of how they make sense of the situation. Teacher B's thinking is more linear and relies on a single, oversimplified perspective. In contrast, Teacher C's thinking involves more iterative processes, in which he seeks additional information both from his prior experience and the current context, and uses multiple information to construct his understanding of the situation.

So, are Teacher B and Teacher C adaptive? Teacher C's case seems a good example of adaptive teaching. As for Teacher B, one may argue that although she has altered her instruction, her perception and interpretation of the student's needs are not accurate, which renders her adaptation ineffective. In other words, adaptive teaching is more than behavioral adaptation – the latter is featured by behavior alterations, whereas the former includes cognitively adaptive noticing, analyzing, and understanding of students' needs in addition to instructional responses. As Gallagher et al. (2020) pointed out, "teachers make many adaptations each day that may not be responsive to students' needs, and these warrant study, but it is adaptations that are focused on meeting students' needs while holding high expectations for their learning, that constitute adaptive teaching" (p.299).

Now, let's look at yet another possibility.

Teacher D has gone through the same thinking processes as Teacher C and realizes that Mutsumi's hesitation could suggest either linguistic or conceptual confusion, or both. Instead of asking Mutsumi, she remembers that the words "python" and "cobra" are used elsewhere in the text description. Specifically, the description of the relationship between snakes and pigs also contains these two words. So, she quickly scans Mutsumi's worksheet and notices that she already drew a prey-predator line between snakes and pigs, and the line is annotated with two small letters "P" and "C." Through that, Teacher D realizes that Mutsumi's confusion is likely about the concept of a "prey-predator" relationship rather than the meaning of python and cobra. Although this is the first time she has Mutsumi in her class, the teacher knows Mutsumi's partner, Jeff, very well. While Teacher D could have asked Mutsumi to articulate her confusion, she thinks to herself: "Will Jeff be able to figure this question out? Yes he should. We went over this

concept last week. I can intervene now or I can let them talk it through and figure it out constructively. This will be a good learning opportunity for Jeff too, and I do not want to take it away from him. I will see what their final report looks like." So, Teacher D walks away without intervening.

On the one hand, like Teacher C, Teacher D is engaged in an adaptive process of making sense of the situation. On the other hand, like Teacher A, Teacher D ends up making no observable change in her teaching behavior. Nevertheless, Teacher D's lack of observable behavior change is a result of her reflection on her knowledge of the students, as well as the priority of her goals and values of teaching. In this sense, it is qualitatively different from Teacher A's non-adaptive behavior. So, is Teacher D's case adaptive teaching? I would argue yes. The lack of observable deviation from the original plan does not always suggest the lack of adaptive observation or interpretation of the situation. In other words, teacher adaptability is a multifaceted concept that involves cognitive, metacognitive, and behavioral adaptations. Behavior alteration is undeniably a common and important feature, yet neither a sufficient nor necessary condition, of teacher adaptability.

The emphasis on teachers' cognitive adaptability is reckoned by the broader adaptive expertise literature. Adaptive expertise is defined as the ability to excel in non-standard situations of the individual's domain (Hatano and Inagaki, 1986). Researchers have called for attention to the dimensionality of adaptive expertise. First, adaptive expertise contains multiple dimensions including one's domain-specific expertise, metacognitive skills, and creative skills (Carbonell et al., 2016). Researchers have suggested that although behavior and cognitive adaptabilities are closely related, the ability to adjust behavior in response to changes in the situation is important yet only one form of adaptability (Collie et al., 2020; Martin et al., 2012). An outcome of

adaptive expertise can be the development of new understanding and/or knowledge of the situation too (Carbonell et al., 2014, 2016). Therefore, in addition to behavioral performance, it is critical to investigate the cognitive and metacognitive dimension of adaptive expertise, such as the knowledge representation that allows for flexibility and creativity in non-standard situations, one's epistemological orientation, etc. In addition, even within the aspect of behavioral adaptability, there can be multiple types of adaptive behaviors, including proactive behavior (i.e., a behavior that impacts the environment), reactive behavior (i.e., a behavior that changes and modifies oneself to better suit the new environment), as well as tolerant behavior that allows one to "continue functioning despite the changing environment or when either proactive or reactive behavior may not be appropriate" (Griffin and Hesketh, 2003, p.65).

In sum, regardless of instructional alterations, teachers' cognitive and metacognitive activities through which they actively and adaptively construct mental models of the changing situation are inherent and critical to adaptive teaching. Treating behavior change in teaching as a necessary feature of teacher adaptability excludes a legitimate possibility where teachers' decision of not altering their instruction is a result of adaptive consideration of multiple information, goals, and values. Also, only examining teachers' cognitive and metacognitive activities that lead to behavior changes would overlook an important part of teacher adaptability. Therefore, two questions deserve further attention when defining and studying teacher adaptability. First, what does the *total* process of adaptive teaching consist of? In particular, what processes are involved in adaptive teaching other than the ones leading to immediate behavior changes? Second, what does it mean for such processes to be adaptive? After all, just because one reaches an understanding of something or makes a responsive decision, it does not

automatically indicate that it is done adaptively. To further elucidate these inquiries, I reference the theories of adaptive cognition in the following section for more theoretical guidance.

An Overview of Adaptive Cognition

The examination of a fuller picture of the cognitive activities during adaptive teaching in this dissertation is grounded in the broader research of adaptive cognition. The exploration of the extent to which human cognition adapts to a changing environment constitutes a longstanding area of inquiry within the field of cognitive science. This research trajectory has given rise to various theoretical frameworks and empirical studies that endeavor to understand the mechanisms underlying cognitive adaptability, including but not limited to human's perception of the environmental information (Gibson, 2014), the development of cognitive structures as a result of their interaction with the physical and sociocultural environments (Piaget, 1964; Vygotsky & Cole, 1978), fluid intelligence (Cattell, 1941, 1971), the analysis of cognitive biases and heuristics (Kahneman & Tversky, 2013), and more naturalistic approaches to intuition in novel problem solving (Klein, 2009, 2022). In short, the concept of adaptive cognition encapsulates a complex interplay between internal cognitive processes and external environment feedback.

Cognitive and Metacognitive Processes of Adaptation

Despite different theoretical origins, insights of adaptive cognition are often gleaned from examinations of various cognitive processes including decision-making, sense-making, and noticing. In decision-making, for instance, researchers have looked into how individuals utilize heuristics to make rapid judgements with incomplete and changing information (Gigerenzer & Gaissmaier, 2011; Payne et al., 1993; Simon, 1955), and how decisions are adjusted as environment fluctuates (Klein, 2009). In the sense-making literature, researchers have examined

the continual and iterative processes of interpreting, organizing, and synthesizing information to create coherent mental models of complex situations (Zhang et al., 2015). Meanwhile, since information provided by the environment is not fixed but perceptual (Gibson, 2014), noticing is another important cognitive process in adaptive cognition, often explored in the context of discerning novel or salient features in the environment. Collectively, these cognitive processes reflect the inherent flexibility and responsiveness of the human mind, underscoring the importance of adaptive cognition in understanding human intelligence.

In addition to the cognitive processes as referenced above, another core component of adaptive cognition is metacognition – the higher-order processes that result in the formulation of the mental schemas to think about cognitive tasks. Metacognition enables individuals to reflect on, evaluate, and adjust their cognitive strategies to meet the demands of various tasks and environments (Cortese, 2022). It bridges the gap between static cognitive processes and dynamic, context-sensitive thinking, contributing to a more comprehensive understanding of human cognition.

Adaptive Cognition in Ill-structured Environments

While the aforementioned cognitive and metacognitive processes are fundamental to adaptive cognition, researchers have posited that characteristics of these processes essential for efficacious adaptation to ill-structured tasks could profoundly differ from those required for well-structured tasks. For instance, Cattell (1941, 1971) proposed the concept of crystallized versus fluid intelligence. While crystalized intelligence refers to an individual's cognitive ability to resolve problems based on existing knowledge stored in memory, fluid intelligence is in essence one's cognitive capacity to perceive intricate relationships in novel problems when crystalized intelligence is of little or no use. Cattell (1971) argues that creativity is due to the crystalized

intelligence providing the foundation of acquired knowledge, “but the final relation perception, which is new, comes from the fluid intelligence action, and is decided by its level” (p.439).

Cattell’s distinction between fluid and crystalized intelligence is significant in many ways, especially in the sense that it elucidates individual differences in problem solving and abstract reasoning abilities. However, it heavily focuses on people’s perceptual capabilities and does not provide a comprehensive picture of other factors, such as metacognitive awareness, which may affect how people perceive, understand, and react to novel changes in the environment. Relatedly, Cattell considers fluid intelligence inherent and not easily modified by cultural or educational influences. Nevertheless, people have questioned the extent to which fluid intelligence is independent of factors that can be influenced by education or cultures (Anum, 2022).

Another important line of work regarding adaptive cognition in ill-structured environment is Lin et al.’s (2005) research of ‘adaptive metacognition.’ The researchers point out that traditional metacognitive interventions frequently focus on tasks that are reasonably well-defined and possess known optimal solutions, such as those found in chess, card games, mathematics, and science problems. These interventions typically engage participants in relatively stable learning environments, wherein both learners and instructors share mutual learning goals and values. In these instances, the primary focus of metacognition lies in monitoring and regulating each phase of a consistent set of optimal activities. These situations offer limited opportunities of problem finding, with minimal requirements for the discovery or negotiation of conflicting values. However, these metacognitive attributes often lose their effectiveness in highly variable contexts. Teaching serves as a prime example of such a context, where the acceptability of adaptive solutions is contingent upon the discovery of, reflection on,

and negotiation among the emergent and interacting values of all parties involved. Consequently, unique metacognitive characteristics become vital for successful adaptation to ill-structured environments. Such characteristics include one's willingness and capability to unearth hidden variability beneath seemingly routine situations, consider multiple perspectives and alternative explanations, and reflect upon one's own values as well as those of others.

Lin et al.'s proposal of adaptive metacognition was ground breaking in the sense that it challenged the traditional conceptualization of metacognition and highlighted the unique qualities of metacognition required for successful adaptations to highly variable environments. However, similar to Cattell's fluid intelligence, the concept of adaptive metacognition only elucidates one aspect of cognitive and metacognitive activities involved in adaptation to ill-structured environments. What the other aspects of adaptive cognition are and how all aspects work together for efficacious adaption to ill-structured environments await more systematic investigation.

In conclusion, adaptive cognition involves a variety of cognitive and metacognitive processes that allow one to perceive, generate new understanding of, and/or respond to changing environments. There are qualitative differences in the characteristics of these processes between adaptation to well-structured and ill-structured tasks. Although researchers have probed into some aspects of such differences, a more systematic explanatory framework would be beneficial to our comprehensive understanding of adaptive cognition. I argue that Cognitive Flexibility Theory (CFT) is such a theoretical framework. Next, I provide a general overview of CFT in terms of its implications on adaptive cognition. More specific implications of CFT on teacher adaptability research will be discussed in Chapter 3.

CFT

CFT, as conceptualized and expounded by Spiro and his colleagues in a series of seminal publications (Spiro et al., 1988, 1996, 2019), stands as a robust theoretical framework of adaptive acquisition and application of knowledge and experience in complex and ill-structured domains. Central to this framework is the imperative of adaptiveness. CFT systematically endeavors to elucidate and cultivate the cognitive readiness and competencies requisite for navigating the multifaceted intricacies endemic to ill-structured domains, facilitating adaptive transfer and integration of accumulated knowledge and experiential insights into novel, real-world contexts. While a comprehensive review of CFT is beyond the scope of this dissertation, I will highlight in the remainder of this section three characteristics of CFT that make it particularly instrumental in advancing the understanding of adaptive cognition.

1. CFT Highlights the Epistemological Differences between Well-structuredness and Ill-structuredness

CFT explicitly differentiates ill-structured domains (ISDs) from well-structured domains (WSDs) in the discussion of knowledge representation and application. In a WSD, orderliness and regularity are found in the applications of the same concept or schema across different cases. Thus, efficiency in knowledge application can be achieved through generalization, abstraction, and proceduralization of the knowledge and/or practice. For instance, Newton's laws of motion epitomize the characteristics of a WSD – They are based on clear, well-defined principles that can be generalized to a broad spectrum of cases, enabling the proceduralization of problem-solving strategies in physics. Through mastering these principles, individuals can develop the ability to approach a wide variety of problems, from celestial bodies to objects on earth, in a systematic, efficient manner.

Conversely, in an ISD, knowledge is multiplicative, interdependent, and contextualized. When a nominally-same concept is instantiated in different cases, there is a great variability and irregularity in terms of the distribution of its meaning, because the meaning of a concept is intimately connected to its use and highly interdependent with other features of its application contexts. There can be family resemblance among the features of cases where a concept is instantiated. However, a single, abstract, top-down, and pre-packaged knowledge structure, which emphasizes invariability of a concept across its applications, is not only insufficient but actually antithetical to the nature of an ISD. Take medical diagnosis – a paradigmatic ISD – as an example. The presence of the same symptoms can be indicative of a wide range of underlying and possibly interacting conditions, which are also interdependent with variables such as the diagnostic approach/techniques, individual patient's history, cultural and socioeconomic contexts. This inherent complexity and ambiguity of medical diagnosis necessitates nuanced and flexible approaches that take into consideration a multiplicity of factors, both interdependent and contextual, with a deep understanding that there can be great variability across different cases. Thus, experienced practitioners often use a combination of knowledge, experience, and intuitive reasoning to navigate the complex landscape of medical diagnosis (Brush, 2017).

It is worth noting that even within a WSD, there can be aspects that have ill-structured qualities (Spiro et al., 1987, 1988). In fact, Spiro and DeShryver (2009) pointed out that "all areas of knowledge application in unconstrained, real-world situations tend to have substantial aspects of ill-structuredness" (p.108). So, while Newton's laws of motion are well-structured in nature, applying it to the in-the-moment prediction of the exact path and stopping point of an aircraft in an emergency landing situation, such as the famous Hudson River landing by Captain Sullivan, is an ill-structured problem – the application of the laws is influenced by multiple

factors including but not limited to the weather, aircraft, and water body conditions, not to mention various value-laden decisions that need to be made by the pilots in split seconds (Klein, 2011).

2. CFT Provides Multifaceted and Systematic Explanations for Adaptive Cognition

Instead of merely focusing on one aspect of adaptive cognition as some of the aforementioned theories did, CFT elucidates multiple and interrelating aspects of adaptive cognition, such as epistemic worldviews, cognitive skills, and knowledge structures. Together, they form a comprehensive, multilayered, and systematic explanatory framework for adaptive cognition required for ISDs.

Adaptive Mindset. The epistemological differences underlying WSDs and ISDs demand very different cognitive attunement (i.e., worldview, mindset) for learning. In a WSD, knowledge construction and application can be effectively handled by a reductive mindset, which is oriented towards reducing the complexity to mechanistic, compartmentalized, and additive components. However, CFT researchers argue that this reductive mindset is antithetical to the nature of an ISD (Spiro et al., 1996). For instance, it may create a 'cognitive shield' (Feltovich et al., 1994, 2004) that steers people away from searching for conceptual variability across instances and to only seeing overgeneralized similarities. On the contrary, the expansive mindset that considers the whole of a situation to be greater than the sum of the parts can help prepare people to expect irregularity and indeterminateness, embrace problem solving with multiple, interdependent, nonlinear, and flexible knowledge representations, move away from fixation on preconfigured schemas, as well as avoid premature closure in learning and problem solving.

Cognitive Skills. Following the expansive worldview/mindset, a series of cognitive skills that are critical for conceptual understanding and knowledge application in ISDs have been specified and examined in the decades of CFT research. These skills tap into important aspects of adaptive cognition, as they weave a comprehensive web of cognitive capabilities required for effective adaptation to novel and ill-structured problems. A selective list of these skills are summarized below (for more lists and explanations of these cognitive skills, see Spiro et al., 2019; The relevance and application of these skills to teacher adaptability will be further specified in Chapter 3).

Understanding Conceptual Variability. CFT promotes the importance of understanding conceptual variability. Because concepts in ISDs do not have a generic, essentialist definitional core, CFT emphasizes that people must be able to adapt the meaning of a concept to its context of application as well as to other concepts it is combining with in the particular context (Spiro et al., 1988, 2019). For instance, researchers argue that the notion of *scaffolding* is a complex concept for which one cannot prepackage a definition that would adequately guide its use (Spiro et al., 2014). Instead, a rich variety of contextual features affect how the concept is applied. Therefore, for teachers to effectively understand this concept and therefore adaptive apply it, they need to shift away from a singular, prescriptive definition of scaffolding to a more situation-sensitive analysis of the forms and purposes for scaffolding (Palincsar, et al., 2007; Palincsar et al., 2019).

Crisscrossing of cases. The emphasis on conceptual and contextual variability leads to CFT's advocate for the practice of case-centered learning and the skill of crisscrossing multiple cases to, for instance, identify hidden similarities in knowledge/experience application between different-appearing contexts, and dissimilarities beneath the surface of similar-appearing events

(Spiro et al., 2019). CFT posits that the interconnectedness and interdependence among conceptual and contextual elements are central to complex understanding and adaptive application (Spiro, et al., 2019). The skill to crisscross – to rearrange, reorder, remix, reorganize – conceptual and case elements for different purposes and in different contexts is critical for the discovery of such interconnectedness and interdependence.

Multiple and situation-sensitive representations. Other skills that go hand in hand with successful case crisscrossing include but are not limited to the skill to seek multiple representations, perspectives, and/or explanations to a phenomenon (Spiro et al., 1988, 1996), as well as the skill to see how a certain aspect, dimension, or manifestation of a concept is highlighted in a particular context and how these highlights vary across situations (Spiro et al., 2019).

Assembly of the schema-of-the-moment. CFT also emphasizes the skill to assemble the schema-of-the-moment. That is, to bring together *parts* of prior knowledge and experiences to construct a schema of the moment in a balanced and mindful way for the task at hand (Schommer, 2011; Spiro et al., 1992; 2017). It is opposed to the retrieval of pre-packaged and intact schemas that miss too much conceptual and contextual variability.

Knowledge Structure. In interaction with the adaptive mindset and skills is the knowledge structure required for and resulted from adaptive knowledge acquisition and application. CFT research has provided empirical evidence on how a rigid, closed, and oversimplified knowledge representation hinders the later application of knowledge and attainment of more advanced concepts (Spiro, 2015; Spiro et al., 1987; 1988; 1989; 1992). On the contrary, the mobilization, contextualization, and expansion of one's mental representations of prior knowledge and experiences – a natural outcome of the aforementioned cognitive skills

and an expansive mindset – in turn afford adaptation of these experiences/knowledge to new and ill-structured problems (Spiro & Jehng, 1990). As Spiro et al. (1987) noted:

> Executive control strategies require flexible knowledge structures to operate upon. In turn, control over flexible representations will give an individual more control over a content domain; rather than monolithic prepackaged knowledge structures constraining an individual to apply knowledge in a fixed and limited manner, the individual controls the knowledge; that is, a great variety of non-predetermined ways to adapt knowledge to the task and content elements involved in the new situation are available. (p.179)

3. CFT Differentiates between Adaptive Performance and Adaptive Readiness

Another important attribute of CFT that is of particular relevance to the research of adaptive cognition is that it differentiates adaptive performance from adaptive readiness. While adaptive performance refers to one's actual behavior of responding to a novel and ill-structured situation by selectively combining fragments of prior cases to form case-specific schemas for sense-making and decision-making purposes, successful adaptive performance is premised by and would further reinforce one's adaptive readiness – one's awareness of conceptual variability and context dependency in ill-structured problems (i.e., expansive worldview), cognitive structures (a.k.a., knowledge structures) that are ready to be adapted to complex issues, and cognitive capabilities (a.k.a., cognitive skills) to detect and examine conceptual variability as well as to adapt varying conceptual dimensions to specific contexts. The reciprocal relationship between adaptive readiness and adaptive performance can be fostered through deliberate practice of open and context-dependent meaning-making at various scales (for examples of kinds of deliberate practice for adaptive readiness and performance, see Spiro et al., 2019).

CFT's distinction between adaptive readiness and adaptive performance is of critical importance to the theorization and examination of adaptive cognition in general and teacher adaptability in particular. It provides a clear and encompassing analytical framework to interpret adaptability through various stages and contexts.

First of all, adaptive readiness is a cognitive predisposition towards adaptation, whereas adaptive performance pertains to one's actual response to novel and ill-structured situations. These represent distinct, yet crucial, facets of adaptability. Adaptive performance depends not just on readiness, but also on personal goals and values, a point exemplified by the cases of Teacher C and Teacher D in Mutsumi's story earlier. Performance alone cannot be considered the singular measure or predictor of one's adaptive readiness, or adaptability in general.

Secondly, adaptive readiness varies by individual and context, influenced by factors like mindset, cognitive skills, and knowledge structure. Adaptive performance, similarly, isn't a fixed quantity. It varies depending on the context and can manifest in different responses like behavior changes, emotional reactions, or the construction of new knowledge. Understanding how individual factors and their interplay manifest in adaptation's various stages and contexts is vital.

Thirdly, the interplay between adaptive readiness and adaptive performance highlights the inherent complexity and ongoing nature of developing adaptability. Studies should not restrict themselves to a linear analysis of moving from readiness to performance or vice versa. Rather, they should concentrate on the dynamic process of adaptability development. For teacher adaptability, it is essential not only to consider how a teacher's adaptive readiness leads to performance but also to explore how adaptive performance influences the growth of readiness.

Last but not the least, CFT suggests that deliberate practice in developing adaptive readiness and performance can provide valuable insights for instructional strategies to enhance

adaptability. Such practice could prove instrumental in accelerating the growth of adaptability, offering a significant contribution to educational methods.

Summary

In conclusion, premised on the foundational distinction between WSDs and ISDs from an epistemological standpoint, CFT establishes a robust theoretical foundation for an integrative understanding of cognitive dimensions and components, transcending mere observable behaviors in adaptive tasks within real-world, ill-structured contexts. The delineation between adaptive readiness and adaptive performance furnishes a framework to analyze the components and their intricate interrelationships across various facets and degrees of an individual's adaptive cognition. This framework presents a renewed lens through which we can scrutinize the existing corpus of research on teacher adaptability.

Four Questions

The multifaceted nature and intricacy of teacher adaptability, as delineated in the initial segment of this chapter, call for a thorough reassessment of the teacher adaptability landscape. Insights derived from an examination of general adaptive cognition and CFT research, focusing on cognitive processes and components inherent in adaptive activities within ill-structured tasks, furnish precise directions for this reassessment. In the subsequent chapter, I engage with pertinent literature through three prisms: teachers' adaptive noticing, sense-making, and decision-making. The ensuing discourse is steered by the following inquiries:

1. What does the current literature, particularly that concerning teacher adaptability, characterize teachers’ processes of noticing, sense-making, decision-making, and the relationship among these processes? To what extent can these processes collectively provide a comprehensive representation of adaptive teaching at the procedural level?

2. How is adaptiveness delineated within and across the processes specified earlier? Specifically, what characterizes the adaptiveness of teachers' processes of noticing, sense-making, decision-making, and the interactions of these processes?
3. Are there existing models of teacher adaptability that address the aforementioned questions while simultaneously encapsulating the dynamic intricacies inherent in adaptive teaching? In other words, are there existing models of teacher adaptability that differentiate yet also integrate question 1 and 2 above?
4. Should the response to the third question be negative, what might a model encompassing the concerns raised in the preceding questions resemble?

CHAPTER 3: RE-ASSESSING THE TEACHER ADAPTABILITY LANDSCAPE

Guided by the four inquiries posed at the conclusion of the preceding chapter, I undertake an expansive examination of the relevant literature concerning teacher adaptability. The primary objective of this dissertation is to develop a new, holistic theory that encapsulates the intricacies of teacher adaptive cognition. Consequently, the intent of this research synthesis diverges from previous systematic literature reviews of teacher adaptability (e.g., Parsons et al., 2018) that focused on summarizing what is known about teacher adaptability studies. More specifically, this reassessment and reconceptualization of the landscape of teacher adaptability research asks what we don't know. The analysis consists of two interwoven parts. First, I conduct an exhaustive exploration of prevailing adaptive teaching research, emphasizing a critical assessment of the foundational assumptions inherent in current teacher adaptability conceptualizations. Meanwhile, I analyze the broader literature on adaptive cognition to identify domains that remain relatively unexplored within the context of teacher adaptability studies.

In the following section, I detail specific methods employed in my research synthesis, including search and selection criteria, coding, and analysis. Next, I answer the four guiding questions based on the results of the research synthesis. In the section of "Re-examining the Process of Adaptive Teaching," various cognitive processes involved in adaptive teaching are examined, each of which reveals important gaps in the current depiction and conceptualization of the adaptive teaching processes. The relationships among these processes are discussed, which give rise to a holographic view on the total process of adaptive teaching (see Summary: A Hologram of the Adaptive Teaching Process). In the following section of "Unpack the Blackbox: Adaptiveness of Adaptive Teaching," research on various cognitive mechanisms underlying adaptivity is reviewed, based on which I argue that the ultimate complexity of teacher

adaptability is brought forth when dimensions of cognitive adaptability are situated within the dynamic, interactive, and holographically integrative process of adaptive teaching. I then illustrate how CFT, as a conceptual and analytical framework of cognitive flexibility, can weave together existing research of adaptive teaching across various dimensions of cognitive adaptability to provide a coherent account for the inherent complexity of teacher adaptability. In the section of "Models of Adaptive Teaching," four existing conceptual models of teacher adaptability are evaluated, which further reveal the inadequacy of the current models in capturing the aforementioned complexity of teacher adaptability. Lastly, in the chapter summary, I answer the fourth guiding question by discussing what is required of an encompassing model of teacher adaptability.

Methods

Search and Selection

To review the current conceptualization of teacher adaptability, I compiled 29 search keywords based on my knowledge of the field, revisions of search terms from previous reviews of adaptive teaching (Gallagher et al., 2020; Parsons et al., 2018), and recommendations from colleagues (see Figure 2 for the complete list of search terms). With these search terms, I searched the Educational Research Information Center (ERIC), Academic Research Premier, Web of Science, and ProQuest for research related to teacher adaptability. I also used Google Scholar to search for any studies that may have been missed in my database search. In addition, more research articles were gleaned from bibliographies.

To be considered for this research synthesis, studies must meet the following criteria: They should have been published in peer-reviewed journals post-1974, be written in English, be available in full text, and focus on teacher adaptability prior to, during, and/or following

instruction in K-16 education. The decision to use 1974 as the demarcation year for the studies under review was influenced by two primary factors. Firstly, this aligns with the assertion by Parsons et al. (2018) that the late 1970s marked a pivotal period in educational research, witnessing a shift towards a focus on individual cognition. Secondly, this review seeks to uncover nuanced aspects in the prevailing conceptualization of teacher adaptability that may have been previously underemphasized. By synchronizing the timeline of the studies reviewed here with that of the most extensive review on teacher adaptability to date, specifically Parsons et al.'s (2018) study, this synthesis offers a parallel and comprehensive perspective.

Figure 2

Search Terms

Adaptive teaching, adaptive instruction, instructional adaptation,
teacher adaptations, teacher adaptive expertise, teacher cognition,
teacher epistemic cognition, teacher metacognition, metacognitive teaching,
adaptive metacognition, teacher sense-making, teacher noticing,
teacher decision-making, scaffolding, instructional scaffolding, teacher scaffolding,
responsive teaching, responsive instruction, teacher response, reflective teaching,
teacher flexibility, reflection-in-action, reflection-on-action, teachable moment,
dialogic teaching, teacher improvisation, improvisational teaching,
teaching improvisation, creative teaching

Initially, 452 articles were identified. Given the central goal of this review – to critically examine the existing conceptualization(s) of teacher adaptability, both conceptual and empirical

studies were screened for inclusion. However, studies that met one or more of the following exclusion criteria were eliminated from the review:

1. Teacher adaptability was not the primary focus of the study;
2. The research questions or purposes were not explicitly stated;
3. Teacher adaptability was not clearly defined in any part of the paper, including but not limited to theoretical framework and discussion of the results.

In total, 95 studies met the inclusion and exclusion criteria.

Coding and Analysis

Guided by the first three research questions as specified at the end of Chapter 2, the analyses of the reviewed studies mainly focus on the conceptualization of teacher adaptability, especially the complexities and intricacies of the cognitive processes and underlying adaptive mechanisms involved in adaptive teaching. To understand the cognitive processes involved in teacher adaptability, I conducted a content analysis (Drisko & Maschi, 2016; Saldana, 2016) of the reviewed studies, which started with three categories a priori: (i) noticing, which refers to teachers' shift in attention to and reasoning about salient features of classroom teaching and interactions; (ii) sense-making, which refers to the iterative gap-defining and gap-bridging activities that aim at creating and updating the teachers' understanding of a concept, problem, and/or situation; and (iii) decision-making, which refers to the decisions teachers made during instruction and how they construct such decisions. The essence of these three categories is drawn from the previous adaptive cognition literature as discussed in Chapter 2. For content that could not be coded based on the a priori categories, a grounded theory methodology was used. Specifically, a two-cycle coding process (Saldana, 2016) was invoked. The initial cycle employed a descriptive coding method (Saldana, 2016; Strauss & Corbin, 1998) to capture the

meaning inherent to authors' definitions and/or descriptions of the cognitive processes. The a priori codes and the new codes from the first cycle were continuously revisited, refined, reorganized and reconfigured to thematic groups with focused coding (Saldana, 2016). This open and descriptive coding stage is important because it revisits the boundaries of the a priori categories in the context of teacher adaptability, allows the identification of both manifest and latent content, and places the analytic attention to the overlaps, relationships, and interactions among differently termed cognitive processes to obtain a more comprehensive picture of the *total* cognitive process of adaptive teaching (see the section of S*ummary: A Hologram of the Adaptive Teaching Process* for more details).

The analysis of the adaptive mechanisms involved in teaching also followed an open and descriptive coding process, which was anchored in the teacher adaptability literature but guided by a broader literature of adaptive expertise and adaptive cognition. First, I immersed myself in the reviewed studies with special attention to cognitive mechanisms (e.g., epistemological belief, cognitive skills, etc.) that authors explicitly claimed to have contributed to teacher adaptability. This process was cyclical as I repeatedly returned to the articles to contextualize the findings from the lens of the specific cognitive process(es) where these mechanisms were studied. In this process, categories and subcategories were developed, reconfigure, and reorganized (see Figure 3). This cyclical and iterative process aimed at unveiling how an adaptive mechanism might manifest itself differently across various cognitive processes. For instance, the skill of intentionally seeking additional information to uncover novel aspect(s) of a seemingly routine teaching situation was identified by Lin et al. (2005) as a critical component of adaptive metacognition in teaching, especially during teachers' sense-making process. The same skill of directing one's attention to subtle but novel information, was conceived as the open marking of

prior experiences during the noticing process (Mason, 2002). Both skills share family resemblance to a great degree (e.g., sensitize oneself to think freshly rather than habitually), but each possesses unique qualities as a result of the context of different cognitive processes. Lastly, since the main goal of this research synthesis is to ask what we don't know about teacher adaptability, themes identified from the review of teacher adaptability literature were compared with broader literature of adaptive cognition and CFT as referenced in Chapter 2. In the subsequent sections, I will report the findings of my critical research synthesis.

Figure 3

Coding Categories and Sub-categories

- Noticing
  - attention
  - marking of prior experience
  - situation awareness
- Sensemaking
  - sensing
  - interpretation
  - gap identification
  - (provisional) mental model
- Decision-making
  - simulation
  - weighing
  - instructional action
  - monitoring
- Metacognition
  - goals
  - epistemic values/orientation
- External barriers
- Prior knowledge/experience
  - knowledge structure
  - knowledge/experience type – content
  - knowledge/experience type – pedagogy
  - knowledge/experience type – technology
- Cognitive skills
  - comparison
  - information seeking
  - avoiding premature closure
  - surprising (dis)similarity
  - contextualization
  - identifying conceptual variability

Re-examining the Processes of Adaptive Teaching

Teacher Noticing

Teacher Noticing in General. Over the past two decades, teacher noticing has become a prominent construct in the field of teacher education and is commonly considered as an important component of teacher expertise (Dindyal et al., 2021; König et al., 2022; Scheiner, 2016, 2021; Van Es & Sherin, 2021). Teacher noticing is often conceptualized as teachers' shift in attention to and reasoning about salient features of classroom teaching and interactions (Scheiner, 2016; Van Es & Sherin, 2021). More specifically, teacher noticing often involves two interrelated processes – attending and interpreting. Attending refers to teachers' efforts to perceive and identify noteworthy features of classroom interactions (Goldsmith & Seago, 2011; Mason, 2002, 2011; van Es & Sherin, 2002). Interpreting concerns how teachers use their knowledge and experiences to make sense of what is observed (van Es & Sherin, 2002, 2021). The interaction between these perceptual and conceptual processes leads to situational awareness – the perception of elements in the environment, the comprehension of their meaning, and the projection of their status in the near future (Endsley, 1995; Scheiner, 2016). Some researchers argue that noticing extends beyond attending and interpreting. For instance, Jacob et al. (2010) identified decision-making as a third dimension of teacher noticing. They described teachers' noticing of children's thinking as three interrelated processes: (1) attending to children's strategies, (2) interpreting children's understandings, and (3) deciding how to respond on the basis of children's understanding. Also emphasizing teachers' active interaction with the environment during noticing, van Es and Sherin (2021) proposed "shaping" as the third dimension, which referred to "teachers constructing interactions, in the midst of noticing, to gain access to additional information that further supports their noticing" (p.23).

Teacher Noticing and Teacher Adaptability. As Mason (2002) points out: "Every act of teaching depends on noticing: noticing what children are doing, how they respond, evaluating what is being said or done against expectations and criteria, and considering what might be said or done next" (p.7). In this sense, teachers' noticing ability is important for them to make appropriate adaptations in teaching to meet students' immediate needs. For instance, Choppin (2011) found that mathematics teachers' adaptation of challenging tasks was informed by their attention to student thinking. More specifically, teachers who attended closely to student thinking were able to make adaptations that enhanced task complexity and students' opportunity to engage with mathematical concepts, whereas those who evaluated student thinking mainly as right or wrong reduced the task complexity and left students struggling to make sense of mathematical concepts. Gheyssens et al. (2021) examined 1,522 teachers' noticing and reasoning of inclusive practice, as well as their self-reported practice of differentiated instruction. The researchers found that teachers who were more proficient at noticing inclusive practices also reported implementing more differentiated practices. Also focusing on equitable and inclusive teaching, Van Es et al. (2022) used data from two teachers' classroom teaching to illustrate how the teachers' noticing of students' sociocultural backgrounds and histories informed their enactment of instructional adaptations. In sum, as Gibson and Ross (2016) state: "Noticing encompasses the ways in which teachers are able during instruction to observe important details in students' response, and interpret this information accurately and comprehensively to adapt instruction in the moment." (p.181)

Despite emerging evidence of the connections between teacher noticing and teacher adaptability, noticing remains an under-looked area in the conceptualization and theorization of teacher adaptability. For instance, teacher noticing was not included in the search terms of

Parsons et al.'s (2018) systematic review of teacher adaptations. Gallagher et al. (2020) incorporated Jacob et al.'s (2010) noticing framework in their review of adaptive teaching in mathematics. However, their conceptualization of teacher noticing in their model of teacher adaptability focuses more on what teachers attend to (i.e., students' thinking and understanding), rather than why and how the selective perception and attention take place. Research on the relationship between teacher noticing and teacher adaptability remains scarce. It is thus both important and necessary to revisit the conceptualization of teacher adaptability and further investigate teacher noticing as an important process of adaptive teaching.

Teacher Sense-making

Sense-making in General. In its broad definition, sense-making refers to the iterative and dynamic gap-defining and gap-bridging activities that aim at creating and updating one's understanding of a concept, problem, situation so as to act in an informed manner (Odden & Russ, 2018; Zhang & Soergel, 2014). Sense-making can be conceptually categorized into two subprocesses – sensing (i.e., information seeking, extracting, and filtering) and sensemaking (i.e., narrowly defined and without a hyphen, it refers to iteratively creating and updating a representation of a situation that can support decisions or effective action) (Choo, 1998; Klein et al., 2006). These two subprocesses are closely intertwined. For example, in the model of individual sense-making developed by Zhang and Soergel (2014), a sensemaker is engaged in several iterative loops of information seeking and data/structure sensemaking. If a data gap is identified when one tries to make sense of a situation or problem, s/he then conducts further search for the missing piece of information and tries to fit it into the knowledge structure. If a gap is identified in one's knowledge structure, the sensemaker then updates or reconstructs the

knowledge structure. The interaction between these processes eventually results in an updated conceptual structure of the problem or situation.

One theoretical significance of sense-making, as illustrated by Zhang and Soergel's (2014) model above, is that it provides a holistic picture of the iterative, dynamic, complex, and interrelated nature of people's cognitive processes when they try to understand a new situation. It also highlights knowledge creation, rather than just action, as a result of sense-making. Therefore, this concept is particularly relevant to the investigation of teacher adaptability, which I will turn to next.

Sense-making and Teacher Noticing. Before I proceed to reviewing the literature of sense-making and teacher adaptability, it is important to clarify the relationship between sense-making and noticing. One might reasonably ask how sense-making is any different from noticing. After all, the subprocesses of sense-making (i.e., sensing and sensemaking) seem to align quite well with the ones of noticing (i.e., attending and interpreting). Researchers of teacher noticing even used the term "sensemaking" to explain their conceptualization of "interpreting" (van Es & Sherin, 2002). So, is it just a rose by another name? While there is indeed a great deal of overlap between these two constructs in terms of the processes they describe, there are also two key differences. First, they come from distinctive theoretical origins and thus have different focuses. Teacher noticing is undergirded by the notion of perception (Dindyal et al., 2021; Gibson, 1986) and selective attention (Mason, 2002). It focuses on the evolution from perception to attention and to awareness (Mason, 2002, 2011; Sheiner, 2016, 2021). With this background, what researchers of teacher noticing mean by "sensemaking" is underpinned by the notion of knowledge instantiation or schema activation (Sheiner, 2021). That is, teachers' use of existing knowledge and experience to interpret and/or guide what they attend to. On the other hand,

sense-making has one of its theoretical roots in learning theory (Piaget, 1936, 1976; Rumelhart and Norman, 1976). In addition to knowledge instantiation through data interpretation and search (similar to Piaget's assimilation, or Rumelhart and Norman's accretion or tuning), sense-making has an explicit focus on the *iterative* process of identifying knowledge gaps through intentionally challenging, updating, and/or restructuring one's knowledge (similar to Piaget's accommodation, or Rumelhart and Norman's tuning or restructuring). Second, while some researchers have pushed the boundary of teacher noticing to include decision-making (Jacob et al., 2010; Kaiser et al., 2015), sense-making emphasizes the construction and update of a mental model/knowledge structure as an outcome, which certainly could lead to and get influenced by decisions regarding actions, but does not have to. In sum, teacher noticing and sense-making complement each other by emphasizing different aspects of teachers' interaction with the instructional environment and their formation of situational awareness. Together, they highlight the complexity of teachers' cognitive activities that are integral and inherent to teacher adaptability.

Sense-making and Teacher Adaptability. The continuum from knowledge instantiation to knowledge restructuring as a possible outcome of sense-making, as well as the processes leading to such outcomes, can be of particular relevance to teacher adaptability research. Researchers have examined the impact of prior knowledge and/or experience on teachers' management of complex data in their teaching adaptation. For instance, Shavelson and Stern (1981) pointed out that due to people's information-processing limitations, teachers tend to reduce the complexity of the original information available in the environment by selectively perceiving and drawing inferences about students via heuristics and attributions based on prior experiences. Moallem (1998) concluded in her ethnographic study that the teacher's thinking process was a simultaneous consideration of different factors, filtered by teachers' prior

experiences and facilitated by teachers' reflection during and after instruction. Perfecto (2012) found that the teachers relied on their experienced structures and routines to cope with the cognitively challenging tasks of reconciling the tension between prescribed curriculum and classroom realities. Other studies have focused on how teachers move beyond their prior experience to update or restructure their knowledge through problem finding (Lin et al., 2005), seeking and using multiple perspectives (Mannikko & Husu, 2019), and keeping an epistemic distance between prior knowledge and a current problem of practice (De Arment, et al., 2013). However, there has been little research so far that systematically examines teacher adaptability with the multistage and iterative model of sense-making. In particular, questions such as how teachers' identification of the information and knowledge gaps interact with and influence each other, what role a teacher's knowledge representation play in such interactions and iterations, what roles these interactions and iterations further play in teacher adaptation, etc., remain largely open.

Teacher Decision-making

Teacher Decision-making and Teacher adaptability. Teacher decision-making is one of the most studied constructs in teacher adaptability (Parsons et al., 2012, 2018; Ankrum et al., 2020; Allen et al., 2013). One of the reasons for the popularity of this construct may be the observable nature of a decision once it's made, especially when it deviates from the original plan. While most studies focus on teachers' decisions of behavior change, one study by Leikin and Dinur (2007) examined situations both when a teacher decided to change and when she decided to stick to the original plan. The researchers argued that inflexibility (i.e., not making adjustments to the original plan) was not always a negative characteristic of a teacher's professionalism, especially when it is intentional, because "a teacher may have serious reasons

for inflexibility, and a teacher's proficiency is generally expressed in a sensible balance between flexibility and inflexibility" (Leikin & Dinur, 2007, p.345). Nevertheless, the authors also acknowledged that the teacher inflexibility they found in the particular study was the result from the teacher's lack of awareness of an alternative learning trajectory.

Another focus of decision-making in adaptive teaching is on teachers' mental processes that lead to the behavior outcome. Researchers have examined teachers' decision-making processes during the preactive (e.g., planning), interactive (e.g., enacting), and postactive (e.g., reflecting) stages of teaching (Parker, 1984; Parsons et al., 2018; Peterson et al., 1978). Although the contextual demands (e.g., student involvement, tasks, etc.) teachers work with at each stage vary, a core characteristic of adaptive decision-making at all stages of teaching is the consideration of alternative instructional strategies or behaviors to meet students' needs (Randi, 2022). For instance, in lesson planning, decision-making is conceptualized as "a process of selecting educational objectives, diagnosing learner characteristics, and choosing from alternative instructional strategies in order to achieve certain learner outcomes" (Peterson et al., 1978, p.418). Parker (1984) considered the quality of teachers' interactive decision making improved when they can "more appropriately select and reject instructional alternatives" (p.221). Leikin and Dinur (2007) investigated teacher's decision on whether to explore alternative learning trajectories when confronted with unexpected response from students. Hoffman and Duffy (2016) pointed out that adaptive teachers engage in reflections where they move beyond familiar options, examine governing variables, and look for alternatives.

In addition to the consideration of alternative instructional behaviors or strategies, an important component of teachers' adaptive decision-making is their ability to weigh different instructional options (Duffy et al., 2009; Hoffman & Duffy, 2016; Lin et al., 2005; Parker, 1984).

While some studies looked into teachers' rationale for their consideration of an instructional alternative (Allen et al., 2013; Parsons, 2012), other researchers have pointed out that even when teachers give reasons to their choice of one or another alternative, the alternatives are rarely compared or contrasted for the optimization of teaching (Duffy et al., 2009; Hoffman & Duffy, 2016; Lin et al., 2005; Parker, 1984; Shavelson et al., 1981). That is, the alternatives are not weighed. As a result, what processes are involved in teachers' weighing of instructional alternatives in their decision-making remains an under-researched area.

Teacher Decision-making with Sense-making and Noticing. Just like how sense-making and teacher noticing have overlaps in terms of the processes they describe, the subprocesses of teacher decision-making are also intertwined with the ones of teacher noticing and sense-making. First, teachers' decision-making is built upon the premise of teachers' monitoring and understanding of students' learning and the teaching situation. In this sense, decision-making seems a natural extension of noticing and sense-making. Second, the relationship among teacher decision-making, sense-making, and noticing is not unidirectional. Jacob et al. (2010) suggested that before the teacher responds, attending, interpreting, and deciding how to respond happen in the background almost simultaneously, "as if constituting a single, integrated teaching move" (p.173). Decision-making also feeds back to teachers' noticing and sense-making. Researchers have pointed out that the decisions made at the beginning of teaching influences teachers' noticing and sense-making later (Peterson et al., 1978). The consideration of instructional alternatives provides teachers another opportunity to examine and reflect on the outcome of their sense-making and noticing. In other words, the interactions among decision-making, sense-making, and noticing are an integral part of adaptive teaching.

Despite the overlaps, each of these three processes also complement each other by conceptually, theoretically, and empirically highlighting distinctive aspects of the adaptive teaching process. As discussed earlier, teacher noticing has a focus on teachers' perception and selective attention, whereas instructional sense-making emphasizes the continuum from knowledge instantiation to knowledge reconstruction as a result of iterations of gap identification and information seeking. Decision-making brings yet another layer to adaptive teaching – consideration and weighing of various instructional alternatives. These distinctions are important, as in combination they provide a richer explanation for the dynamic and interactive process of adaptive teaching.

Summary: A Hologram of the Adaptive Teaching Process

> *"Unlike normal photographs, every small fragment of a piece of holographic film contains all the information recorded in the whole."*
>
> *- Michael Talbot, The Holographic Universe (1991)*
>
> *"In the holographic record information becomes distributed, … much as the waves produced by throwing a pebble into a pond spread to its edges. Several such waves initiated by several pebbles will interact or 'interfere,' and the record of these interference patterns constitutes the hologram."*
>
> *- Karl Pribram, Transcending the Mind/Brain Problem (1979, p.118)*

In this section, I have reported the findings of my research synthesis regarding the processes of adaptive teaching from three lenses – teacher noticing, sense-making, and decision-making. The purpose is not to mechanically or reductively break down teacher adaptability into three definitive, separate, and sequential constructs. Quite to the contrary, by explicating the relationships among these constructs, a hologram of the adaptive teaching process is constructed,

where every part is a whole and the whole is enfolded in parts. More specifically, all three areas of research examine *the* process in which the teacher adapts to a complex and unpredictable teaching environment. It is thus not surprising that researchers of teacher noticing extend their investigation to teacher decisions, or that researchers of teacher decision-making strive to understand teachers' monitoring and understanding of the teaching situation. Meanwhile, each perspective is influenced by its own theoretical underpinnings. The examination of decisions with a noticing undertone likely focuses more on how teachers' provisional response may in turn influence what they notice and interpret, whereas the investigation of decision with a sensemaking focus may highlight whether the decision is a result of schema instantiation or re-construction. These perspectives are like the pebbles in Pribram's (1979) quote above – when their interactions or inferences with each other are examined, a hologram of the phenomenon that they all try to depict emerges.

The implication of this holographic approach to depicting and conceptualizing the adaptive teaching process is twofold. First, it brings our attention to under-researched areas that may not be revealed under a single theoretical lens and thus contributes to a more comprehensive description of the adaptive teaching process. For instance, there is a need to integrate noticing and its relevant concepts (e.g., perception, attention, situational awareness, etc.) into the conceptualization of the adaptive teaching process. More attention should be paid to how teachers carry out the iterative process of information seeking and knowledge restructuring in their sense-making of complex teaching situations, how teachers weigh instructional alternatives, etc. Second, it supports a non-reductive approach to investigating the dynamic, interactive, and iterative nature of the adaptive teaching processes, where each process connects to and is

reflected by others. Then, the questions become: What connects these processes? What makes these iterations and interactions possible? This leads me to my inquiry in the next section.

Unpack the Blackbox: Adaptiveness of Adaptive Teaching

In their research synthesis of teachers' instructional adaptations, Parsons et al. (2018) conclude that the adaptiveness of teaching has two features. First, it relates to students. Second, there is a common set of teacher actions as instructional adaptations. By now, I hope it has become evident to my readers that while this conclusion may have answered what adaptiveness means behaviorally in teaching, it does not address what adaptiveness means cognitively. How would an adaptive teacher perceive and make sense of students' behaviors, construct a mental model of the teaching situation, come up with instructional alternatives, evaluate trade-offs of each alternative before s/he makes a decision? On the foundation of the dynamic, interactive, and holographically integrative processes of adaptive teaching as sketched out in the section above, I continue my survey of relevant literature to flesh out what adaptiveness means in cognition in general and teacher cognition in particular. I then discuss the implication of CFT on the understanding and examination of the multidimensionality of "adaptiveness" in a complex domain like adaptive teaching.

Various Angles on Adaptiveness

Adaptive Expertise in General. The term "adaptive expertise" was coined to contrast with "routine expertise" (Hatano & Inagaki, 1986). In its original conceptualization, adaptive expertise entails the same extent of domain knowledge and ability to execute familiar procedures flawlessly as routine expertise. The difference is that individuals with adaptive expertise are able to perform effectively and creatively when confronted with situations that are uncommon to their domain, whereas routine experts do not have such ability. Later, some researchers point out that

it is not necessary for individuals to be content experts in a particular domain in order to display adaptive expertise (Fisher & Peterson, 2001; Spiro et al., 2019). Others argue that experts are adaptive by definition and adaptivity is the central quality of expertise (Hoffman, 1998; Ward et al., 2018). While there are different opinions regarding the degree of content mastery in adaptive expertise, one thing remains consistent: Adaptiveness in adaptive expertise (or expertise, depending on the conceptualization) focuses on one's ability to effectively apply, adapt, stretch, and create knowledge to address changing, complex, unpredictable, and non-routine situations.

Researchers have pointed out a number of factors that make adaptive expertise "adaptive." First of all, a knowledge representation (i.e., organization, abstraction, consolidation) that allows for flexibility plays a key role in adaptive expertise (Barnett & Koslowski, 2002; Carbonell et al., 2014; Rayne et al., 2006; Schwartz et al., 2005). For instance, a knowledge organization that links multiple perspectives and solution paths correlates positively with adaptive expertise (Rayne et al., 2006). Relatedly, the correlation between adaptive expertise and prior experiences is mediated by the type of experience and cognitive skills used during the experience. If the experience favors rigid and closed organization of knowledge, then it has a negative impact on adaptive expertise (Rayne et al., 2006). Experience with changing and unpredictable situations or tasks, or experience that requires deep or inductive reasoning skills, on the other hand, positively correlates with adaptive expertise (Barnett & Koslowski, 2002; Reder and Schunn, 1999). In addition, some research found that analogical problem-solving skills (Bell & Kozlowski, 2008), innovative skills (Carbonell et al., 2016), cognitive flexibility (Crawford et al., 2005) are positively associated with adaptive expertise. Lastly, individuals with adaptive expertise are found to have epistemological stances that view knowledge as dynamic

and evolving rather than static (Crawford et al., 2005; Fisher & Peterson, 2001), and that view error-making as learning opportunities (Hatano & Inagaki, 1986).

Adaptive Expertise in Teaching. Adaptive expertise in the domain of teaching shares many features with adaptive expertise in general but also has its own domain-specific characteristics. Lin et al. (2005) proposed the term "adaptive metacognition" to refer to teachers' ability to discover and negotiate conflicting values and practices, and both their willingness and ability to search for what is novel beneath the surface level. Seeking for additional, novel, and contrasting information is thus an important skill of adaptive teachers, so is their use and integration of multiple information and explanations in the process of trying to understand the situation (Crawford et al., 2005; Eilam & Poyas, 2006; Leikin & Dinur, 2007; Lin et al., 2005). Mannikko and Husu (2019) found how teachers used professional knowledge and practical experiences in their instructional adaptation was influenced by two kinds of orientations to teaching. Teachers with a fixed orientation to teaching, which consists of a set of static and pre-existing knowledge structures and routine-like experiences, tend to use more recall and rules, and rely on their predetermined beliefs and habits in their teaching adaptations. Conversely, teachers with an open orientation to teaching, which consists of dynamic and evolving innovative knowledge and skills, are able to use prior knowledge and experiences in novel ways with interactive observations.

Despite existing research on a number of factors associated with adaptive expertise in teaching, many questions await further investigation, especially when these factors are situated within the processes of adaptive teaching as reviewed in the last section. Some of these questions are listed below.

- What is the nature of the knowledge representations that enable adaptiveness in teaching? More specifically, what is considered an adaptive representation of prior knowledge and/or experience? What makes it adaptive?
- How are prior experiences or knowledge structures activated during different processes of adaptive teaching? Would the activation of a prior experience in one subprocess (e.g., noticing) influence other subprocesses of adaptive teaching (e.g., sensemaking, decision-making, etc.) concurrently?
- What subprocesses are influenced by metacognition in adaptive teaching and how?
- What exactly is the adaptive epistemological orientation/disposition composed of?
- What is the relationship between knowledge representation, cognitive skills, and disposition in adaptive teaching?

With these questions, I again expand my literature review to the general research on noticing, sense-making, and decision-making below. Attention is specifically directed to perspectives that are under-researched in the current teacher adaptability literature.

Adaptiveness in Noticing. Adaptiveness is not an explicitly discussed construct in the literature of teacher noticing. In its neutral form, noticing is a shift of attention (Mason, 2002; Scheiner, 2016; Van Es & Sherin, 2002). In the practice of teaching, teachers' attention can be shifted to focus on routine information, but it can also be shifted in a way to sensitize oneself to act freshly rather than habitually (Mason, 2002, 2011). It is the latter that has adaptiveness as an inherent property. Specifically, adaptiveness arises from the intentionality of noticing. For instance, Mason (2011) differentiates among not noticing (e.g., not recognizing or recalling at all), barely noticing (e.g., recognizing upon reminders), marking (e.g., making a remark about what is noticed), and recording (e.g., being able to give brief but vivid descriptions of the

incident noticed). On this basis, he considers experience as fragmentary – when recalling, one recalls marked fragment(s) of the experience and reconstructs these fragments into a story to make sense of the current situation. Therefore, intentional marking is important for future activating and use of prior experience. To be adaptive in this process, Mason (2002, 2011, 2017) suggests one to keep multiple, preferably conflicting, interpretations open when marking and defer classifying, explaining away, choosing among interpretations, or making conclusions. In this way, future incidents in which students act similarly can be approached with complexity and flexibility rather than simplicity and rigidity. This notion of marking fragments of experiences during noticing sheds light on adaptive teaching in terms of prior experience activation. That is, rather than passively perceiving the classroom environment, teachers can intentionally produce adaptive mental representations by marking fragments of their observation with multiple interpretations, which may, in turn, make their future noticing more adaptive.

Adaptiveness in Sense-Making. In the sense-making literature, adaptiveness resides at various levels. First, sense-making is undergirded by an epistemological frame of "figure something out" – to build a new explanation for something not yet understood (Hutchison &Hammer, 2010; Kapon, 2016; Odden & Russ, 2018; Rosenberg et al., 2006). In that respect, sense-making is adaptive by nature. Second, sensemakers are engaged in processes of knowledge integration, where they build new knowledge out of "pieces" of knowledge and high-level concepts abstracted from daily experiences (Hammer et al., 2005). Knowledge/experience integration, again, is a critical component of adaptiveness in sense-making. Third, in a chaotic, complex, and unpredictable environment, sense-making is considered provisional, and doubting is an essential component for adaptive sense-making (Maitlis & Sonenshein, 2010; Weick, 2010). As Maitlis and Sonenshein (2010) state:

> "… all sensemaking is provisional. Doubt reminds us of this provisionality and encourages us to keep generating new understandings (Yanow and Tsoukas, 2009). One never makes a finite sense of a situation because things are always changing. Where commitment, identity, and expectations get us into deep trouble is when we have the false belief that our sensemaking is finished and that we have arrived at the answer." (pp.565-566)

The provisionality of sense-making is of critical importance to adaptive teaching – it sensitizes teachers to the changing environment and encourages them to keep updating their understanding of students as the classroom interactions unfold. However, the provisionality of sense-making in teachers' adaptive process has received little examination conceptually or empirically so far.

Adaptiveness in Decision-Making. Adaptive decision-making has been conceptualized in a variety of ways. Some consider it a rational and thorough analysis of possible alternatives with the goal of finding the optimal choice (Busemeyer & Johnson, 2004; Janis & Mann, 1977; Pitz & Harren, 1980). Others argue that rather than optimizing, humans set the threshold of their weighing among decision alternatives as being sensible and "good enough" (Simon, 1955, 1957). In either case, the awareness of the threshold reveals an important aspect of metacognition in decision-making – knowing when and why to stop and move on is itself an important component of adaptiveness (Glöckner et al., 2014). In addition, some researchers argue that rather than comprehensively comparing alternatives, decision-making is conducted through strategies or heuristics such as eliminating potential decisions that fall below more important criteria (Tversky, 1972), going with the first course of action that makes sense under the current situational constraints (Klein, 2011; Klein et al., 1986), etc. These strategies represent different information search and integration approaches in decision-making. In this regard, adaptiveness

lies within choosing and/or integrating different strategies in one's "adaptive toolbox" (Gigerenzer et al., 1999). Then, how does one decide on the cognitive processes and strategies? Laureiro-Martínez and Brusoni (2018) point out that decision makers' ability to adjust their processing mode to different types of tasks help them become more adaptive. Specifically, if the task environment is well structured with known alternatives, decision makers will achieve higher performance by reacting rapidly to the situational demands, drawing from experience and learned behaviors; if the task environment is ill-structured with unknown options, decision makers will benefit from more deliberate reflection and analysis.

Summary. In sum, research on adaptive expertise, noticing, sense-making, and decision-making has provided a myriad of accounts for what constitutes adaptiveness in adaptive teaching. Relevant constructs range from epistemological orientations, processing modes, cognitive skills, to knowledge representations. Some constructs, such as the epistemological orientations, are studied across contexts. Others, such as the provisionality of sense-making, intentional marking in noticing, awareness of threshold in decision-making, etc., are examined from particular and individual lenses. Regardless of the scope and context of the constructs, each of them brings a critical dimension to cognitive adaptability in teaching. In other words, adaptiveness in teaching is also a multidimensional concept.

The conceptualization of adaptiveness in teacher adaptability is further complicated when the dimensions of adaptiveness are situated in the holographic structure of the adaptive teaching process, where each subprocess (e.g., noticing, sense-making, decision-making, etc.) reflects the whole and the whole is enfolded in all of its subprocesses. First, a dimension of adaptiveness that influences multiple subprocesses of adaptive teaching may vary in its manifestation, depending on the characteristics of the subprocess(es) and other dimensions that influence the same

subprocess(es). For instance, the cognitive skill of seeking multiple perspectives may be manifested in the noticing process in the form of attending to multiple cues, the sense-making process in the form of doubting, and the decision-making process in terms of weighing action alternatives. When theorizing teacher adaptability, therefore, it is important to be able to discern the concrete instantiations of a dimension of adaptiveness and understand the conceptual variability of the dimension as a result of various instantiations.

Second, a feature of adaptiveness that impacts a subprocess of adaptive teaching may spread its influence to other subprocesses as a result of the interactivity among the subprocesses. Take the provisionality of sense-making as an example. If a teacher considers her/his sense-making provisional, s/he will likely consider a potential decision that is based on her/his understanding of the situation provisional as well. S/he may thus be more prone to engaging in an iterative process where s/he notices particular elements in her/his mental simulation of the decision and uses them to update the provisional sense made earlier. In other words, the provisionality spreads from sense-making to decision-making.

Third, the dimensions of adaptiveness may interact with each other across the process of adaptive teaching in various ways. For instance, the intentionally open-ended marking during the noticing process may allow more flexible representations of prior experiences and/or knowledge in the sense-making and decision-making processes. The latter, in turn, can guide one to notice more diverse information about a given incident.

To really understand what adaptiveness entails in adaptive teaching, it is critical to systematically conceptualize and examine the interconnectedness and interdependency among the dimensions of adaptiveness in teaching. Nevertheless, there has not been any framework that provides a coherent and systematic explanation about the inherent relationships among these

dimensions of teacher adaptability. As pointed out in Chapter 2, CFT provides a robust theoretical foundation for an integrative understanding of cognitive dimensions and components involved in adaptive cognition in general. In the following section, I will discuss the implications of CFT as an explanatory framework for adaptive cognition in the domain of teaching, and how that may contribute to a renewed conceptualization of teacher adaptability.

Weaving It Together: Adaptiveness in Adaptive Teaching from A CFT Perspective

Ill-structuredness and Well-structuredness in Teaching. As reviewed in Chapter 2, CFT explicitly differentiates ISDs from WSDs in the discussion of knowledge acquisition and application. Because of the epistemological differences between the two types of domains, strategies of adaptive knowledge acquisition and application that work for one may be antithetical to the other. This distinction yields two important implications to the conceptualization of adaptiveness in teacher adaptability. First, teaching contains both well-structured and ill-structured aspects. On the one hand, classroom teaching often contains routines. Teachers develop a repertoire of routines from their past experience and knowledge, which can be beneficial when teachers respond to certain changes in their teaching (more on this later). On the other hand, researchers argue that the classroom environment is unpredictable and ill-structured (Lampert, 2001; Lin et al., 2005). Even in seemingly routine practice, the application of prior routines may encounter considerable variability (Lin et al., 2005; Mannikko & Husu, 2019). There is rarely a one-size-fits-all solution. This gives rise to the second implication – adaptiveness in teaching is context-dependent. If the problem at hand has a definitive and optimal solution (e.g., whether the students should line up on the left or right side of the hallway), it becomes a well-structured adaptation. Adaptiveness in this case may be as simple as choosing among preconfigured instructional strategies from a teacher's repertoire of

routines. On the other hand, if a problem entails novelty, does not have a definitive or optimal solution, and cannot be solved algorithmically (e.g., how to address a student's question in a culturally responsive way), adaptiveness may require flexible and creative integration of past experiences, knowledge and the current context. This difference between adaptiveness in a WSD and ISD is important, because it prescribes two opposite epistemological stances towards teaching and corresponding cognitive skills needed for adaptation, as to be discussed below.

Expansive Versus Reductive Mindset. CFT argues that the epistemological differences underlying WSDs and ISDs demand very different mindsets for learning. While a reductive mindset that reduces the complexity to mechanistic, compartmentalized, and additive components works well for WSDs, ISDs requires an expansive mindset that tends to the integrative, interdependent, and flexible nature of knowledge. The implication of this CFT feature on teacher adaptability is threefold. First, it provides a theoretical foundation for previous findings regarding teachers' epistemological stances/orientations/dispositions in adaptive teaching, such as the open vs fixed orientations found by Mannikko and Husu (2019), the dynamic vs static orientations discussed by Crawford et al. (2005). Second, it moves beyond the aforementioned research by specifying the domain characteristics (e.g., WSD vs ISD) when discussing the affordances and constraints of each mindset. Both mindsets can lead to behavioral adaptations, but the effectiveness of the adaptation depends on the match between the mindset and the nature of the situation (Laureiro-Martínez & Brusoni, 2018). Therefore, it is important to examine the epistemological underpinning of an adaptive behavior to understand the nature of adaptiveness inherent to such a behavior. Third, in real-world contexts (e.g., classroom teaching), the well- or ill-structuredness is not always straightforward when one encounters a novel situation. In this case, researchers of CFT argue that one should keep the expansive mindset as

the primary and overarching mindset, and switch to a more reductive mindset when regularities are detected, rather than the other way around (Spiro, et al., 1996). The notions of mindset shift and the primary cognitive mindset introduce another layer to the complexity of teacher adaptability, and are worth further investigation.

Understanding Conceptual Variability. CFT emphasizes that people must be able to adapt the meaning of a concept to its context of application as well as to other concepts it is combining with in the particular context (Spiro et al., 1988, 2019). Concerning teacher adaptability, an adaptive teacher needs to avoid the tendency to rely on generic conclusions of a phenomenon (e.g., an English language learner's comprehension error is because of language barriers) or definitions of a concept (e.g., what reciprocal teaching means, see Palincsar et al., 2007 for more details). Rather, the teacher must be able to detect how the meaning of a phenomenon or the use of a concept varies across cases.

Case-Centered Understanding. Related to conceptual variability, another CFT skill is to situate a concept and its interactions with other concepts in the context of cases, rather than reducing cases to mere illustrations of generalizable concepts. One example of case-centeredness in adaptive teaching is a teacher's skill of analyzing the interactivity between conceptual and contextual variables in a past experience, rather than generalizing the complexity of the past experience away.

Crisscrossing. CFT considers the skill to crisscross – to rearrange, reorder, remix, reorganize – conceptual and case elements for different purposes and in different contexts critical for the discovery of interconnectedness and interdependence among concepts. For instance, a teacher's skill to activate and juxtapose multiple and very different prior experiences based on

one incident indicates her/his adaptivity in terms of identifying and using various combinations of conceptual and contextual features of a case/experience.

Seeking Multiple Representations or Explanations. Among all CFT cognitive skills, the skill to seek multiple representations, perspectives, and/or explanations to a phenomenon is perhaps the most studied in teacher adaptability research. Many studies have used a teacher's ability to seek and account for multiple perspectives as an indicator of the teacher's adaptability (Crawford et al. 2005; De Arment, et al., 2013; Lin et al., 2005; Yoon et al., 2019).

Looking for Surprising Similarities/Dissimilarities. CFT emphasizes the ability to look for and identify hidden similarities in knowledge/experience application between different-appearing contexts, and dissimilarities beneath the surface of similar-appearing events (Spiro et al., 2019). The search for surprising dissimilarities is similar to Lin et al.'s (2005) "problem finding" (i.e., searching for contrasting information) and Mason's (2012) emphasis on intentional marking (i.e., marking what is attended to with multiple and preferably contrasting interpretations) as discussed earlier. However, the investigation in the other direction – the identification of surprising similarities among prior knowledge and/or experience – remains scarce in the teacher adaptability literature.

Situation-Sensitive Selective Highlighting. Another skill to aid one's adaptability is to see how a certain aspect, dimension, or manifestation of a concept is highlighted in a particular context and how these highlights vary across situations. In adaptive teaching, this could mean, for example, the teacher's ability to notice and understand how the configuration of an instructional strategy changes as the context changes.

Assembly of Schema-of-the-Moment. CFT's concept of assembly of schema-of-the-moment relates to adaptive teaching at two levels. On the one hand, emphasizing the

combinatory play of ideas/schema (Spiro et al., 2019), this construct partially overlaps with skills such as knowledge integration (Hammer et al., 2005) and innovation (Carbonell et al., 2016) in adaptive teaching and adaptive expertise research. On the other hand, it goes beyond these skills by incorporating metacognitive components such as the awareness of environmental affordances and constraints (see Parsons et al., 2018 for a detailed review on these factors) on a potential schema-of-the-moment and the consideration of trade-offs of the candidate schemas-of-the-moment (Schommer, 2011).

Avoiding Premature Closure. The avoidance of premature closure is another important metacognitive skill emphasized in CFT (Schommer, 2011; Spiro et al., 2019). The only thing that does not change is the change itself. In the context of teacher adaptability, this means teachers acknowledge the provisionality of their sense-making and decision-making, and monitor the efficacy of their instructional responses.

Knowledge Representation. CFT's emphasis on flexible knowledge representations as a premise as well as an outcome of adaptation addresses an important gap in teacher adaptability research. That is, it illustrates how adaptiveness can be achieved at the level of knowledge creation (Spiro et al., 2019). The reciprocal relationship between knowledge representation and adaptive processing skills also reveals the mechanisms underlying the cognitively iterative processes of adaptive teaching (e.g., how the flexible knowledge representation created as a result of adaptive sense-making enables more adaptive noticing, which further influences sense-making and decision-making).

Accelerated Development of Adaptive Skills. Another important strand of CFT research focuses on instructional approaches to accelerating learners' development of an expansive mindset and adaptive skills (Spiro et al., 1987, 1989; Spiro & Jehng, 1990). CFT

researchers argue that oversimplification at the early stages of learning would impede the development of conceptual complexity and thus adaptivity in more advanced learning, so it is important to introduce complexity from the beginning. Nevertheless, the concern over learners' cognitive overload is legitimate. Therefore, CFT advocates the *New Incrementalism* in expertise development. That is, to start with smaller real-world chunks of complexity that maintain the epistemological features of ill-structured domains as an alternative to building from oversimplified to complex (Okolo, et al., 2021; Spiro et al., 2019). Related instructional approaches include direct instruction about the meta-features of the expansive mindset, deliberate practice that exposes learners to a set of carefully-chosen crossroad cases so that learners can examine the connections "across different parts of cases along different conceptual dimensions to emerge in different configurations in different contexts for different purposes" (Spiro et al., 2019, p.965), practice of situation-specific assembly of knowledge and experience, etc. (See Spiro et al., 2017, 2019 for more examples). These practices, carrying a cognitive message about flexibility and adaptability, would accelerate the development of an expansive mindset and adaptive skills that may otherwise require an extended period to possibly develop (Spiro et al., 2019). Lastly, the implementation of these approaches is afforded by a learning environment that is flexible enough to allow the crisscrossing among cases, selective highlighting of case features, context-specific combinatory play of different aspects of cases, etc. (See Spiro & Jehng, 1990 for an example of such environments).

The instructional aspect of CFT provides insights into not only the understanding but also the development of teacher adaptability. It shows that the development of the *ways* to adapt one's knowledge/experience to ill-structured situations does not have to wait for the completion of the development of one's content expertise. Practically, it gives guidance to teacher education and

professional development that aim at developing teachers' adaptability to changing environments. Methodologically, it enables interventions that aim at understanding the role of cognitive adaptability in teachers' noticing, sense-making, and decision-making processes.

Summary. CFT provides an encompassing theoretical foundation to understand and examine the multidimensionality of "adaptiveness" in a complex domain such as adaptive teaching. It sheds light on the question "what does adaptiveness mean in not only the response to but also the understanding of a novel and complex situation?" First, it points out the importance to differentiate adaptiveness in well-structured and ill-structured domains/situations, and thus provides a more refined analytical framework for teacher adaptability. Second, it provides a coherent account for the dimensions of adaptiveness. In an ISD, adaptiveness at the epistemological level refers to the embracing of an expansive mindset as the primary cognitive attunement. At the cognitive processing level, the recognition, mobilization, and re-integration of fragments/aspects of prior knowledge and experiences as interconnected, dynamic, context-sensitive, and re-combinable units is central to the idea of "adaptiveness." More importantly, the relationship among the expansive mindset, flexible knowledge representation, and adaptive knowledge assembly/application is not unidirectional. Rather, they are dynamic and mutually reinforcing. Lastly, CFT provides instructional suggestions on how to develop teacher adaptability.

Models of Adaptive Teaching

The dimensions of adaptiveness and their relationships with each other, situated within the dynamic, interactive, and holographically integrative process of adaptive teaching, bring out the ultimate complexity of teacher adaptability. In this section, I address the third question that

guides my literature review: Is there any available model of teacher adaptability that accounts for and captures the dynamics and complexity of adaptive teaching?

Parsons et al.'s and Gallagher et al.'s Models of Adaptive Teaching

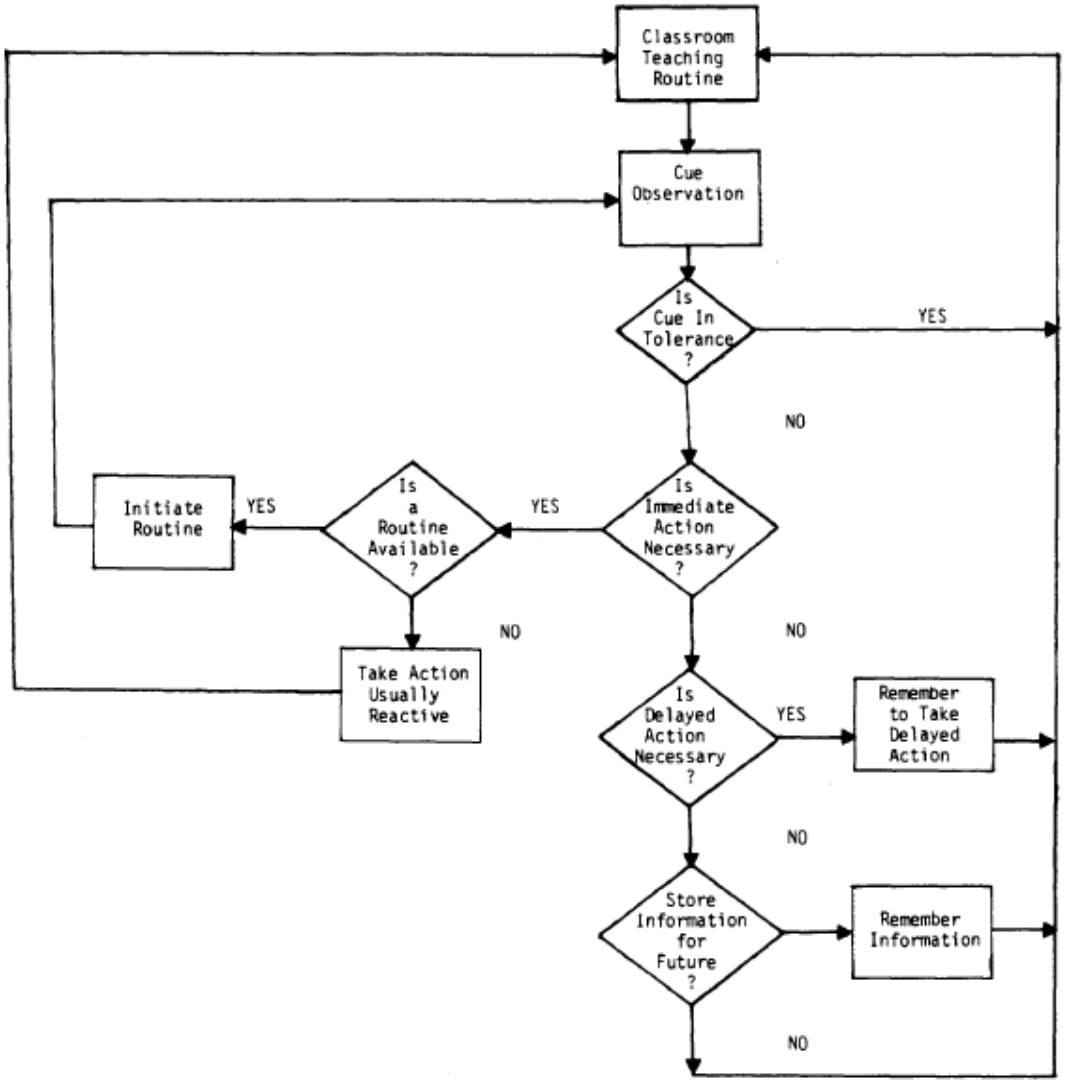
Parson et al. (2018) developed a model of adaptive teaching (Figure 1a) based on their review of 64 studies on teachers' instructional adaptations. In this model, adaptive teaching is a cyclical process among adaptation stimuli, an adaptive individual, and adaptive actions. Teacher reflection, metacognition, and action are influenced by teacher factors, external affordances and barriers. Gallagher et al. (2020) further improved this model by incorporating teacher noticing, especially what they notice (e.g., the stimuli, learning trajectory, or their own actions), into teacher reflection and metacognition (Figure 1b). While both models try to provide an overall picture of factors involved in the feedback loop of adaptive teaching, neither model gives information about *how* these factors influence teachers' attention to, interpretation of, and decision about the teaching situation. In addition, the mix of process-oriented constructs such as teacher thinking with other factors such as teacher beliefs, knowledge, and experience blurs the relationships among these factors. In this sense, this macro-loop among stimuli, metacognition, and action is inadequate at capturing the multilevel and multidimensional nature of adaptiveness.

Shavelson & Stern's Model

In their seminal review on teachers' pedagogical thoughts, judgements, decisions, and behavior, Shavelson and Stern (1981) developed an information-processing model (Figure 4) to depict how teachers make decisions during teaching. In this model, classroom teaching is conceived as carrying out well-established routines and responding to any deviation from the routines.

Figure 4.

Model of Interactive Decision-making



Note. Reprinted from "Research on Teachers' Pedagogical Thoughts, Judgments, Decisions, and Behavior," by R. J. Shavelson, R. J., and P. Stern, 1981, *Review of Educational Research, 51*, p.483. Copyright 1981 by SAGE Publications. Reprinted with permission.

By depicting a process where the teacher actively monitors the students' actions and makes use of previous experiences to address rising changes in the classroom, this model is significant at the time by situating teachers' instructional decisions beyond behaviorism into a

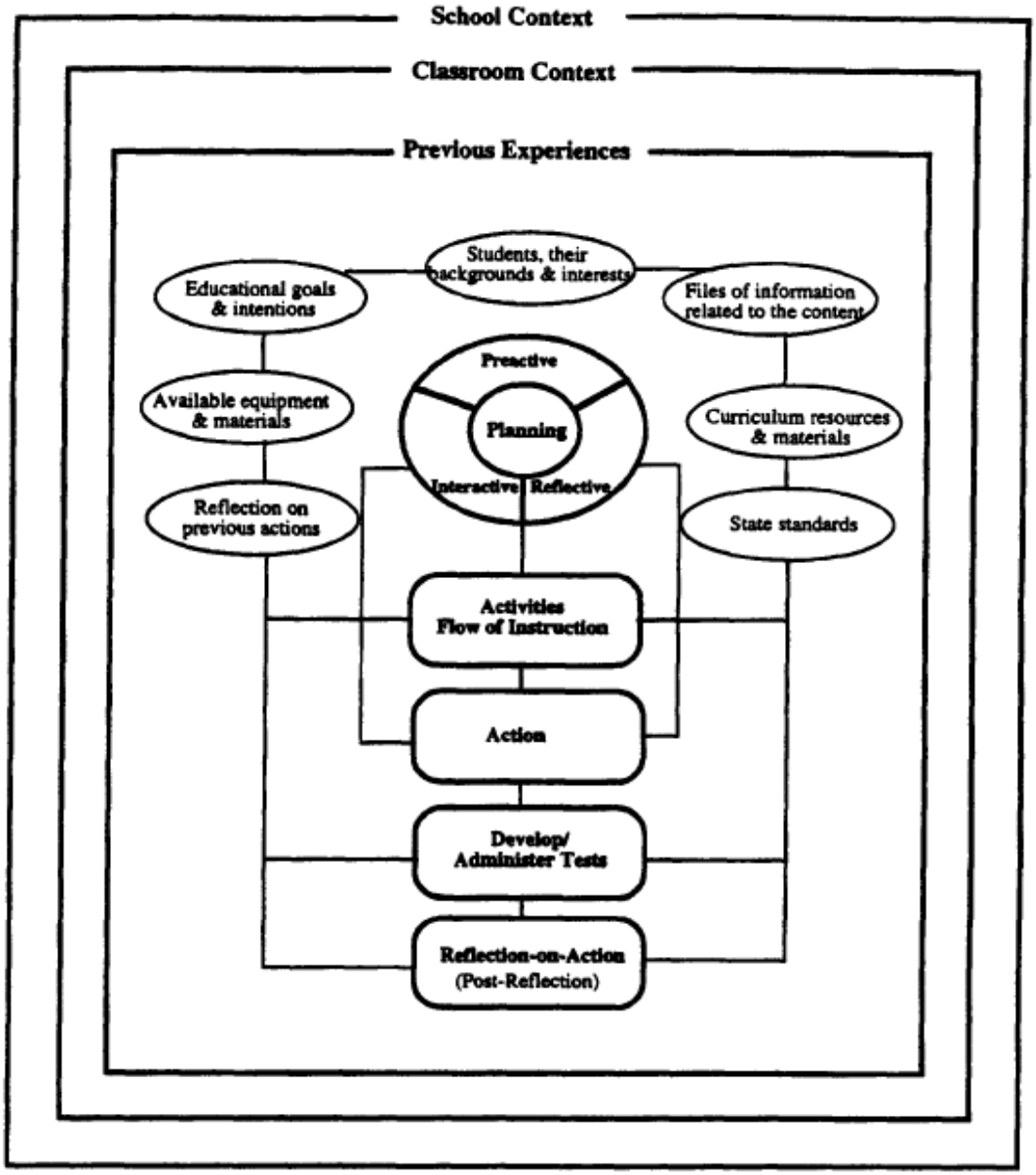
cognitivism paradigm. It also reveals that a lack of behavioral response to an unexpected change in the classroom does not necessarily suggest the absence of cognitively adaptive processes such as noticing, interpreting, weighing options, etc. However, many questions remain unanswered. For instance, what leads, and how it leads, the teacher to notice and become aware of what is going on in the classroom? When the change of routine is deemed necessary, how does the teacher determine that an alternative routine from his/her previous experience may or may not help with the problem at hand? Yet the most significant caveat is its lack of explanation on the creative aspect of teaching. The researchers consider the teacher's reaction "spontaneous" when there is no available routine to address the cue. What does "spontaneous" mean here? What cognitive processes are involved in this spontaneous reaction? In sum, by reducing teaching to selection among well-established routines, this model is oversimplified in many ways.

Moallem's Model

In an ethnographic study, Moallem (1998) examined how an expert science teacher planned, conducted, and reflected on her teaching over a seven-month period. In the model of the teacher's thinking and teaching process (Figure 5), the teacher's thinking was filtered through her perception and interpretation of the contexts based on her past experiences. Moallem argued that the teacher's preactive, interactive, and reflective teaching were all different parts of one activity rather than linearly separated phases in teaching. Therefore, in Moallem's model, the reciprocal relationship between planning and teaching actions happened throughout teaching regardless of the stages. Lastly, Moallem argued that when the teacher decided on the instructional strategy, she simultaneously considered different factors, including information of the context, content, students, as well as the teacher's own goals, objectives, and past experiences.

Figure 5.

Moallem's Model of Adaptive Teaching



Note. Reprinted from "An Expert Teacher's Thinking and Teaching and Instructional Design Models and Principles: An Ethnographic Study," by M. Moallem, 1998, *Educational Technology Research & Development, 46,* p.56. Copyright 1998 by the Association for Educational Communications and Technology. Reprinted with permission.

Moallem's model was conceptually significant in a number of ways. First, the emphasis on the teacher's consideration of multiple factors, as well as the interactive relationship among the teacher's different forms of knowledge, beliefs, actions and reflections bring out the complexity of the teacher's thinking. Second, while many researchers categorize planning as the stage of preactive teaching (Peterson et al., 1978; Shavelson & Stern, 1981), the boundary between planning and plan execution is blurred in Moallem's model. In this sense, planning becomes a cognitive process in which the teacher constructs, revises, and updates a mental model of the teaching situation and its possible solutions through reflection during and after classroom teaching. Such a process happens throughout the entire teaching activity rather than just during the preactive stage. In other words, Moallem's model provides a more integrative account of teachers' thinking during teaching.

Nevertheless, this model has clear limitations. First, it is based on one teacher's teaching practice and therefore is not generalizable. Second, while an interactive relationship among prior experience, contexts, knowledge, and other factors is conceptually highlighted, the researcher's depiction of this relationship stops short at "a simultaneous consideration of different factors" (p.57). The processes through which these factors work together are not reflected by this model. Nor are the iterative processes in which the teacher seeks, integrates, and makes sense of information explicated. Relatedly, how these iterative processes contribute to the teacher's adaptive response are not fully explained by the model. In other words, if one hopes to explain what differentiated adaptive teachers from less adaptive ones, this model is insufficient.

Leikin and Dinur's Model

In their examination of a mathematics teacher's decision-making when managing whole-class discussions, Leikin and Dinur (2007) developed a model that depicted factors affecting

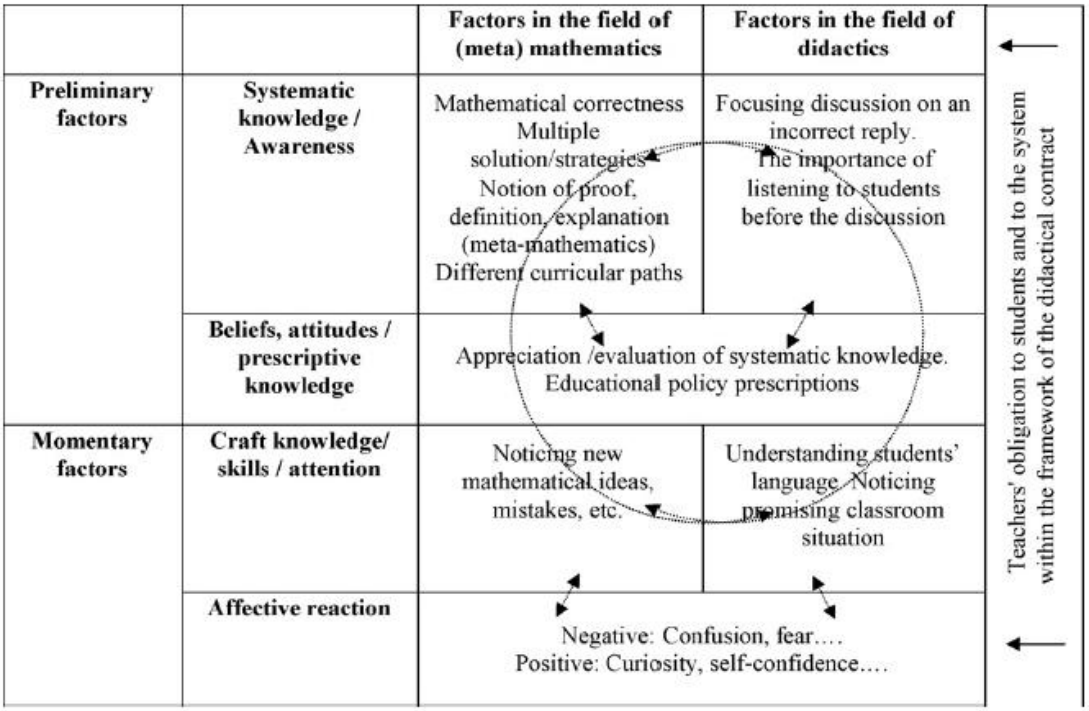
teacher flexibility and the relationships among these factors (Figure 6). This model was designed to highlight three features of these factors: diversity, reciprocity, and intentionality. First, like Moallem's model, Leikin and Dinur's model contains diverse factors that influence teachers' decision-making. The researchers categorized all factors into three groups: preliminary factors, momentary factors, and the teacher's didactical contract (See Figure 6 for details). Second, these factors are often in a reciprocal relationship. For instance, the momentary factors are usually the product of preliminary factors (e.g., the teacher's mathematical knowledge can help him/her notice and understand the potential value of the students' ideas). However, if momentary factors allow for flexibility, the preliminary factors may be modified (e.g., the teacher's curiosity leads to the discovery of additional solutions to the problem and thus enriches his/her knowledge). Lastly, the influence of the preliminary and momentary factors on teacher flexibility is further shaped by the didactical contract – teacher's sense of responsibility towards students. In other words, even if the teacher is aware of alternative directions the discussion may take, s/he may intentionally decide to be inflexible and follow the original plan as a result of his/her commitment to what students must learn.

Leikin and Dinur's model is the only model so far that examines factors, and more importantly, their dynamic interactions, that influence adaptiveness in teaching. Nevertheless, this model does not cover the processes of adaptive teaching. In other words, the interactive relationships among these factors are not contextualized in the interactive and iterative processes of adaptive teaching. Second, this model acknowledges the potential legitimacy and intentionality of teachers' inflexible behaviors in adaptive teaching by taking teachers' didactical contract into consideration. In other words, it does not exclude inflexibility from adaptiveness.

However, other factors that may influence teachers' decision of not altering their behaviors (e.g., the threshold of their teaching practice, time limits, etc.) are not discussed.

Figure 6.

Leikin and Dinur's Model of Teacher Flexibility



Note. Reprinted from "Teacher Flexibility in Mathematical Discussion," by R. Leikin and S. Dinur, 2007, *Journal of Mathematical Behavior, 26,* p.345. Copyright 2007 by the Elsevier Inc. Reprinted with permission.

Summary

In summary, existing models of teacher adaptability tend to exhibit two primary types of reductionism. The first reductionist approach arises from an inadequate distinction between teachers' cognitive processes – such as noticing and decision-making – and their foundational cognitive capabilities, which include constructs like knowledge structure, metacognitive awareness, and reflective competencies within the domain of adaptive teaching. For example,

within Parsons et al.'s (2018) and Gallagher et al.'s (2020) models, teacher thinking is recognized as a contributory factor to teachers' metacognitive processes. However, the models do not sufficiently explicate the distinctions between these intertwined constructs. Furthermore, the models developed by Leikin and Dinur (2007) as well as Moallem (1998) identify determinants such as prior experience or knowledge that purportedly shape teachers' instructional adaptability. Yet, these models conflate cognitive processes with capabilities, at times treating them interchangeably without a clear operational demarcation.

The second form of reductionism is characterized by the models' failure to integrate cognitive processes with capabilities effectively. Models that incorporate an array of cognitive determinants and processes, as documented by Gallagher et al. (2020) and Parsons et al. (2018), amalgamate process-oriented constructs (e.g., teacher thinking) with capability-oriented constructs (e.g., experience, knowledge, beliefs) in a homogeneous category. This conflation occurs without an in-depth analysis of how these constructs interact and inform one another. Additionally, Shavelson & Stern (1981) present models that address potential algorithms of cognitive processes while remaining ambiguous about the cognitive capabilities that facilitate such processes.

These forms of reductionism, specifically the inability to discriminate between the actual cognitive processes of teachers and their cognitive faculties, or to examine on in the absence of the other, lead to an imprecise grasp of this fundamentally complex and nuanced construct. Consequently, this could give rise to explanatory frameworks of teacher adaptability that are incomplete or lack the necessary subtlety.

Chapter Summary

With the goal to understand the intricacies of teacher adaptability, the expansive research synthesis above has revealed three insights. First, adaptive teaching involves processes such as noticing, sense-making, and decision-making that are integral to each other. Together, they form a dynamic, interactive, iterative, and holographically integrative process of adaptive teaching. Second, adaptiveness in adaptive teaching resides at many levels, including epistemological stances, processing skills, knowledge representations, behavioral performance, etc. CFT – centering around how one adapts prior knowledge and experiences to novel, ill-structured, and real-world situations – provides a coherent and systematic theory to conceptualize and examine the multidimensionality of teachers' cognitive adaptability. Third, when various dimensions of adaptiveness are situated within the interactive and iterative process of adaptive teaching (e.g., how the knowledge representation that influences one's noticing affords or constrains the processing skills one uses to construct a provisional decision, and how such a provisional decision feeds back to one's noticing), the inherent complexity of teacher adaptability is further revealed.

Meanwhile, the critical review of the existing teacher adaptability literature has also revealed two gaps in the current teacher adaptability research. First, there is not yet a sufficiently comprehensive depiction of the cognitive processes and their interrelationships to capture the *dynamics* and *complexity* of teachers' mental activities during instructional adaptation. Second, there is not yet a systematic explication of teachers' cognitive readiness for adaptation – a *multidimensional* concept consisting of interrelated cognitive elements such as epistemological mindsets, cognitive skills, and knowledge representations that explain the nature of the adaptive behaviors.

As elaborated in the summary of my examination of existing models of teacher adaptability, I argue that an important contributor to the gaps above is the lack of a theoretical framework of teacher adaptability that not only *differentiates* but also *integrates* cognitive processes and the underlying cognitive capabilities of adaptative teaching. This conclusion provides insights into the last question at the end of Chapter 2 – which characteristics should a model of teacher adaptability incorporate to address the gaps in the current conceptualization of teacher adaptability? To begin with, the model must delineate, in a comprehensive manner, the potential cognitive processes involved in adaptive teaching. It is crucial that the model also reflects, in a flexible manner, various ways in which these cognitive processes may interact with each other. As a result, the model can reflect and highlight different cognitive processes, interactions, and pathways that are unique to the individual contexts of adaptive teaching. Furthermore, the model must distinguish cognitive processes that drive teachers' adaptive performance and the underlying capabilities that contribute to teachers' adaptive readiness. It should also explicate how different cognitive capabilities for adaptation are interrelated. Finally, and of equal importance, the model should facilitate a methodical exploration of how cognitive capabilities and processes interact. These aforementioned characteristics set the stage for introducing a new theoretical framework of teacher adaptability, which will be elaborated in the following chapter.

CHAPTER 4: TEACHER ADAPTIVE-COGNITION THEORY

The lack of a theoretical model that not only differentiates but also integrates the cognitive processes and cognitive mechanisms of adaptive teaching, as illustrated in Chapter 3, calls for a new framework of teacher adaptability. To address this void in the current teacher adaptability research, I propose the Teacher Adaptive-Cognition Theory (TACT) – a new model of teacher adaptability. The TACT framework provides two closely related yet distinct accounts of teacher adaptability. The first is a *descriptive* account that scrutinizes the dynamic cognitive processes that drive adaptive teaching. In particular, this part of the TACT model (Figure 7) depicts teachers' cognitive and metacognitive processes of adaptive teaching, and highlights the interactive, interrelated, and iterative relationships among these processes. The second account is an *explanatory* account that investigates various dimensions of teachers' cognitive abilities that may impact their adaptive teaching processes. Guided by the CFT framework, this part of the model (Figure 8) situates the aforementioned cognitive and metacognitive processes within a multidimensional system of cognitive capabilities for adaptation. While each account brings in unique complexities of adaptive teaching, neither of them alone fully constitutes teacher adaptability. Therefore, the TACT model highlights the *interactions* between these two aspects and the *variability* of such interactions in different contexts.

Cognitive Processes of Adaptive Teaching

The first part of the TACT model (Figure 7) maps out the cognitive and metacognitive processes that drive teachers' adaptive performance. The context of teaching is dynamic, shaped by the interplay between two key components: situational facts and student actions. Situational facts comprise tangible elements such as classroom setup and teaching materials, as well as intangible elements like the social, cultural, and linguistic backgrounds of students. These

components serve as historical records, reflecting the cumulative experiences and actions of everyone involved in the teaching and learning process. Take, for example, the scenario presented in Chapter 2 involving Mutsumi. The worksheets distributed by the teacher are imbued with a wealth of considerations: the teacher's grasp of the subject matter, educational objectives, and an understanding of the students' abilities and needs. Similarly, Mutsumi's linguistic background is a tapestry of her cultural and educational journey brought into the classroom setting.

Figure 7.

The Integrated Model of Teacher Adaptability (Part I)

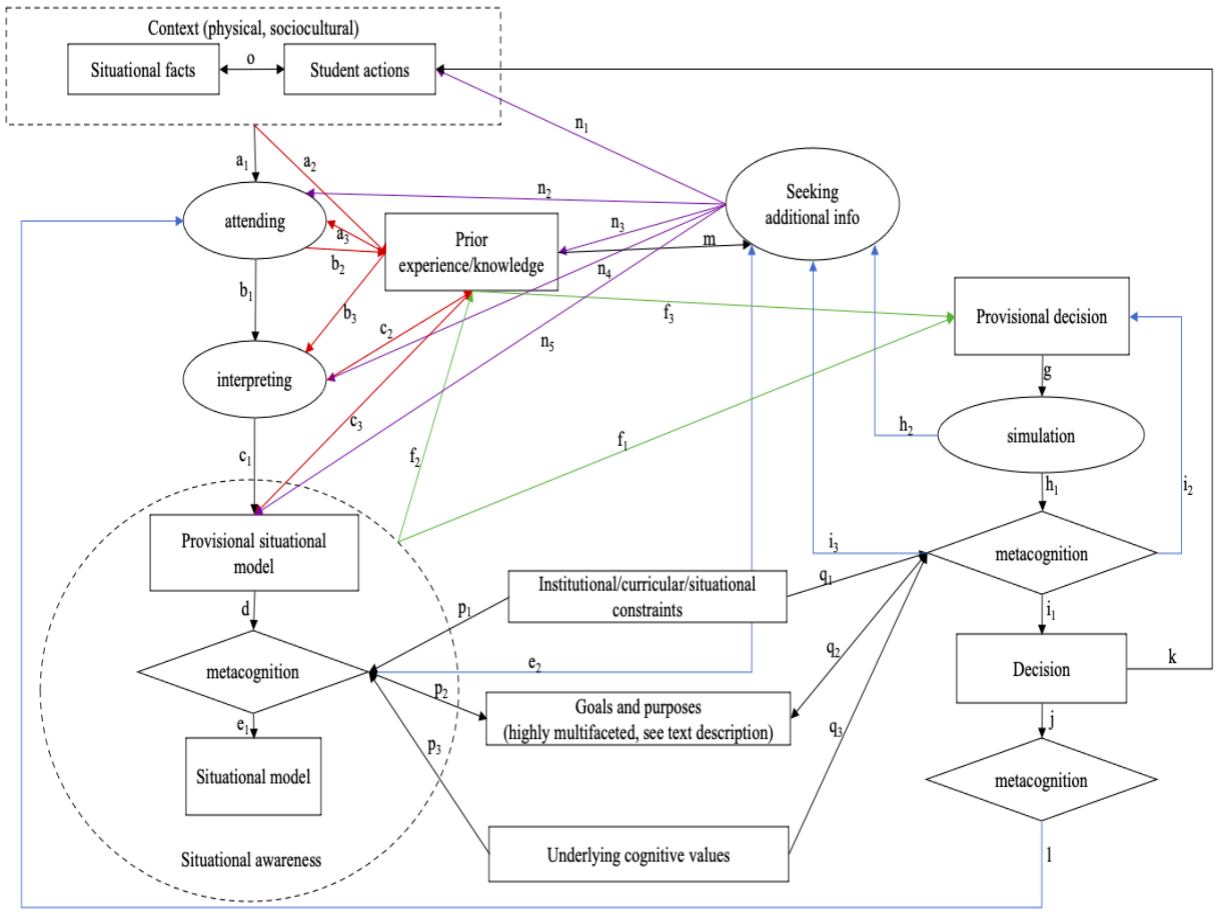
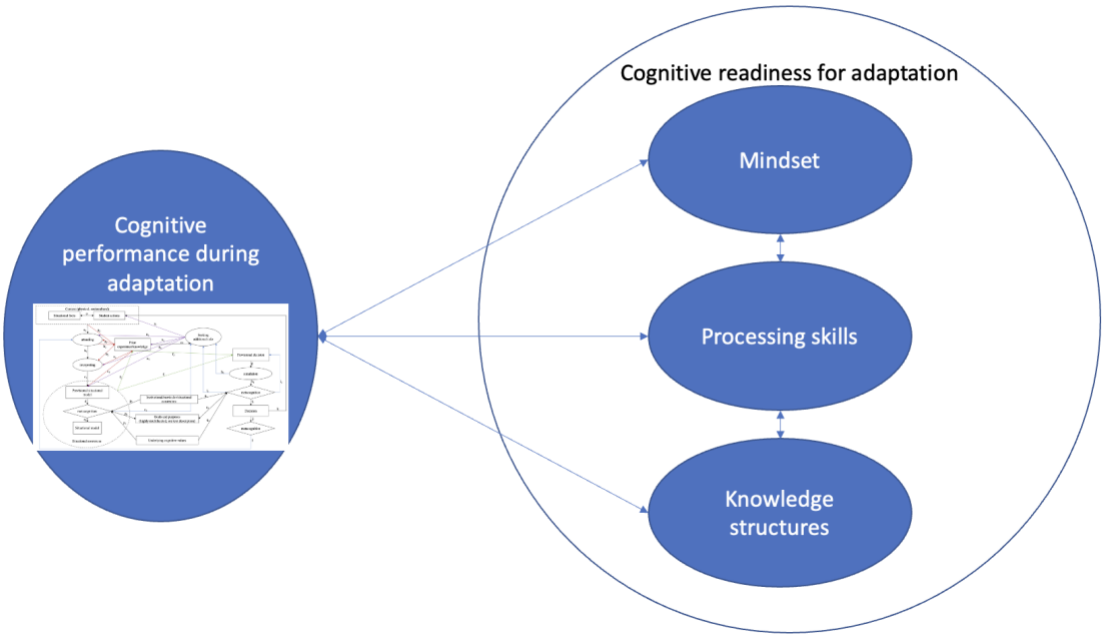


Figure 8.

The Integrated Model of Teacher Adaptability (Part II)[1]



However, these situational facts are not mere static backdrops. They are dynamic entities within the sociocultural discourse, continuously shaped by the interactions between students and teachers. As learning progresses, these elements evolve. For example, as students engage with a worksheet, it becomes a canvas reflecting not only the teacher's instructional intent but also the students' comprehension of the material. Moreover, classroom language policies, such as restricting the use of languages other than English, may not alter a student's heritage but can significantly affect the extent to which students contribute their linguistic and cultural knowledge to the learning environment.

[1] The second part of the TACT model focuses on the relationship between cognitive readiness for adaptation and cognitive performance of adaptation. However, it does not mean that the latter is only influenced by the former, or that cognition is rational, logical and functions without emotion. Quite to the contrary, cognition can be influenced by motivational factors such as goals, emotion, and values, as well as external factors such as curriculum, policy, and time constraints.

Student actions, the second critical component, refer to students' behaviors in the learning process. As denoted by process o, these actions are both influenced by situational facts and can modify them. For instance, the interactions Mutsumi has with her peers are facilitated by the teacher-provided worksheet, yet they also contribute to the evolution of that worksheet as a learning tool. Like situational facts, student actions are embedded in the sociocultural discourse, collaboratively constructed by both teachers and students. In essence, the teaching context is neither static nor isolated. It is a continually evolving ecosystem influenced by the ongoing process of teaching and learning.

The processes labeled a_1 and a_2a_3 delineate the teacher's efforts to perceive and identify contextual changes that are salient – for instance, Mutsumi's facial expressions – and/or that activate recollections of the teacher's past knowledge and experiences, such as recognizing Mutsumi's hesitation in relation to a problem that previously perplexed other students. The information that captures the teacher's attention is then interpreted: b_1 represents interpretation within the immediate context, while b_2b_3 signifies interpretation through the lens of past knowledge or experiences. For example, the teacher might interpret Mutsumi's perplexity by considering the current problem she is attempting to solve, evaluating her dynamics with her classmates, reflecting on what is known about Mutsumi's linguistic heritage, and/or recalling a similar problem that confused previous students, among other factors. Each piece of information – whether a current observation or a recalled event – contributes to the teacher's overall interpretation of the situation. In other words, this cognitive interpretation is a multidimensional process, factoring in the immediate situational variables as well as the teacher's accumulated and marked (Mason, 2002) prior professional knowledge or experiences.

Drawing upon the interpreted cues, the teacher constructs a mental model to make sense of the situation, integrating reasoning about the current context (c_1) and/or prior knowledge/experience (c_2c_3). This integration culminates in situational awareness, defined by Endsley (1995) as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (p.36). The development of situational awareness can be further broken down to the formation and evaluation of provisional mental models of the situation. As mentioned earlier, provisionality is a critical feature of adaptive sense-making (Maitlis & Sonenshein, 2010; Weick, 2010). When a provisional mental model is formed, the teacher can engage in metacognitive activities to assess its suitability against the current context. These activities encompass assessing institutional/curricular/situational constraints (for example, the urgency of resolving a problem), goals and purposes[2] (such as fostering an inclusive classroom or preparing for tests), and underlying cognitive values (like the conscious pursuit of diverse explanations).

The metacognitive processes as referenced above may solidify a mental model applicable to the moment at hand (e_1) or prompt the teacher to seek further information (e_2). In Mutsumi's scenario, Teacher C initially attributes the student's confusion to a misunderstanding of the terms "cobra" and "python." However, the teacher's cognitive commitment to considering multiple explanations drives a deeper inquiry, leading to the hypothesis that Mutsumi might also be grappling with the concept of the prey-predator relationship.

Situational awareness plays a crucial role in guiding decision-making. A teacher's decisions are informed by both an acute awareness of the present circumstances (f_1) and a

[2] It is worth mentioning that the goals and purposes are highly multifaceted and may evolve as the situation unfolds. Discussion on the nature of goals in adaptive sense-making is beyond the scope of this paper, but one can refer to Klein et al.'s (2007) Flexecution model for more details.

reservoir of prior knowledge and experience in decision-making (f_2f_3). This dual awareness facilitates the assembly of situation-specific schemas for decision-making. During this phase, the teacher may mentally simulate the potential decision (g) to anticipate its outcomes, an exercise that may uncover gaps in information, prompting a new cycle of information seeking (h_2). Consider the example of Teacher D in Mutsumi's case. Upon simulating the outcome of providing direct instruction to Mutsumi, Teacher D realizes that she has overlooked the possible assistance that Mutsumi's partner, Jeff, could offer. This insight prompted her to reflect on Jeff's understanding of the topic and integrate it into her revised decision.

These provisional decisions undergo scrutiny through metacognitive reflection, considering factors such as time constraints (e.g., the urgency of action), goals and purposes (e.g., the preference for direction instruction versus collaborative learning), and cognitive values (e.g., assessing unexpected correlations or deviations from past experiences). Such metacognitive activities may result in a balanced solution of the moment (i_1), direct revision of the provisional decision (i_2), and/or search for additional information (i_3). In the scenario with Mustumi, Teacher D's commitment to engaging all students in constructive science inquiry influences her choice to refrain from intervening, allowing Jeff to collaborate with Mutsumi on the problem.

Once a decision is enacted, it can impact the context, especially students' actions (k), necessitating the teacher's active and deliberate monitoring (l). In Mutsumi's case, Teacher D's resolve to "see what their final report looks like" exemplifies such vigilant follow-up post-decision. This iterative process of decision-making and monitoring is crucial in adapting teaching strategies to meet the evolving needs of the classroom.

The aforementioned processes are inherently non-linear. The activation and mobilization of prior knowledge/experience (as indicated by processes a_2a_3, b_2b_3, c_2c_3, f_2f_3) often reveal

discrepancies or gaps when juxtaposed with the present context, prompting further information seeking activities (m). These activities, in turn, could impact students' actions (n_1), teacher's noticing (n_2), interpretation of the context (n_4), construction of situational models (n_5). The search may also encourage the re-evaluation and potential revision of one's existing knowledge or experiences (n_3). Consider the examples of Teacher C and Teacher D in Mutsumi's case. Both teachers' prior experiences with students who had difficulty grasping the prey-predator concept lead them to question the initial assumption that Mutsumi's confusion is solely due to her linguistic capabilities. Faced with insufficient evidence to support either hypothesis, this recognition of an information gap incites Teacher C to initiate a clarifying dialogue with Mutsumi. Similarly, Teacher D embarks on an information search, informed by the recollection that related English terms had appeared in earlier worksheet questions. This insight prompts a review of Mutsumi's worksheets to verify her understanding of those terms, consequently refining Teacher D's mental model of the situation. When Teacher D contemplates providing direct instruction on the prey-predator relationship but hesitates, she opts to gather more information. This shifts her attention to Jeff, Mutsumi's partner. She further attempts to gather information based on her prior knowledge of Jeff's mastery over the topic so as to assess whether Jeff might be able to assist Mutsumi. She also attends to the collaborative dynamics between Jeff and Mutsumi to deliberate whether it can be a collaborative opportunity that benefits both students. Both Teacher C's and Teacher D's cognitive activities exemplify the nonlinear and recursive nature of the processes of noticing, sense-making, and decision-making in adaptive teaching. As discussed in depth in Chapter 3, these processes, rather than segmented, sequenced, and isolated, expand into and exert influence on each other, forming a hologram of the total process of adaptive teaching. This holographically integrative process of adaptation is enabled by

the teacher's active and intentional engagement in adaptive information-seeking within the context of their accumulated knowledge and the immediate circumstances of the classroom.

In addition to information seeking, the nonlinearity of the processes is afforded by flexible access and use of prior experiences/knowledge. For instance, if a particular prior experience is activated when one tries to interpret what s/he attends to, the solution aspect of the same experience – how problems were solved in the particular prior experience – may be activated as well, which could directly project to the construction of a provisional decision even though a situational model is not fully built. Take Mutsumi's case as an example again. When Teacher C tries to understand Mutsumi's confusion, he activates his prior experience with students who were confused about a prey-predator relationship. At the same time, other aspects of the same experience, such as how he has addressed this problem in the past, may also be activated as an instructional alternative, even though a mental model of Mutsumi's situation is not fully formed or finalized. Similarly, when prior knowledge/experiences are activated in the assembly of a decision of the moment, contextual variables in the particular knowledge/experiences may bring in new insights about the current situation and thus update one's understanding of the situational model in sense-making. In other words, a prior experience/knowledge acts like a complex and rich hub with spokes pointing to other related experiences, concepts, solutions and thus influencing multiple adaptive processes simultaneously. Such nonlinearity explains, to a certain degree, what Moallem (1998) meant about "a simultaneous consideration of different factors" (p.57). It also speaks to the dynamic and holographic nature of the adaptive teaching process. That is, instead of following a linear "noticing → sense-making → decision-making" algorithm like a computer program, the adaptive teaching process consists of the activation, contextualization, and integration of multiple aspects

of prior knowledge/experiences that bring forward various cognitive processes. The prior experience/knowledge hubs thus are what weave together the cognitive processes such as noticing, sense-making, and decision-making.

Lastly, it is worth noting that the cognitive and metacognitive paths delineated in this model are all possible mental processes a teacher can go through in adaptive teaching, but a teacher does not have to go through all of the processes to be adaptive. For instance, when time is of the essence, there may not be many or any occurrences of additional information seeking. If the problem at hand has a clear and logical solution based on the contextual variables, prior knowledge/experience may not always be activated. Meanwhile, going through all the processes does not guarantee the adaptiveness of the decision. This brings me to the second part of this model as explained below.

Cognitive Capabilities of Adaptive Teaching

While the first part of the TACT model delineates the cognitive pathways a teacher might navigate during adaptive teaching, the second part of the TACT model, informed by the CFT framework and depicted in Figure 8, illustrates the complexity and interrelated nature of the cognitive capabilities foundational to adaptive teaching. This part of the model posits that each aspect of the cognitive process in adaptive teaching, as outlined previously, is shaped by several core elements: the teacher's epistemological mindset (expansive vs reductive), their processing skills (such as seeking multiple representations, doubting, looking for surprising similarities and dissimilarities, context-specific selective highlighting of conceptual aspects, and so on), and the adaptability of one's knowledge structures. Consider, again, the adaptive responses from different teachers in Mutsumi's example. Teacher B's response could be influenced by a reductive mindset that simplistically and rigidly relies on a sole and pre-configured knowledge

structure – English language learners' developing English proficiency – to interpret every obstacle Mutsumi encounters in her learning. This reductive mindset creates a cognitive shield that allows the teacher to explain away any inconsistent data and thus turn a blind eye to other potential explanations. In contrast, both Teacher C and Teacher D have an expansive mindset and flexible knowledge structure about English language learners' learning needs, which allow them to keep an open mind when encountering a new problem and intentionally look for alternative explanations. However, Teacher C and Teacher D employ different cognitive skills in their response to the alternative explanation. Teacher C sees the similarity between his previous students and Mutsumi in terms of their conceptual misunderstanding of the prey-predator relationship, so he provides more examples of the prey-predator concept – a response that worked before. Teacher D, on the other hand, sees the similarity as Teacher C does, but he also notices the dissimilarity between these two seemingly similar events. That is, Mutsumi's partner Jeff may be able to engage Mutsumi in a constructive conversation to clarify this concept. So, he chooses to keep observing rather than intervening.

These aforementioned elements are not isolated. They exert mutual influence, creating an interconnected web of cognitive dimensions that collectively inform a teacher's adaptability. In particular, one's mindset can influence the use of cognitive skills in problem solving. This is consistent with findings from previous research on teachers' epistemological orientation towards teaching and its impact on teachers' adaptive teaching strategies (Crawford et al., 2005; Mannikko & Husu, 2019). Meanwhile, the acquisition and application of cognitive skills may contribute to the development and activation of certain mindset. For instance, teachers' skill of seeking additional and unconforming information may contribute to their increasing awareness of the variability of the same concept across teaching scenarios and values (Lin et al., 2005).

Also, teachers' skills of noticing new mathematical ideas may influence their evaluation of systematic knowledge (Leikin & Dinur, 2007). Furthermore, although remaining as an under-researched area in teacher adaptability, researchers from the broader adaptive decision-making field have argued that the metacognitive skill of reflecting on the nature of the problem at hand and matching it with the corresponding cognitive mindset is in itself an attribute of adaptability and can further enhance the adaptive response of the problem solver.

The interconnectedness among the adaptive elements is also evidenced through the reciprocal relationship between adaptive skills and flexible knowledge structure. For instance, as discussed in-depth in Chapter 3, the skill of doubting – an essential component of adaptive sense-making (Maitlis & Sonenshein, 2010; Weick, 2010) – reminds the sense-maker of the provisionality of the knowledge structure. Similarly, the skill of intentional marking of multiple, preferably conflicting, interpretations during the noticing process (Mason, 2002, 2011) affords an open and flexible mental representation of the knowledge or experience for later adaptation. Conversely, a flexible mental representation, consisted of interconnected and mobilized fragments of past knowledge and experience, makes it possible for one to develop and practice the skills such as recognizing novel information underneath the surface, selectively highlighting situation-specific aspects of knowledge or experience, and integrating past knowledge and experience to assemble the schema-of-the-moment (Spiro et al., 1988, 1996, 2019).

Last but certainly not the least, the second part of the TACT model differentiates teachers' cognitive performance during adaptation from their cognitive readiness for adaptation, both of which are indispensable aspects of teacher adaptability. Cognitive readiness for adaptation is a cognitive predisposition that is influenced by cognitive elements such as the mindset, cognitive skills, and knowledge structure. However, cognitive performance during

adaptation is not influenced by one's cognitive readiness alone and should not be confounded with the latter. Teachers' adaptive performance can also be impacted by motivational factors such as emotions, goals, and values, external factors such as curricular, resources, and policy constraints, and so on. Furthermore, while teachers' cognitive readiness for adaptation can influence their adaptive performance, the influence could be mutual, especially when facilitated by deliberate practice that guides teachers to reflect on their cognitive activities during adaptation, raises teachers' awareness of the ill-structuredness of teaching, and helps teachers practice cognitive skills and develop knowledge structures needed to navigate such ill-structuredness.

In conclusion, existing teacher adaptability research has examined some of the individual elements or relationships as referenced above. Nevertheless, the TACT model provides a systematic framework for the investigation of the interconnectedness among these elements. This interconnectedness underscores the need for a holistic understanding of how these various cognitive capabilities contribute to the adaptive teaching process.

An Integrative Framework of Teacher Adaptability

The TACT model not only distinguishes between the cognitive processes and capabilities essential to adaptive teaching but also integrates these critical aspects of teacher adaptability. As to be elaborated below, by contextualizing the examination of each aspect within the other, the model facilitates a systematic exploration of the multifaceted and dynamic complexities inherent to the adaptability of teachers.

First, the TACT model examines cognitive capabilities within specific cognitive processes, thus providing a framework to analyze the variability of the same cognitive capabilities in different adaptative processes. Specifically, when the same adaptive capability is

situated in different cognitive processes of adaptive teaching, they may be manifested differently. For instance, the cognitive skill of seeking multiple perspectives can be expressed in different ways: it might emerge as the recognition of diverse cues during processes a_1 and a_2a_3, or as weighing action alternatives in i_1, i_2, and i_3. Likewise, the interaction between two cognitive capabilities may present distinctively across various cognitive processes. For instance, the influence of an expansive mindset on the skill of looking for surprising similarities or dissimilarities may be manifested in a_1 and a_2a_3 as intentional marking of conflicting information, b_1 and b_2b_3 as doubting, and e_2 as active search for unconforming information.

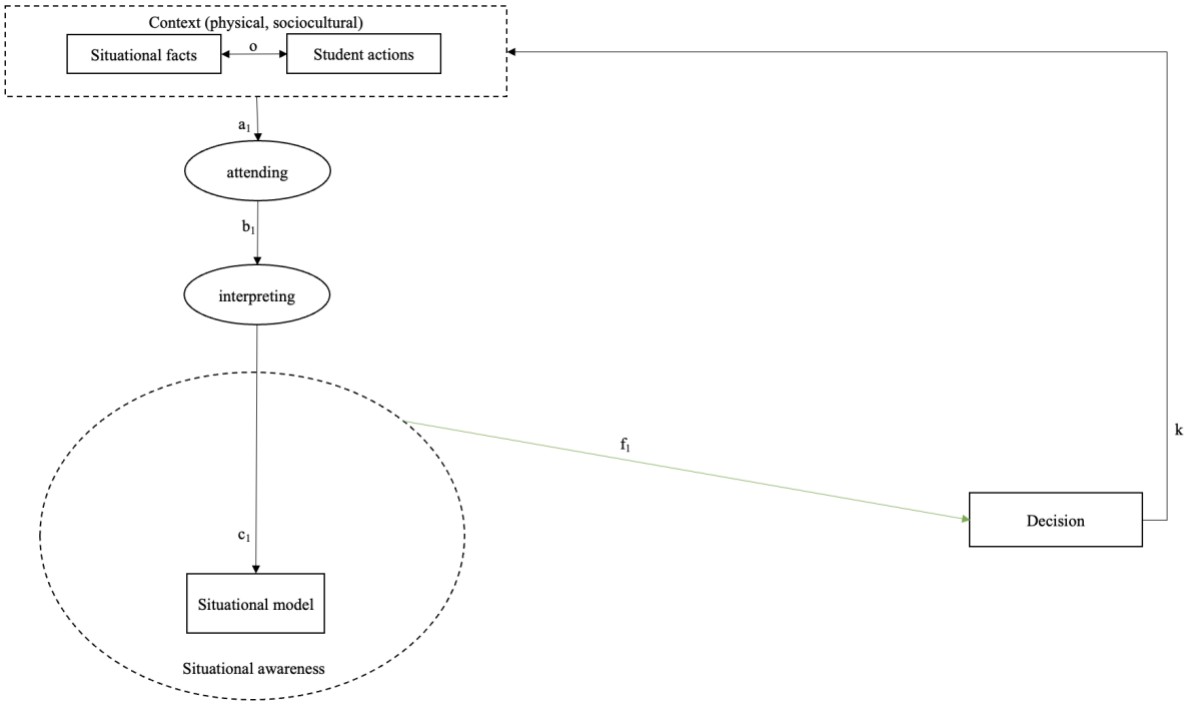
Another ramification of the TACT model's nuanced approach to understanding cognitive capabilities within adaptive teaching activities is that it offers a refined analytical framework to differentiate seemingly similar adaptive behaviors. By dissecting the intricate workings of cognitive processes and capabilities, the model enables researchers to identify and analyze the subtle distinctions in cognitive functioning that give rise to particular adaptive actions. For instance, both Teacher B and Teacher D in Mutsumi's case engage in the behavior of assessing, an adaptive behavior listed in Parsons et al.'s (2018) model. Teacher B's assessing behavior is mainly manifested through process a_1 and b_1, reflecting his ability to notice salient and situation-specific cues such as Mutsumi's facial expression and linguistic background. However, Teacher D's assessing behavior – scanning Mutsumi's worksheet to clarify the student's understanding of the related English terms – is mainly manifested through processes c_2, m, n_2 and b_2b_3, reflecting his ability to seek surprising similarities and dissimilarities, as well as to avoid premature closure. Clearly, both Teacher B and Teacher D engage in adaptive teaching, but there are inherent differences between their adaptability.

Second, the TACT model enables researchers to explore the broader ramifications of a cognitive capability in a systematic way, examining how it permeates and impacts related cognitive processes, as well as the interactive pattern among these processes. As elaborated upon in Chapter 3 and revisited earlier this chapter, the TACT model underscores the inherently integrative and interactive nature of the cognitive processes during adaptation. Each individual cognitive process is inherently integral to the rest of the cognitive activities. Any impact on an individual cognitive process has a rippling effect on other related cognitive processes and thus the whole adaptive process. This feature of the model facilitates analyses that extend beyond the direct influence of a single cognitive capability on a specific cognitive process.

Take the influence of the epistemological mindset on teachers' sensemaking processes in Mutsumi's case as an example. Teacher B's reductive mindset influences her interpretation of observed cues, markedly affecting process b_1, where she primarily considers the most overt cues – Mutsumi's facial expression and linguistic background. This effect is not confined to b_1 but extends to other cognitive processes, including a_1 (only attending to the immediately obvious cues in the context), c_1 (forming one and only one situational model), f_1 (forming one and only one decision based on immediately available cues). This extensive influence fosters a linear cognitive pathway for Teacher B, as depicted in Figure 9a, characterizing her adaptation to the new situation.

Figure 9a.

Teacher B's Cognitive Processes of Adaptation

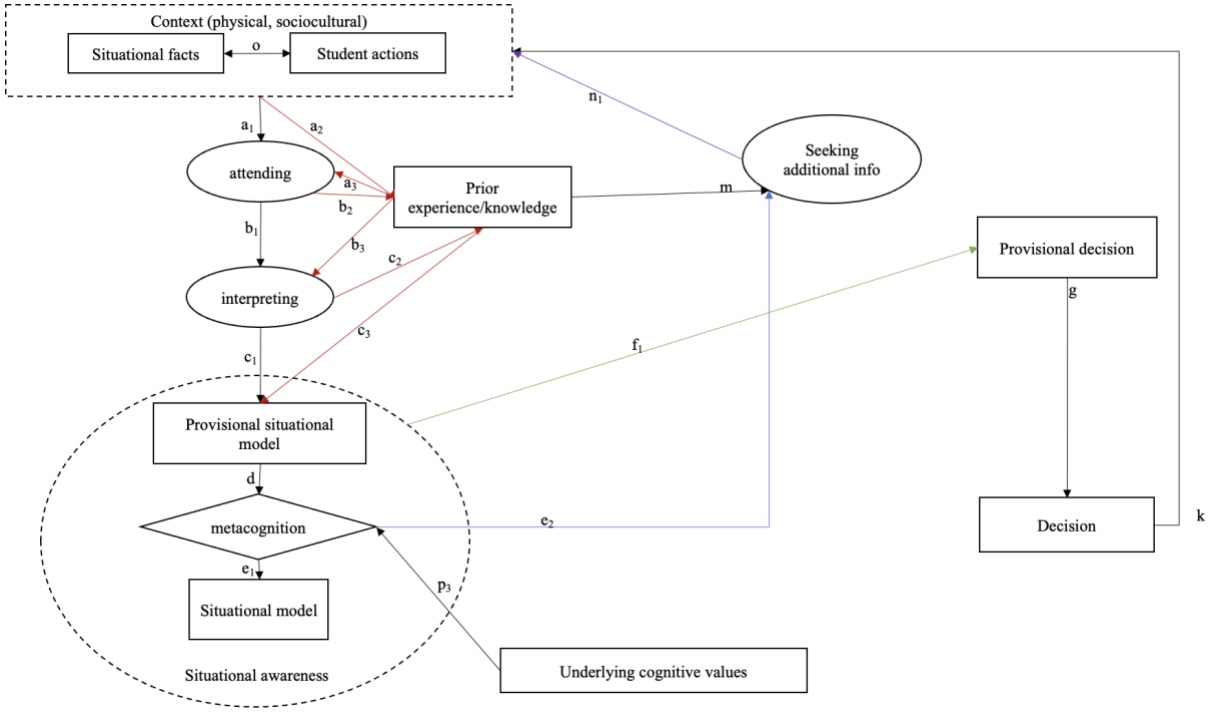


Conversely, Teacher C's expansive mindset triggers a broader activation of cognitive processes as illustrated in Figure 9b, such as recalling similar confusion from previous students in b_2 and forming alternative interpretations of observed cues in b_3. This effect does not merely operate in isolation but "lighting up" various processes depicted in the TACT cognitive map in a non-linear way. In particular, it encourages a more comprehensive search for understanding in e_2 (realizing the needs to seek deeper insights into potential conceptual misunderstanding rather than just linguistic ones) and m (seeking further signs of conceptual instead of linguistic misunderstanding), initiates additional information gathering through interacting with the student in n_1, and facilitates attention to diverse indicators in the student's answer that signify a conceptual misunderstanding in a_2a_3. This approach also leads to another round of b_2b_3 when the teacher interprets multiple cues based on newly collected data, and $c_1c_2c_3$ when the teacher forms

a candidate schema of the moment based on both immediate context and prior experience. Ultimately, Teacher C's expansive mindset lays the groundwork for a dynamic and non-linear array of cognitive activities.

Figure 9b.

Teacher C's Cognitive Processes of Adaptation

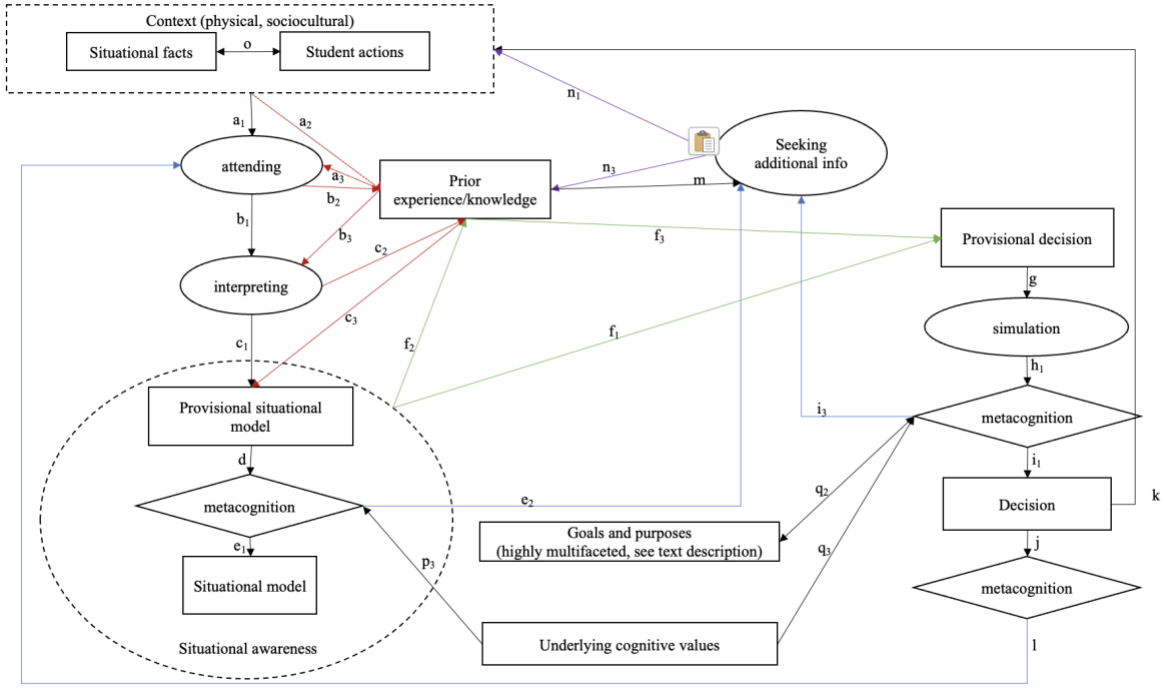


Teacher D's cognitive performance is also influenced by her expansive mindset. The direct impact of the expansive mindset on concrete cognitive processes can be observed at multiple occasions in Teacher D's case. As illustrated in Figure 9c, the rippling effects of these direct influences of the expansive mindset, when woven together, form a complex mental map of Teacher D's adaptation in teaching. More specifically, Teacher D's expansive mindset activates b_2b_3 when she tries to interpret Mutsumi's noticeable hesitation. Similar to Teacher C's case, it has a rippling effect on other cognitive processes such as e_2 and m. This rippling effect is further mediated by Teacher D's flexible knowledge of the worksheet. That is, the worksheet is not

merely regarded as a physical artifact that facilitates students' learning, but also a collection of information that can be versatilely utilized to facilitate teachers' in-the-moment assessment of students' understanding. This flexible mental representation of the worksheet enables the teacher's search for additional information within her knowledge of the worksheet structure in n_3 and for Mutsumi's answer to previous questions that involve the same English terms on the worksheet in n_1. These cognitive activities further lead to a new round of $a_1a_2a_3$ (attending to salient cues in the context as well as hidden ones facilitated by prior experience), $b_1b_2b_3$ (interpreting cues observed within the context as well as informed by prior experience), and $c_1c_2c_3$ (constructing mental models of the situation based on the interpretations of the immediate context and prior experience). Meanwhile, another direct effect of Teacher D's expansive mindset is observed in processes $f_1f_2f_3$, where she actively explores and evaluates multiple solutions to the problem at hand, such as providing direction instruction for Mutsumi and encouraging peer collaboration between Mutsumi and her partner, Jeff. This effect also creates a rippling effect on other cognitive activities, such as seeking information about the two students' collaborative dynamics in n_1 and recalling Jeff's understanding of the concept in n_3. These information seeking activities, again, enable another round of attending ($a_1a_2a_3$), interpreting ($b_1b_2b_3$), and mental model construction ($c_1c_2c_3$). It also feeds to processes j and l where the teacher intentionally monitors students' interactions and learning for potential adaptations in future teaching. Together, these direct influences of the expansive mindset and their rippling effects across various cognitive processes give rise to a rich picture of Teacher D's adaptive cognition.

Figure 9c.

Teacher D's Cognitive Processes of Adaptation



The three examples above show that, on the one hand, the inherent connections among cognitive processes afford the rippling effects of any impact of cognitive capabilities on the cognitive processes. The examination of the teacher's total cognitive process thus provides a context for the systematic investigation of different cognitive capabilities and their interrelationships in adaptive teaching. On the other hand, exploring the interplay between cognitive capabilities enables further identification of subtle interactions among cognitive processes influenced by these capabilities. For instance, when making sense of Mutsumi's noticeable pause in her interaction with her partners, both Teacher C and Teacher D demonstrate an expansive mindset that drives them to examine alternative explanations. Nevertheless, in processes n_1 and n_3, where Teacher D refers to Mutsumi's worksheet to evaluate her linguistic understanding of the related terms, Teacher D also demonstrates her cognitive skill of activating

multiple and different prior experiences (e.g., former students' learning of the same topic and the instructor's design of the worksheet for the same topic) and juxtaposing them with the current context to understand the conceptual and contextual variability of the problem at hand – an important skill that is closely related to the expansive mindset. The same interplay between the particular mindset and cognitive skill can inform the identification of the cognitive processes f_2f_3, n_1, and n_3 when Teacher D juxtaposes current and prior experiences of interactions with the students involved to contemplate possible solutions to the problem. It thus explains some of the nuanced differences between Teacher C and Teacher D's cognitive processes as shown in Figure 9b and Figure 9c. In other words, both Teacher D and Teacher D have performed adaptive teaching. However, the cognitive processes they engage in and the underlying cognitive capabilities that give rise to and are contextualized by the cognitive processes are different. In this sense, the information about the teacher's cognitive adaptability is distributed across the interactions between the cognitive processes and capabilities.

Conclusion

In sum, while the first part of the TACT model provides a comprehensive map to describe teachers' cognitive and metacognitive processes, the second part offers explanatory power for the investigation of adaptiveness in teaching. Both parts are indispensable for the conceptualization and discussion of teacher adaptability. By distinguishing cognitive processes and capabilities of adaptive teaching, the TACT model provides a clear framework for each of them. Nevertheless, the TACT model moves beyond the differentiation between these two aspects of adaptive teaching. It provides a systematic analytical framework that integrates these two aspects by contextualizing the investigation of one within the other. By doing so, the TACT model allows researchers to discern the concrete instantiations of a cognitive capability of

adaptation and understand the conceptual variability of the capability as a result of various instantiations. It facilitates a systematic examination of the interactive effects of cognitive capabilities in the formation of cognitive process patterns. With both parts together, the Model goes beyond behavioral changes in discursive contexts or merely mechanisms leading to behavioral changes in teaching, reveals the ultimate and inherent complexity of teachers' adaptive cognition in teaching, and provides a conceptual foundation for the discussion of teacher adaptability.

CHAPTER 5: CONCLUSION AND IMPLICATIONS

With an emphasis on theory-building, the current dissertation presents the journey of the development of the TACT model, a novel theory of teacher adaptive cognition that aims at providing a comprehensive and much-needed perspective on the cognitive complexity inherent in adaptive teaching. This journey commences with a question about a prevailing definition of teacher adaptability. That is, teacher adaptability is indicated by teachers' deviation from the original teaching plan in response to student and situational demands. I argue that this definition fails to differentiate several core elements of teacher adaptability. First, it confounds teachers' behavioral performance of adaptation (such as their observable deviation from the original teaching plan) with their cognitive performance of adaptation (such as the total cognitive and metacognitive activities during their response to novelty in teaching situations). Second, it fails to differentiate teachers' cognitive performance of adaptation (for instance, the instantiations of one's cognitive capabilities in specific cognitive processes during adaptation) with their cognitive readiness for adaptation (such as the cognitive capabilities and their interrelationships with each other). As illustrated through four hypothetical teaching scenarios in Chapter 2, the lack of such distinctions may result in a conflation of distinct constructs that are essential to the understanding of the multifaceted nature of teacher adaptability. Without clear separations, it becomes difficult to conduct precise research that can contribute to the theoretical frameworks in the field, to create assessment tools that accurately measure teacher adaptability, and to design professional development programs that target specific areas of adaptability. This conflation might also lead to overlooking the potential for certain cognitive or metacognitive strategies to serve as mediators or moderators in the adaptation process, thereby limiting the understanding of how these strategies can be cultivated and utilized in teacher training and practice.

While the development of the TACT model is motivated by my dissatisfaction with the current conceptualization of teacher adaptability, it is grounded in a critical and extensive review of adaptive cognition within and beyond the field of teaching. In particular, guided by the general theories of adaptive cognition and CFT as reviewed in Chapter 2, I engage in a critical research synthesis of relevant literature of teacher adaptability as well as the broader fields such as adaptive expertise, decision-making, and so on in Chapter 3 to answer four questions: 1) What are the comprehensive cognitive processes involved in adaptive performance within the context of teaching? 2) Upon which underlying factors does the manifestation of teachers' adaptability in these processes depend? 3) Does a current model exist that adequately captures the complexities inherent in adaptive teaching practices? 4) If such a model is absent, what features must it embody to accurately represent the nuances of this phenomenon? This extensive review has provided the following insights for the aforementioned questions. First, the total cognitive process of adaptive teaching is comprised of interrelated subprocesses representing three types of cognitive activities, including noticing, sense-making, and decision-making. Despite different theoretical underpinnings, these activities all highlight the non-linear nature of the cognitive processes involved in teachers' attention to, interpretation of, awareness of, and responses to the changing teaching situations. Second, the nonlinearity and thus different patterns of the cognitive processes when teachers navigate novel and unpredictable teaching situations are often undergirded by teachers' cognitive readiness for adaptation, which is constituted of cognitive capabilities such as teachers' epistemological mindset, cognitive skills for adaptation, and flexible mental representation of prior knowledge and experiences. These cognitive capabilities are not isolated from each other, and thus require a systematic way to understand their interconnections. Third, existing models of teacher adaptability often fail to either clearly

distinguish teachers' cognitive process of adaptive teaching from their cognitive capabilities of adaptive teaching, or sufficiently integrate the cognitive processes and capabilities to bring out the intricacies involved in adaptive teaching. Fourth, for a new model of teacher adaptability to effectively address the aforementioned caveats of the current conceptualization of teacher adaptability, the model needs to provide a comprehensive depiction of the cognitive processes of adaptive teaching to allow different cognitive activities, their interactions, and various cognitive pathways to be selectively highlighted in different contexts of adaptive teaching. The model also needs to be specific and systematic about the cognitive capabilities that underlie the formation of different pathways or patterns of the cognitive processes of adaptive teaching. In addition, the model should be able to facilitate a methodical exploration of how cognitive capabilities and processes interact.

The intellectual exploration into the conceptualization of teacher adaptability, as summarized above, gives birth to the TACT model – a dual-part model that provides both a descriptive and an explanatory account of adaptive teaching. As described and discussed in depth in Chapter 4, the TACT model emphasizes that, to effectively understand teacher adaptability, analyses of the cognitive processes and capabilities of adaptive teaching should be *systematically* contextualized within each other. On the one hand, the influence of cognitive capabilities on adaptive teaching should be scrutinized through various cognitive processes in teachers' noticing, sense-making, and decision-making activities. This approach permits researchers and educators to understand the conceptual variability of cognitive capabilities, in that an individual cognitive capability, as well as its interaction with other cognitive capabilities, may present divergently across different cognitive processes. Moreover, the cognitive processes and their inherent interdependencies with each other furnish a dynamic network, through which the

repercussions of cognitive capabilities on the entirety of teachers' adaptive teaching can be traced.

On the other hand, an analysis of teachers' cognitive readiness for adaptation affords a systematic approach to uncover and chart the evolution of cognitive pathways, thereby facilitating a comprehensive mapping of the cognitive process inherent in adaptive teaching. Specifically, by examining teachers' cognitive capabilities and their interactions, researchers may trace cognitive performance that may or may not lead to immediate adaptive behaviors in teachers' development of mental models and response to changes. This approach yields a more nuanced understanding of the dimensions of teacher adaptability. The construction of three distinct cognitive process maps for teachers, as presented in Figures 9a, 9b, and 9c of Chapter 4, serves to illustrate the analytical depth afforded by the TACT framework.

Implications

The TACT model has important implications on the advancement of theory, empirical research, and practice of teacher adaptability, as well as adaptive cognition in general. First and foremost, by providing an encompassing, integrative, and more nuanced approach to the understanding of teachers' adaptive cognition, the TACT model uncovers aspects that have been overlooked by existing theories of teacher adaptability and thus advances our conceptualization of teacher adaptability. Specifically, it differentiates behavioral performance of adaptation, cognitive performance of adaptation, and cognitive readiness for adaptation. Meanwhile, the understanding that teacher adaptability cannot be dictated by any of the aforementioned aspects alone but is distributed in the interactions among these constructs is critical for a contextualized and synergistic, rather than mechanistic, conceptualization of teacher adaptability. As a result, the TACT model is able to address critical questions that were neglected or left unanswered by

previous models of adaptive teaching. For instance, the TACT model explicates how teachers' cognitive processes and adaptive capabilities exert mutual influence on each other, thereby details the mechanisms through which factors such as teachers' beliefs, knowledge, and experience influence their attention to, interpretation of, and decisions about the teaching situation; The TACT model also clarifies how teachers' cognitive engagement differs from, and is also connected to, teachers' metacognition. Both of the aforementioned aspects elucidate nuances that were not detailed in the SRR models by Parsons et al. (2018) and Gallagher et al. (2020), or the earlier framework by Leikin and Dinur (2007). Furthermore, the TACT model's approach to mapping teachers' cognitive processes during the construction of mental models and the evaluation of potential responses to a novel teaching situation provides substantial insights into the inherently creative nature of teaching. This is a departure from the primarily reactive depiction of improvised teaching in Shavelson and Stern's model (1981). Additionally, by acknowledging the nonlinearity of cognitive processes in adaptive teaching – facilitated through the active seeking of information and the fluid use of prior knowledge and experience – the TACT model offers a more nuanced interpretation of Moallem's (1998) concept of "simultaneous consideration of different factors" (p.57), thereby enriching our understanding of teachers' adaptive cognition. In conclusion, the holistic, dynamic, and context-sensitive nature of the TACT model allows it to capture the full picture of teachers' adaptive cognition while tackling nuances and variabilities of the interactions between teachers' adaptive capabilities and processes. It serves as a pivotal step forward in the conceptualization of teacher adaptability.

Secondly, by distinguishing between cognitive processes and capabilities while offering a systematic way to examine their interplay with each other, the TACT model not only charts new territory for research but also furnishes a highly specific framework to guide future empirical

investigations of teacher adaptability. For instance, many existing studies of teacher adaptability focus on teachers' instructional actions, from which researchers trace back to teachers' cognitive activities contributing to such instructional decisions with techniques such as class observation (Anfrum et al., 2020), teacher reflection (Farrell, 2006), simulated recall (Muir et al., 2010), and so on. While these studies and techniques have yielded valuable insights, we must approach the conclusions drawn from such research with caution, particularly regarding the extent to which they provide a comprehensive understanding of teachers' cognitive activities, processes, and capabilities in the context of adaptive teaching. Consider, for instance, the study by Anfrum et al. (2020). The researchers developed the Adaptive Teaching Observation Protocol, identifying nine distinct observable adaptations, including introducing new content, inserting a new activity, omitting a planned activity, providing a resource or example, modeling a skill, inserting a mini lesson, suggesting a different perspective, conducting an individual conference, and changing grouping structure, as indicators of adaptive teaching. They applied this protocol to code adaptations in 13 video-recorded lessons, triangulated by analysis of lesson plans and post-observation interviews. Their findings indicated that instructional adaptations were infrequent – averaging one every 25 minutes – and that only four of the nine types of adaptations were consistently observed. The researchers posited that the scarcity of adaptations could be attributed to curricular constraints or to teachers' lack of experience or motivation. Although this protocol is a seemingly robust instrument for detecting observable instructional changes, its scope is limited in terms of descriptive and interpretive power. For instance, it is unclear whether identical adaptations reflect a consistent degree or kind of teacher adaptability, or whether they are prompted by the same cognitive processes and abilities. Additionally, the lack of observable instructional adaptation does not necessarily imply an absence of the cognitive activities that

underpin teachers' recognition of, interpretation of, and response to unforeseen teaching situations. Thus, if we solely measure teacher adaptability by visible instructional changes or the cognitive processes that lead to such changes, we risk overlooking many critical and subtle elements of adaptive teaching.

Conversely, the theoretical orientation of TACT focuses our analytical lens on the distinction and interrelations of three major constructs. First, teachers' cognitive performance of adaptation refers to the cognitive pathways consisted of cognitive processes involved in teachers' noticing, sense-making and decision-making activities. Second, teachers' cognitive readiness for adaptation refers to teachers' cognitive capabilities such as their adaptive mindset, adaptive skills, and adaptive knowledge structure, as well as their interrelationships with each other. Teachers' cognitive adaptability is distributed in the interaction of the first two constructs. The third construct – teachers' behavior of adaptation – is a natural product of the other two constructs and thus needs to be understood in the context of teachers' adaptive cognition. TACT's focus on both the differentiation and integration of the three constructs provides guidance for hypothesis development in empirical research, as to be further explicated in the section of "Future Research."

The nature of the three constructs of the TACT model also sheds light on the investigation methods and techniques of empirical research. For instance, approaches commonly used in higher-level thinking process or expertise research such as concurrent think-aloud tasks (Chi et al., 1981; Crawford et al., 2005; Eccles & Arsel, 2017; Ericsson & Simon, 1993; Van Someren et al., 1994) can be effective in obtaining data on teachers' cognitive performance. In particular, the think-aloud task assumes that information attended to in short-term memory during task performance is accessible and can be verbalized. Therefore, by asking participants to

do concurrent reporting, that is, to verbalize one's thoughts as they are experienced in the task performance, the think-aloud method provides a window to participants' noticing and cognitive reasoning processes instead of merely observable instructional behaviors (see Crawford et al., 2005 and Van Someren et al., 1994 for more in-depth debate and discussions on the ecological validity of think-aloud approaches in the context of research on higher-level thinking process).

The think-aloud tasks as referenced above should be carried out in tandem with multiple, rich cases of teaching. This is well-aligned with the emphasis of the TACT framework on uncovering the intricacies and complexities of teachers' adaptive cognition in teaching. As pointed out by Lee Shulman (1992), well-crafted cases that portray realistic problems in teaching show little respect for disciplinary boundaries, are messy and recalcitrant, and rarely admit a single right answer. They are thus ideal as pieces of vivid, rich, yet controllable realities to contextualize, teach, and research teachers' sense-making and decision-making in dilemma-driven and ill-structured situations (Merseth, 1991; Shulman J., 1992; Spiro, 2015). Such cases can be presented in various modalities, depending on the teaching tasks and study design. Emerging technologies such as virtual reality can also be leveraged in the design of cases.

Furthermore, semi-structured interviews can be designed and used after the think-aloud tasks to gain more insights into teachers' adaptive process. These semi-structured interviews are similar to the use of post-observation interviews or simulated recalls in previous teacher adaptability research, except that they serve three specific purposes when used in combination with the think-aloud tasks. First, in case of participants' incomplete, fragmented, and/or ambiguous utterances in the think-aloud task, which is to be expected, the interview will provide an opportunity to clarify the literal[3] meaning of these utterances with the participant right after

[3] The utterances are treated as the data of thought processes. So the purpose of the clarification questions asked in the interview is not to have participants reconstruct, interpret, or elaborate on the utterances, because retrospective

the think-aloud task. Secondly, researchers of teacher adaptability have pointed out that it is challenging for teachers to be aware of often implicit adaptive processes (Mannikko & Husu, 2019; Mylopoulos & Scardamalia, 2008). Considering that the TACT framework emphasizes rich descriptions of the interactive, iterative, and integrative adaptive processes, especially ones centering around the activation and (creative) utilization of prior knowledge/experience, a semi-structured interview can be used to guide participants' reflections on these topics. Similarly, they may also be structured to probe into participants' cognitive capabilities, especially their knowledge structure and use of cognitive skills. Lastly, the data obtained from the interviews will be combined with rather than in lieu of the concurrent think-aloud data, serving as elaborations and triangulations of the latter.

In addition to the think-aloud and interview approaches, researchers may consider the use of epistemological questionnaires to measure teachers' epistemological mindsets. One example is the Cognitive Flexibility Inventory (CFI) developed by Spiro and colleagues (1988). CFI can be used to assess people's epistemological beliefs and preferences as these relate to advance knowledge acquisition and application in ill-structured and complex domains. To further contextualize the questionnaire in the realm of adaptive teaching, researchers may consider asking participants to elaborate on their rating of each item by illustrating their choice with an example from their prior teaching experiences. If combined with all previously mentioned approaches, researchers can use the semi-structured interviews to triangulate both the CFI and think-aloud data, and thus add depth to the interpretation of teachers' adaptive readiness and performance. For instance, when discrepancies between participants' questionnaire answers and

explanation may not reflect the actual content of working memory (Charters, 2003; Ericsson & Simon, 1980). Instead, this portion of the interview is solely to clarify the literal meaning of the utterance when an utterance is incomprehensible. Participants will be instructed to tell the researcher if they do not remember what the word was instead of coming up with a new explanation in the interview.

their performance in the think-aloud task are spotted (e.g., one indicates in the CFI questionnaire that s/he always approaches a problem from a holistic rather than compartmentalized view, but repeatedly breaks a complex phenomenon to individual parts and examines each part separately), the researcher can ask them during the interview to reflect on the reason for such discrepancies (e.g., misunderstanding of the CFI item, context-specific factors that lead to conceptual variability, etc.).

It is worth noting that all of the aforementioned techniques can be used in combination with class observations, such as the ones demonstrated in the Anfrum et al. (2020) study as discussed earlier. The difference is that the observed instructional actions will be interpreted via, compared to, and triangulated with data of teachers' adaptive cognition. In other words, teachers' behavioral performance of adaptation is understood in the context of teachers' cognitive performance of and readiness for adaptation – rather than the other way around – and thus result in a more comprehensive and accurate picture of teacher adaptability.

Another implication of the TACT model on empirical research of teacher adaptability lies in the research design. While clearly distinguishing the three constructs of teacher adaptability as discussed above, the TACT model also emphasizes the interplay among these constructs. In this sense, I argue that mixed method study, when well-crafted, may provide the most descriptive and interpretive power for a phenomenon as complex as teacher adaptability. More specifically, a mixed-method study design integrates quantitative methods, which excel in identifying patterns and generalizability through statistical analysis, with qualitative approaches, which provide depth in conceptual and contextual variabilities through narratives and detailed observations, thereby capturing the dynamic and situated nature of teacher adaptability. Furthermore, given the highly specific approaches to obtaining data of the three distinctive constructs of teacher adaptability, as

discussed above, mixed methods can validate findings across different data sources, enhancing the reliability and validity of the research. Through this synergistic approach, we can better understand how teachers navigate complex classroom dynamics, make real-time decisions, and modify their instructional strategies to meet diverse student needs, ultimately contributing to a more robust model of teacher adaptability.

Thirdly, the TACT model has important implications on the practice of adaptive teaching at various levels. By delineating the specific constructs of adaptability, the model offers a framework that educators can employ to enhance their instructional practices. At the classroom level, teachers can use the TACT model in their reflection on their teaching to self-assess and thus further develop their adaptive strategies, ensuring that they are responsive to the fluctuating needs of their students. This is especially important as teachers nowadays, in the face of a breadth of inclusive teaching philosophies – often in the form of general principles or checklists (Gargiulo & Metcalf, 2022; Nelson & Ralabate, 2017; Rose & Meyer, 2002) – as well as evolvingly complex educational standards (National Research Council, 2013, 2015), are challenged with increasing demands to adapt these general principles or standards to specific student groups or individuals. The TACT model helps teachers understand how to reflect on their own cognitive performance and capabilities, and consequently develop their ability to juxtapose their prior knowledge/experience, general guidelines, and the changing teaching situation to effectively respond to students' emerging and diversifying needs. At the institutional level, teacher educators and educational leaders can implement professional development programs centering around the TACT model to cultivate a culture of adaptability, equipping teachers with the necessary skills and mindsets to adjust their teaching strategies according to student needs and emerging educational challenges. For instance, deliberate practice can be designed to

practice adaptive noticing, sense-making, and decision-making. Although cognitive processes delineated in the TACT model may seem complex at first, through deliberate practices, a lot of those processes may become automatized and more manageable cognitively. Finally, at the policy level, the TACT model sheds light on the intellectual workings and competencies teachers utilize to tailor their teaching to specific classroom contexts, thereby serving as a theoretical rebuttal to the trend of fixed curricula and the idea of 'teacher-proof' education. It can further inform the creation of educational policies that support and foster adaptive teaching, recognizing it as a critical component of effective education. Such policies might encourage ongoing teacher training, the development of adaptive curricula, and the allocation of resources to support dynamic teaching environments. Through these multifaceted applications, the TACT model serves as a valuable tool for advancing the practice of teaching, ultimately contributing to a more agile and responsive education system.

Last but certainly not the least, although an in-depth examination of the TACT model's impact on specific domains of psychological inquiry such as decision-making, adaptive expertise, and so on is beyond the scope of this dissertation, the implication of this model on the broader field of adaptive cognition is evident. As elucidated in Chapter 2, the theoretical progression in ill-structured problems necessitates acknowledging that well-structured and ill-structured tasks are epistemologically distinct, thereby requiring fundamentally different cognitive processes and capabilities for effective adaptation. Prior research has investigated the individual cognitive capabilities that contribute to these differences (Cattell, 1941; Lin et al., 2005). The TACT model's delineation of adaptive readiness extends it by offering a systematic way that not only encapsulates these individual aspects but also probes their interrelations and their collective influence on adaptive performance and processes.

Further, while existing conceptual models such as the Recognition Primed Decision Model (Klein, 2006) and various heuristic-based models (Kahneman & Fedrick, 2002) offer insights into cognitive strategies employed in rapid problem-solving scenarios, they may not fully account for adaptations that occur in less time-pressured contexts. The TACT model presents a detailed blueprint of adaptive processes, allowing for the illumination of different cognitive pathways based on a variety of factors such as cognitive capabilities, values, goals, external constraints. It also allows a systematic examination of the repercussions of a particular factor on different cognitive process. Thus, the TACT model accounts for the contextual and conceptual variabilities inherent in adaptive cognition and offers a more holistic understanding. In essence, the TACT model enriches our conceptualization of adaptive cognition by framing it within a broader, more versatile context.

Future Research

As this dissertation marks the inception of the TACT framework, it is merely the inaugural step in a longer scholarly journey. For the framework's evolution, future research could pursue several avenues. Initially, the formulation of hypotheses within the TACT framework's scope could lead to empirical validation efforts. For instance, research could investigate if an expansive epistemological mindset correlates with specific patterns of adaptive processes, and how these are affected by teacher's cognitive skill set and their proficiencies, structure and mastery level of knowledge, and external constraints. Further investigation might delve in the influence of general versus domain-specific epistemological orientations on these aforementioned correlations. Studies can also be carried out to evaluate if certain states of adaptive readiness – specific combinations of cognitive capabilities – are more conducive to eliciting flexible cognitive performances during adaptation. Conversely, researchers can

investigate whether deliberate practice of certain cognitive process patterns can foster the development of adaptive readiness, and if so, how.

Moreover, future endeavors should aim to refine and augment the TACT framework. The results of the empirical studies as proposed above will certainly and substantially inform this theory-enhancement effort. Meanwhile, the extension of the TACT framework's applications beyond instructional settings is also recommended, through empirical or conceptual means, or a combination of both. As previously indicated, the TACT framework already has notable implications for the advancement of adaptive cognition theories. By examining and validating the framework across multiple domains, the potential exists to evolve the TACT into a domain-general model of cognitive adaptability, potentially revising its nomenclature by omitting the initial 'T' to reflect its broadened applicability.

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