AN EXPLORATION OF TEACHERS' DYNAMIC DECISION-MAKING WHILE DESIGNING INSTRUCTION AND INTEGRATING TECHNOLOGY

by

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ABSTRACT

Dynamic decision-making plays a critical role in teachers' instructional design and technology integration processes. Teachers' dynamic decision-making while designing instruction and integrating technology directly influence the design and development of teaching practices, student learning experiences, and the learning environment. However, limited studies have investigated how teachers engage in dynamic decision-making in designing instruction and technology integration contexts, wherein teachers navigate a variety of dynamic and interrelated factors to inform their design decisions for instruction. This study utilized the critical decision method (CDM) approach to investigate how teachers engage in dynamic decision-making processes, instructional design judgments, and pedagogical reasoning while designing instruction and integrating technology for their students. The findings of this study can help us develop a better understanding of teachers' dynamic decision-making processes, pedagogical reasoning, and design judgments while designing instruction for technology integration. It can also suggest professional development or teacher education guidelines that aim to develop teachers' instructional design decision-making skills for technology integration.

INDEX WORDS: dynamic decision-making, instructional design judgment, pedagogical reasoning, technology integration.

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2022

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May 2022

DEDICATION

In memory of my grandfather, Mr. Yanming He, with my deepest love and gratitude. I am honored to be your granddaughter.

ACKNOWLEDGEMENTS

I would like to thank the following people for helping and supporting me throughout this journey.

My sincere appreciation and gratitude to my advisor, Dr. Jill Stefaniak. This doctoral degree would not be possible without your selfless support, mentorship, and contributions. I have learned so much from you, and I truly appreciate the patience and great advice you have provided me.

Many thanks to my committee members, Dr. TJ Kopcha, and Dr. Julie Kittleson, for your support and mentorship. Your insights into my research have been very much helpful.

Thanks to all my family members who were there with me along this journey. Thanks to all my friends and colleagues who encouraged me throughout the challenging process. Thanks to all the in-service teachers who agreed to be involved in this study. I learned a great deal from all of you.

A special thanks to my daughter, Claire Lin, who would be proud of her mother for earning this degree.

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INTRODUCTION

Everybody makes decisions. Teachers make decisions for their teaching and students. Instructional designers make decisions for the design and development of instructional practices. A decision refers to a choice based on a decision maker's reasoning, analysis, and comparison among several possible alternative options. In real-world settings, a decision-making process allows decision-makers to conduct a reasoning process that results in a final decision (Simon, 1979). Every decision-making process leads to a choice, no matter in what context the decision-making process occurs. An examination of decision-making processes in real-world contexts can help researchers understand how decision-makers navigate among multiple factors and make decisions that determine their following actions and practices.

Decision-making is critical to teachers and students (Jonassen, 2000). Teachers often make a myriad of decisions for instruction when they design or implement lessons and teach students. When teachers design instruction for students, they need to address various factors including student needs, subject matters, classroom capacities, and other factors such as school protocols and time frames. A prior theoretical paper has indicated that teachers' design decisions for instruction range across an integrative paradigm including analysis, design, development, implementation, and evaluation for their teaching practices (Branch, 2009). Teachers' design decisions for instruction directly affect their teaching practices in real-world settings and student learning experiences (Stefaniak et al., 2021).

Decision-making processes include two major constructs: rational decision-making and dynamic decision-making. Rational decision-making presents a time-consuming reasoning process that considers benefits and costs of alternative options (Jonassen, 2000). An influential model of rational decision-making presents a linear step-by-step approach that consists of eight structured and time-consuming steps: (1) identify the problem; (2) establish decision criteria; (3) weigh decision criteria; (4) generate alternatives; (5) evaluate the alternatives; (6) choose the best alternative; (7) implement the decision; and (8) evaluate the decision (Jonassen, 2010; Klein, 1998). Compared to rational decision-making, dynamic decision-making allows teachers to make prompt decisions based on a variety of factors under a specific context (Jonassen, 2012; Klein, 2008). In real-world settings, teachers are involved in a myriad of rational and dynamic decision-making processes when designing instruction because of a variety of complex, contextualized, and fast-changing factors involved in teaching and learning. Unlike rational decision-making that allows teachers to have sufficient time and resources to make decisions, dynamic decision-making entails decision-makers (i.e., teachers) to utilize several domains of information and contextual analyses and make timely decisions for their teaching and students (Jonassen, 2000; Simon, 1979).

In the digital age, multiple types of technology have changed the learning environment, student learning experiences, and teachers' instructional practices (Kopcha et al., 2020; Xu & Stefaniak, 2021). Teachers' dynamic decision-making while designing instruction for technology integration has become increasingly important because of many technology-related factors that are transforming teaching and learning (Heitink et al., 2016; Stefaniak et al., 2021). Teachers are often faced with technology-integrated learning environments where multiple factors such as learner needs, teaching practices, pedagogical strategies, and technological issues (e.g., access to technology, technology support, digital platforms) have influenced their design decisions related to teaching and learning. Thus, teachers' dynamic decision-making processes for technology integration play an essential role in teachers' instructional design for technology use (Jonassen, 1997, 2002).

Jonassen (2000) claimed that decision-making can be viewed as an instance of problem-solving. Teachers need to acquire problem-solving knowledge and skills to make appropriate instructional decisions in real-world settings. Ill-structured problems refer to complex, unstructured, and contextualized problems that require problem-solvers to employ multiple domains of information (i.e., expertise, experiences, and contextual analyses) to solve problems (Jonassen, 2000). Ill-structured problem-solving is mostly relevant to dynamic decision-making, however, it requires rational decision-making knowledge and skills as well when problem-solvers are provided with enough time and resources to make contextual analysis and decisions.

Technology integration represents the use of technology in various educational settings (e.g., Ertmer, 1999; Ertmer et al., 2012; Hermans et al., 2008; Jonassen et al., 1998; Kopcha et al., 2020). A good example of technology integration in recent times is that teachers must make use of different types of technology to transfer their face-to-face instructional practices to online teaching practices because of the pandemic negatively impacting the entire educational system. The definition of technology integration was provided by Ertmer (1999) who cited Salomon and Perkins' (1996) higher levels of technology integration. Ertmer (1999) claimed that student-centered learning can be promoted through technology-integrated instruction. A similar definition of technology integration was offered by Jonassen et al. (1998) that emphasized a constructivist and collaborative perspective of technology use in classrooms. In 2010, Ertmer and Ottenbreit-Leftwich (2010) elaborated the definition of technology integration for 21st century learners and emphasized the role of teachers in technology integration. Both Jonassen et al.'s (1998) and Ertmer's (1999) descriptions about technology integration explained high-level technology integration and differences between learning *from* technology and learning *with* technology. While learning *from* technology considers technology as media to deliver and present information, learning *with* technology emphasizes how technology engages students as a knowledge construction tool for information analysis, knowledge interpretation, and representation.

Because technology-enhanced learning environments are complex, fast-changing, and contextualized, technology integration calls for teachers to approach technology-related instructional problems as an ill-structured problem-solving process by employing teachers' multiple domains of information including their knowledge, skills, beliefs, and experiences in terms of technology use. At the same time, teachers need to make instructional decisions for technology integration according to a variety of contextual factors such as dynamic learning environments and student needs (Jonassen, 2012). Teachers' dynamic decision-making process where they consider multiple factors to make design decisions for technology integration and instruction is critical to be examined.

To help teachers make effective decisions while designing instruction, scholars from the field of instructional design have developed a variety of instructional design theories, models, and principles that aim to provide teachers with practical guidance and integrative frameworks for instructional design decision-making (e.g., Branch, 2009; Merrill, 2002; Reigeluth et al., 2016; Reiser, 2001, 2017; Silber, 2007). However, traditional instructional design models have been criticized because they do not successfully address the complexity of instructional design decision-making processes (Gray et al., 2015; Reigeluth, 2013). Although these instructional design models claim that instructional designers should remain flexible during instructional design processes, they only present instructional design as a procedural protocol without adequate explanations or clarifications on how teachers should leverage different factors within specific contextual-relevant changes or adjustments to make effective design decisions for instruction (Agyei & Voogt, 2012; Kopcha et al., 2020; Ottenbreit-Leftwich et al., 2010; Wang et al., 2014).

Due to the complexity of integrating technology into instructional practices, teachers' dynamic decision-making while designing instruction is often open-ended and contextualized without a universal and structured solution (Jonassen, 2011, 2012; Nelson, 2003; Park & Ertmer, 2008). Even when standards and technology are set for teachers ahead of time, teachers still need to confront ill-structured situations with different learning contexts, student needs, and pedagogical practices (Stefaniak et al., 2021). Thus, teachers need to learn to make instructional decisions for technology integration based on their experience, expertise, and contextual factors (Jonassen, 2000, 2012). Teachers' decision-making skills while designing instruction have been recognized as a critical skillset of teachers in the digital age (Kopcha et al., 2020; Stefaniak & Xu, 2020). It has also become the research focus of some empirical studies in terms of teacher education and instructional design practices (e.g., Boschman et al., 2015; Cviko et al., 2013; Greenhow et al., 2008). However, most empirical studies have put their emphasis on decision-making products rather than processes (e.g., Hew & Brush, 2007; Inan & Lowther, 2010; Pella, 2015; Starkey, 2010); they provided scholars explanations on *how* teachers make decisions by leveraging different factors instead of *why* teachers make decisions in certain ways. Teachers' dynamic decision-making processes while designing instruction and integrating technology are thereby under minimal investigation (Kopcha et al., 2020).

Three critical theoretical concepts are closely related to teachers' dynamic decision-making processes while designing instruction and technology integration: (1) dynamic decision-making, (2) instructional design judgment, and (3) pedagogical reasoning. These concepts serve as theoretical constructs that guide the present study and reflect the complexity and unstructured processes of teachers' decision-making in designing instruction.

Dynamic decision-making refers to how teachers make prompt decisions in a dynamic learning environment (Jonassen, 2012). While rational decision-making enables decision-makers to conduct a one-way, well-structured decision-making process based on a comparison among different options, dynamic decision-making requires decision-makers to make decisions under time pressure and multiple sources of information (Klein, 2008). Teachers are always engaged in dynamic decision-making contexts in real-world settings because of a variety of dynamic factors affecting teaching and learning, such as student needs, affordances of the learning environment, and teachers' knowledge and expertise (Ertmer, 1999; Stefaniak et al., 2021).

Instructional design judgment represents teachers' ability to "recognize situations, cases or problems (of instructional design) and then to deal adequately (effectively, economically, elegantly) with them" (Dunne, 1997). It presents how practitioners (i.e., teachers) make decisions in their design processes (Nelson & Stolterman, 2012; Smith & Boling, 2009). Instructional design judgment requires teachers to have adequate knowledge, conceptual design sense, and critical flexibility for instructional design (Gray et al., 2015; Yanchar & Gabbitas, 2011). Compared to the concept of dynamic decision-making, the emphasis of instructional design judgment is more focused on teachers' internal factors and flexibility instead of how teachers leverage and analyze a variety of contextual factors for decision-making. When teachers make design judgments, teachers are engaged in a design space where they make a balance between internal and external factors influencing the learning environment (Ertmer & Koehler, 2014). The design space allows teachers to make a balance among various factors and develop appropriate instructional practices pertaining to both teachers and students to benefit student learning (Stefaniak et al., 2021).

Pedagogical reasoning is about how teachers transform their knowledge into the design and implementation of pedagogical practices (Shulman, 1987). Rather than the TPACK model that uncovers three areas of knowledge teachers should have for technology integration (Koehler & Mishra, 2009), teachers' pedagogical reasoning process directly affect their instructional design judgments and dynamic decision-making processes because pedagogical reasoning allows teachers to identify and reflect on their transformation process from their knowledge base to instructional practices, thereby making appropriate design decisions for their teaching and learning contexts (Shulman, 1987; Starkey, 2010). A case study of Niess and Gillow-Wiles (2017) utilized a systems pedagogical approach to explore how teachers were engaged in pedagogical reasoning processes while integrating technology in their classrooms. Stefaniak et al. (2021) additionally pointed out that teachers' pedagogical reasoning should be investigated with their dynamic decision-making processes since the pedagogical reasoning framework failed to capture the affordances of the learning environment (Shafto et al., 2014; Webb & Cox, 2004). Both dynamic decision-making and pedagogical reasoning are critical in examining teachers' decision-making processes while designing instruction and technology integration since the interplay of the two theoretical constructs reflects the complexity within instructional decision-making that teachers have experienced (Stefaniak et al., 2021). Thus, a systematic understanding of teachers' dynamic decision-making, instructional design judgments, and pedagogical reasoning processes for technology integration is needed to support the transformation of teacher knowledge into effective technology-integrated pedagogical practices.

A recent theoretical paper by Kopcha et al. (2020) claimed that little has been done to investigate teachers' decision-making processes for technology integration. Several recent studies have explored decision *products* rather than how teachers or practitioners are engaged in dynamic decision-making *processes* (e.g., Greenhow et al., 2008; Hew & Brush, 2007; Inan & Lowther, 2010). Due to a lack of evidence that has examined teachers' decision-making processes for technology integration and their design for instruction, some scholars call for more empirical studies to understand the complexity and underlying factors affecting teacher decision-making processes that can inform effective professional development opportunities promoting teachers' decision-making knowledge and skills (Gray et al., 2015; Kopcha et al., 2020; Smith & Boling, 2009; Stefaniak et al., 2021). For example, Smith and Boling (2009) indicated that the current research lacks the research focus on the investigation of designers' roles and design judgment in design processes. Gray et al. (2015) agreed with Smith and Boling (2009) and argued that design judgment should be examined within practitioners' design processes in practice. Stefaniak et al. (2021) also indicated that more empirical studies exploring teachers' pedagogical reasoning and dynamic decision-making processes should be conducted to inform practices and professional development strategies for instructional design.

This study aims to examine how teachers are engaged in dynamic decision-making processes while designing instruction and integrating technology. Through the investigation of teachers' dynamic decision-making processes, instructional design judgments, and pedagogical reasoning pertaining to technology integration, scholars can have a richer understanding of the complicated cognitive and reasoning processes that teachers are involved in, thereby informing pedagogical approaches and professional development initiatives that can help promote teachers' decision-making knowledge and skills for technology integration and instructional design.

Specifically, the research questions for this study are:

1. How do teachers engage in dynamic decision-making processes and pedagogical reasoning while designing instruction and integrating technology?
2. What is the relationship between teachers' design judgments and their dynamic decision-making processes for instructional design and technology integration?

Statement of the Problem

In the digital age, technology has changed education in many ways. Different types of technology and technology-integrated practices have influenced teachers' instruction, the learning environment, and student learning experiences. It has created both opportunities and challenges for teachers and students. In real-world settings, teachers often make decisions while integrating technology in their instruction; thus, their dynamic decision-making processes have become increasingly critical for the design and development of teaching practices, student learning experiences and outcomes, and the learning environment (McKenney et al., 2015; Summerville & Reid-Griffin, 2008).

Despite increasing emphasis on promoting teachers' decision-making knowledge and skills for instructional design or technology integration (Kopcha et al., 2020), few studies have investigated how teachers engage in decision-making in designing technology-enhanced instruction, especially how it changes throughout the design process. Even fewer studies have examined teachers' dynamic decision-making processes in technology integration and instructional design contexts, wherein teachers navigate a variety of dynamic and interrelated factors such as student needs, content, pedagogy, learning environments, technical problems, and other contextual issues to inform their design decisions for instruction. Therefore, to develop teachers' decision-making knowledge and skills in grappling with various factors and complexities in instructional design and technology integration, researchers and teacher educators need to have a better understanding of how teachers engage in dynamic decision-making processes, instructional design judgments, and pedagogical reasoning while designing technology-integrated instruction for their students.

This study aims to explore how teachers apply dynamic decision-making, design judgments, and pedagogical reasoning while designing instruction that integrates technology in their instructional solutions. By examining how teachers perceive and navigate different factors such as pedagogical approaches and technology use, researchers can gain a better understanding of teachers' dynamic decision-making, design judgments, and pedagogical reasoning surrounding technology integration. From this study, researchers can identify teachers' reasoning processes through the investigation of teachers' navigation and analysis of different factors and affordances within the design space and the problem-solving space, thereby helping teachers make appropriate dynamic design decisions for their instructional solutions in terms of technology integration.

Definitions and Key Terms

Decision: A decision refers to a final choice based on a decision-maker's reasoning, analysis, and comparison among several possible alternative options (Simon, 1979, 1993).

Decision-making: A decision-making process allows decision-makers to conduct a reasoning process that results in a final decision (Simon, 1979, 1993). Typically, decision-making follows a general procedure - decision-makers first examine the characteristics of multiple options from a broader choice set and then select the best option based on their analysis results (Beach, 1993; Jonassen, 2000). Decision-making has been recognized as a specific type of problem-solving (Jonassen, 1997, 2000, 2012). Jonassen (2000, 2012) also indicated that decision-making knowledge and skills can promote problem-solving knowledge and skills.

Design space: Design space refers to how teachers make a balance between internal and external factors influencing the learning environment when designing instruction (Ertmer & Koehler, 2014). It creates a space where dynamic decision-making can help decision-makers make a balance within the design space and develop appropriate instructional practices pertaining to both teachers and students (Stefaniak et al., 2021).

Dynamic decision-making: Dynamic decision-making, also named as naturalistic decision-making, presents a decision-making process in which decision-makers need to make prompt decisions by synthesizing multiple sources of information (Klein, 2008). In real-world settings, dynamic decision-making often involves decision-makers making timely decisions based on multiple domains of information such as contextual analyses, their knowledge base, and their experiences (Jonassen, 2012; Kopcha, 2012; Zhao & Frank, 2003).

Ill-structured problems: Ill-structured problems commonly happen in dynamic real-world environments; thus, it requires decision-makers to conduct multifaceted/multi-staged analyses on a variety of conditions, such as people's needs, contextual factors, and affordances of the environment (Jonassen, 2010, 2012). Ill-structured problem-solving involves both rational decision-making and dynamic decision-making.

Instructional design judgments: Instructional design judgments refer to the process where teachers and/or practitioners solve complicated design problems and make corresponding design decisions. Nelson and Stolterman (2012) identified that design judgments result in “good design decisions”. While a design decision refers to “what and how” for a design, instructional design judgments indicate “why” a design decision has been made (Lachheb & Boling, 2021; Nelson & Stolterman, 2012).

Rational decision-making: Rational decision-making refers to a procedural reasoning process that considers all benefits and costs of alternative options (Jonassen, 2000). Rational decision-making does not involve time pressure, so it provides decision-makers with adequate time and resources to conduct option comparisons and make decisions (De Martino et al., 2006; Jonassen, 2010; Klein, 1998).

Technology integration: Technology integration refers to the use of technology in educational contexts (e.g., Ertmer, 1999; Ertmer et al., 2012; Hermans et al., 2008; Jonassen et al., 1998; Kopcha et al., 2020). Ertmer (1999) proposed that student-centered learning can be promoted through high-level technology-integrated instruction. Jonassen et al. (1998) highlighted a constructivist and collaborative perspective of technology use in classrooms. Both Jonassen et al.’s (1998) and Ertmer’s (1999) descriptions of technology integration explained high-level technology integration and emphasized the importance of learning *with* technology.

Well-structured problems: Well-structured problems have clear-defined variables, states, and goals (Jonassen, 2000). Well-structured problems allow decision-makers to solve problems through one-way, rational, and procedural analysis. Well-structured problem-solving only requires problem-solvers to leverage procedural knowledge to solve problems following a step-by-step procedure.

CHAPTER 2

LITERATURE REVIEW

The literature review chapter aims to provide an overview of studies exploring decision-making, pedagogical reasoning, and instructional design judgments for designing instruction and technology integration. Studies discussing decision-making theories and process models are reviewed. Studies exploring teachers' decision-making while designing instruction and integrating technology are reviewed. Meanwhile, the chapter aims to explain the connections between the concepts of teachers' decision-making, pedagogical reasoning, instructional design judgments, and technology integration to inform the present study. The literature review chapter will provide a holistic insight into teachers' decision-making processes, design judgments, and pedagogical reasoning surrounding technology integration.

The purpose of this study is to investigate how teachers apply their dynamic decision-making, instructional design judgments, and pedagogical reasoning while designing instruction and integrating technology in K-12 settings. This chapter is divided into three sections. The first section is about decision-making theories, process models, and relevant research about decision-making. The second section discusses the inner connections of the theoretical constructs that comprise technology integration, instructional design judgments, and various factors affecting teachers' decision-making and pedagogical reasoning for technology integration. Empirical studies that have narrowed their research focus to teachers' decision-making and pedagogical reasoning for technology integration or instructional design judgments are discussed. The third section contains both theoretical and empirical studies that have explored decision-making, instructional design judgments, and pedagogical reasoning for technology integration and instructional design contexts, as well as studies that have discussed the potential research gap between recent studies and the research needed in terms of teachers' decision-making processes.

Definition of decision-making and theoretical models

Decision-making has been recognized as a specific type of problem-solving (Jonassen, 1997, 2000, 2012). Problem-solving, as Jonassen (2000) described, is "any goal-directed sequence of cognitive operations" (Jonassen, 2000, p.65). Jonassen (2000, 2012) claimed that decision-making knowledge and skills can support teachers' problem-solving knowledge and skills. Decision-making problems necessitate a goal-directed, problem-solving process in which decision-makers identify the benefits and limitations of different options and choose from a set of choices (Jonassen, 2000, 2010, 2012). Typically, a decision-making process follows a general procedure: decision-makers first examine the characteristics of multiple options from a broader choice set and then select the best option based on their analysis results (Beach, 1993; Jonassen, 2000).

Decisions to solve problems vary in complexity (Jonassen, 2000). Jonassen (2000) categorized real-world problems into two types: well-structured problems and ill-structured problems. Well-structured problems have clear-defined variables, states, and goals, thus these decision-making problems only require decision-makers to solve problems through one-way, rational, and procedural analysis. Jonassen (2000) described a variety of well-structured problems that can be solved through simple decision-making processes -- during which, decision-makers only need a finite number of "concepts, rules, and principles being studied to a constrained problem situation" (p.67). Although prior researchers (Simon, 1973) had long believed that learning to solve well-structured problems can positively inform people how to solve ill-structured decision-making problems, Jonassen (2000) indicated that more recent research in terms of situated and real-world problem-solving makes a clear distinction between well-structured problems and ill-structured real-world problems. Well-structured decision-making problems and ill-structured real-world problems entail different decision-making processes and intellectual skills (Jonassen, 2000).

Complex decision-making problems are also named as ill-structured problems. Ill-structured problems commonly happen in dynamic learning environments; thus, it often requires decision-makers to conduct multifaceted/multi-staged analyses on various factors, such as people's needs, contextual factors, and affordances of the environment (Jonassen, 2010, 2012). Jonassen (2000, 2012) defined design problems as one of the most complex and ill-structured kinds of problems. The *designing for instruction* process enables teachers to possess adequate decision-making knowledge and skills to address multiple factors such as learner needs and contextual analyses (Herrmann, 2016; Jonassen, 2012).

Yates et al. (2003, 2006) and Jonassen (2012) explained different kinds of decisions in various contexts. Specifically, decision types include choices, acceptances/rejections, evaluations, and constructions (Jonassen, 2012). Choice decisions often involve a broader set of alternatives; acceptances/rejections decisions allow people to make binary choices (i.e., yes/no decisions); evaluation decisions require decision-makers to make statements of worth or evidence-based arguments to support commitments to act; construction decisions are made based on available resources and goal-oriented analyses. According to Jonassen (2010, 2012), complex or ill-structured decision-making problems, such as those problems associated with instructional design, contain multiple types and stages of decision-making; thus, solving design decision-making problems requires teachers to employ appropriate decision-making approaches such as conducting analyses, evaluations, and examinations. Table 1 below presents definitions of these decision types and examples of teachers' decisions for technology integration in K-12 settings.

Table 1. *Summary of decision types and examples of teachers' decisions for technology integration in K-12 settings.*

Decision types (Jonassen, 2012; Yates et al., 2003, 2006)	**Definition**	**Examples of teachers' decisions for technology integration in K-12 settings**
Choices	When decision-makers select a subset from a larger set of alternatives.	Teacher decides to use a digital tool to present the subject content.
Acceptances/Rejections	When decision-makers make a binary choice in which one option is accepted and the other one is rejected.	Teacher encounters some technical problems and decides not to use digital tools but pencils and papers to lead the learning activity.
Evaluation	When decision-makers make decisions that are backed up with commitments to act.	Teacher decides to use a specific digital tool to assess students' learning performances.
Constructions	When decision-makers create ideal solutions through the analysis of given resources.	Teacher creates an online learning module that supports digital students' learning during the pandemic.

A decision-making process can be categorized as rational and dynamic (i.e., naturalistic) (Jonassen, 2012). Rational decision-making is typically conducted when decision-makers have enough time and resources to compare different alternatives (Jonassen, 2012). Rational decision-making does not involve time pressure, such that teachers would have enough time to analyze alternatives, collect resources, and make decisions. Rational decision-making consists of a series of linear actions to evaluate alternatives and make decisions (De Martino et al., 2006; Jonassen, 2010; Klein, 1998). Teachers can refer to various methods, resources, knowledge, and experiences to make rational decisions.

Dynamic decision-making, also named as naturalistic decision-making, requires teachers to make decisions within short time frames in dynamic settings (Jonassen, 2010; Klein, 2008). Due to the highly dynamic nature of classrooms and instruction, teachers are always involved in dynamic decision-making processes in teaching and learning (Brehmer, 1992). A dynamic decision-making process often involves teachers making prompt decisions based on contextual analyses, their knowledge base, and their experiences (Jonassen, 2012; Kopcha, 2012; Zhao & Frank, 2003). It also refers to how teachers make timely decisions while designing instruction for technology integration for a dynamic, ill-structured learning environment. A summary of the two decision-making types and real-world examples in K-12 educational settings is presented below (see Table 2).

Table 2. *Summary of decision-making and examples of teachers' decision-making in K-12 settings.*

Decision-making	Definition	Relevant studies	Examples of teachers' decision-making in action in K-12 settings
Rational decision-making	A time-consuming decision-making process that provides decision-makers enough time and resources to compare different alternatives.	Jonassen, 2010, 2012; Klein, 1998	Teacher asks students to complete a group project in science learning and allocate corresponding learning tasks for the learning objectives.
Dynamic decision-making	Also named as naturalistic decision-making. It is a contextual-related decision-making process that involves high-level dynamic changes in decision-making contexts and short time frames.	Endsley, 1995; Hsiao & Richardson, 1999; Jonassen, 2012; Klein, 2008	Teacher finds some students having troubles in completing learning tasks and decides to design some performance-support learning activities to help the students.

A variety of theoretical mental models and frameworks have been developed to guide teachers' decision-making (Tarter & Hoy, 1998). For example, Hsiao and Richardson (1999) systematically discussed decision-making in different educational contexts by investigating theoretical process models and corresponding empirical studies. This study developed a dynamic decision-making framework that identifies significant variables influencing the decision-making process teachers employ (Hsiao & Richardson, 1999). The variables include decision-makers' cognitive factors, task complexity, and decision-making environments. Similarly, Duschl and Wright (1989) conducted a case study to present a model of teachers' decision-making for planning and science teaching. Their decision-making model described how teachers' science knowledge, beliefs, and judgments can affect their pedagogical decisions.

One of the most essential decision-making models is the rational decision-making model. The rational decision-making model is an influential sequential approach to decision-making developed by Klein (1998) and elaborated by Jonassen (2010). This model consists of a sequence of eight structured steps: (1) identify the problem, (2) establish decision criteria, (3) weigh decision criteria, (4) generate alternatives, (5) evaluate the alternatives, (6) choose the best alternative, (7) implement the decision, and (8) evaluate the decision. This model is intended to be used when teachers have sufficient time to collect resources, establish criteria, conduct analyses, and compare different options – not for time-pressured instructional situations. The rational decision-making model has been widely discussed in the context of problem-solving (Dauer, Lute, & Straka, 2017; Meyer, 2018) and case-based learning (Cevik & Andre, 2012; 2014).

Dynamic decision-making requires decision-makers to make decisions based on a variety of factors within a context and a short time frame (Jonassen, 2012). A dynamic decision-making process involves situated contextual awareness and a reflective process (Klein, 2008). Klein (2008) indicated that successful dynamic decision-making may not involve option comparison, a key step in a rational decision-making process. The recognition-primed decision (RPD) model developed by Klein et al. (1986) described how people use their pattern-matching skills to make dynamic decisions. Klein (2008) claimed that the RPD model is a "blend of intuition and analysis," while "the pattern matching is the intuitive part, and the mental simulation is the conscious, deliberate, and analytical part" (p.458). Based on the RPD model and related dynamic decision-making case studies, Klein (2008) asserted that dynamic systems thinking paired with contextual analysis is critical for teachers' dynamic decision-making.

Another foundational mental model for dynamic decision-making is the situation awareness (SA) model developed by Endsley (1995). Based on an analysis of related medical cases, the SA dynamic decision-making model emphasizes the role of situated awareness in a decision-making process. This model encourages decision-makers to investigate all related contextual factors before making decisions. The SA dynamic decision-making model has been extensively applied and discussed in the field of medical education and other professional settings (e.g., Kaempf et al., 1996; Kushniruk, 2001; Pliske & Klein, 2003). However, the SA dynamic decision-making model has not been extensively applied or discussed in K-12 settings.

The literature also explains the reflective decision-making process regarding instructional design in both higher education and K-12 settings (Kenny et al., 1999; Langer & Colton, 1994; Simmons & Schuette, 1988; Tracey & Hutchinson, 2013; Wendell et al., 2017). Reflective decision-making is based on Schön's (1983) concept of reflection-in-action, which characterizes reflective activities as a support for decision-makers' identity development. Schön (1987) argued that decision-makers may not be able to explain what knowledge or skills they use for decision-making explicitly. Thus, researchers can leverage reflection-in-action to help teachers or student designers (i.e., decision-makers) show and deliver their decisions without speaking out what they are doing (Schön, 1991). However, limited studies have connected the decision-making process to reflective practices in K-12 settings to examine if reflection-in-action approaches can facilitate dynamic decision-making based on students' knowledge, beliefs, values, and reflective contextual analysis.

For instructional design decision-making, Tracey et al. (2014) discussed how student designers use reflective practice to make design decisions and develop their professional identity within the design thinking framework. They investigated the use of reflective writing assignments in an introductory instructional design course and identified that meaningful reflections from practitioners can help promote their understanding of design concepts, experiences, and identity attributes. Kenny et al. (1999) evaluated instructional elements and pedagogical strategies that can improve student teachers' reflective decision-making. This study employed qualitative research methods to identify how pre-service teachers responded to a planned series of interactive multimedia programs that aimed to promote reflective decision-making skills. Through self-reported surveys, tracking data, and semi-structured interviews, it indicated that video portions in the program could promote reflective decision-making in teachers. Both studies are about instructional design decision-making of pre-service teachers.

A case study by Wendell et al. (2017) explored reflective decision-making in K-12 settings. This study utilized video recordings and a naturalistic inquiry methodology to explore reflective decision-making in elementary students' engineering design curriculum. The result showed that six elements support students' reflective decision-making process: "articulating multiple solutions, evaluating pros and cons, intentionally selecting a solution, retelling the performance of a solution, analyzing a solution according to evidence, and purposefully choosing improvements" (Wendell et al., 2017, p.356).

Another critical decision-making model for technology integration is presented by Kopcha et al. (2020). The Teacher Response Model (TRM) of technology integration describes teachers' decision-making as "an ongoing, emergent process – one in which perception and action both inform and are informed by a variety of internal and external factors" (Kopcha et al., 2020, p.10). The TRM model explains teachers' decision-making processes rather than the products of their decision-making for technology integration. Additionally, this model addresses three key quests of decision-making for technology integration discussed in the existing literature: (1) value-driven, (2) embedded in a dynamic system, and (3) a product of a teachers' perception of what is possible. The TRM model considers teachers' decision-making regarding technology integration as a dynamic and evolving process based on their negotiations of teacher beliefs, knowledge, experiences, contextual factors, and students' perspectives. Based on the findings of this study, the researchers also call for more empirical studies that can investigate teachers' dynamic and evolving decision-making processes.

In addition, a recent theoretical paper by Stefaniak et al. (2021) introduced a conceptual framework to address the critical role of pedagogical reasoning and dynamic decision-making in teachers. This framework suggested that teachers should establish parameters for their design contexts, where they could develop a bounded contextualized design space through their understanding and analysis towards their predispositions (internal factors) and external conditions influencing the learning environment. Meanwhile, this conceptual framework adapted Webb and Cox's (2004) framework for pedagogical reasoning in terms of technology integration. It recognized that the affordances offered by both teachers and students contribute to the learning activities and teaching practices in the learning context. The overall consideration and analyses on both internal and external factors enable teachers to engage in effective instructional design decision-making that addresses systematic implications existing in the learning environment.

Table 3 aims to summarize all the decision-making models and their applicable contexts. The procedure of these decision-making models and related studies discussing the applied contexts of these models are listed.

Table 3. *Summary of decision-making models and applicable contexts.*

Decision-making models	**Theoretical constructs**	**Relevant studies**	**Suggested applicable contexts**
The rational decision-making model	Rational decision-making	Jonassen, 2010, 2012; Klein, 1998	Case-based learning; Problem-solving; higher education and K-12 contexts.
The recognition-primed decision (RPD) model	Dynamic decision-making	Hsiao & Richardson, 1999; Jonassen, 2012; Klein, 2008	Medical contexts; high-level dynamic professional contexts.
The situation awareness (SA) model	Dynamic decision-making	Endsley, 1995; Kaempf et al., 1996; Kushniruk, 2001; Pliske & Klein, 2003	Medical contexts; high-level dynamic professional contexts.
The reflective decision-making framework	Reflection-in-action; Dynamic decision-making	Kenny et al., 1999; Tracey et al., 2014; Wendell et al., 2017	Instructional design; teacher education; K-12 and higher education settings.

The teacher response model (TRM) of technology integration	Technology integration; Dynamic decision-making	Kopcha et al., 2020	Technology integration; teacher education; K-12 contexts.
The framework supporting learning design in the digital age.	Dynamic decision-making; Pedagogical reasoning	Stefaniak et al., 2021	Instructional design; K-12 contexts; technology integration; teacher education.

Definitions of technology integration

Technology has changed education in many ways; it has created both opportunities and challenges for teachers and students. For at least the past two decades, researchers have widely discussed technology integration and relevant strategies supporting technology-enhanced pedagogical practices in diverse educational contexts (e.g., Hermans et al., 2008; Inan & Lowther, 2010; Kopcha et al., 2020; Pittman & Gaines, 2015). Researchers have proposed various definitions of technology integration.

Ertmer (1999) described technology integration by citing Salomon and Perkins' (1996) 'higher levels of technology integration. She claimed that student-centered learning can be promoted through technology-integrated instruction:

> … (student) basic skills are learned within the context of answering real questions or solving real problems. In these types of learning environments, technology serves both as a *tool* that enables a student-centered curriculum as well as a *stage* on which meaningful learning activities can be played out. (p.50)

A similar definition of technology integration is offered by Jonassen, Carr, & Yueh (1998) with the support of Salomon, Perkins, & Globerson's (1991) work. Their definition highlighted a constructivist and collaborative perspective of technology use in classrooms:

> … the primary distinction between computers as tutors and computers as Mindtools is best expressed by Salomon, Perkins, and Globerson (1991) as the effects *of* technology versus the effects *with* computer technology. Learning *with* computers refers to the learner entering an intellectual partnership with the computer … when students work with computer technologies, instead of being controlled by them, they enhance the capabilities of the computer, and the computer enhances their thinking and learning. (pp. 30-31)

Jonassen et al.'s (1998) and Ertmer's (1999) descriptions about technology use explained high-level technology integration and differences between learning *from* technology and learning *with* technology. Specifically, learning *from* technology considers technology as media to deliver and present information; learning *with* technology emphasizes how technology engages students as a knowledge construction tool for information analysis, knowledge interpretation, and representation. Thus, the differences between the two concepts are mainly about whether technology supports or creates learner-centered collaborative learning environments. Learning *with* technology assures technology's role as a constructive learning tool to enhance learner-centered, engaging, and authentic learning experiences (Jonassen & Reeves, 1996).

Both Jonassen et al.'s (1998) and Ertmer's (1999) interpretations of technology integration highlight students' meaningful, authentic learning experiences, and communications and collaborations between teachers, learners, and technology. The definition of learning *with* technology has soon been adopted by scholars who sought to examine constructivist, student-centered technology-enhanced teaching practices in various educational settings. The learning contexts range across K-12 learning environments (e.g., Cviko, McKenney, & Voogt, 2013; Guzey & Roehrig, 2009; Heitink et al., 2016; Hew & Brush, 2007; Hermans et al., 2008; Zhao et al., 2002), teacher education (e.g., Alger & Kopcha, 2010; Glazer et al., 2009; Kopcha, 2012; Ottenbreit-Leftwich et al., 2010), and instructional design (e.g., Agyei & Voogt, 2012; Boschman et al., 2015; Lee & Kim, 2017).

Based on the definition of technology integration offered by Ertmer (1999) and Jonassen et al. (1998) that technology integration is to provide students with constructive, learner-centered, and authentic learning experiences with the use of technology (i.e., learning *with* technology), prior research on instructional practice has examined how technology can be effectively integrated into classroom instruction and instructional design. Many studies have identified significant factors that can affect teachers' instructional design decisions about technology integration. These factors and related studies will be discussed later in this chapter.

Instructional design judgments for technology use

Teachers' instructional design judgment is an essential theoretical construct that is closely related to teachers' decision-making for technology use (Gray et al., 2015; Hammond, 1988; Yanchar & Gabbitas, 2011). Design judgments refer to how instructional designers make decisions in their design processes (Nelson & Stolterman, 2012; Smith & Boling, 2009). Teachers often work as instructional designers to make technology-integrated design decisions for their teaching contexts. Thus, design judgments allow teachers to use their knowledge, conceptual design sense, and critical flexibility for instructional design to address multiple factors in their design practices (Gray et al., 2015; Zhu et al., 2020).

A complex problem-solving process often entails design judgments to “reduce the complexity of the situation or solve the issue that has been encountered” (Lachheb & Boling, 2021). Compared to dynamic decision-making, instructional design judgments emphasize more on internal factors such as teachers’ perceptions, knowledge, and their critical “sense” while designing instruction (Gray et al., 2015). Prior research has discussed how expert and novice instructional designers approach design processes in different ways (Cross, 2004; Kim & Ryu, 2014). The process is similar to how teachers make design decisions for technology integration in instructional design practices. Some studies have suggested that expert instructional designers (and experienced teachers) can form meaningful problem representations based on their knowledge, experiences, and a variety of information and contextual factors (Ertmer et al., 2008; Rowland, 1992). By comparison, novice instructional designers (and pre-service teachers) are more likely to capture external and shallow features of the design task, thereby failing to make a systematic design analysis that considers all essential factors and information.

Nelson and Stolterman (2012) proposed twelve types of design judgments: (1) framing judgment, (2) default judgment, (3) deliberated off-hand judgment, (4) appreciative judgment, (5) appearance judgment, (6) quality judgment, (7) instrumental judgment, (8) navigational judgment, (9) compositional judgment, (10) connective judgment, (11) core judgment, and (12) meditative judgment. Table 4 presents examples of these instructional design judgments in K-12 settings based on Nelson and Stolterman’s (2012) classification.

Table 4. *Summary of design judgments and examples in K-12 settings.*

Design judgment	**Definition** (Nelson & Stolterman, 2012)	**Judgments in instructional design** (Lachheb & Boling, 2021)	**Example of design judgment in K-12 settings**
Framing	A problem framing process that defines the boundaries of the design project.	Defining the boundaries of the design project by emphasizing its focus and outcomes.	Teachers make decisions on whether to design a learning module, a lesson plan, or a performance-support learning activity for students.
Default	An automatic decision-making process without too much mental efforts.	Generating "automatic" response to a situation without hesitation, and without too much thinking.	Teachers consult with subject matter experts (such as learning coaches or media specialists) to develop a lesson or an online learning activity (following the general procedure of school policy).
Deliberated off-hand	A recall of prior experiences or successful instructional design cases.	Recall of previous successful default judgments, consciously.	Teachers consult with media specialists for what digital tools are most used by other teachers for online learning activities with elementary students.
Appreciative	A prioritized design decision-making based on an emphasis on certain aspects of a design, considering various options, perspectives, and information.	Emphasizing certain aspects of a design, and backgrounding others.	Teachers appreciate an online learning module developed by the media specialists and make certain changes and adjustments to accommodate student needs.
Appearance	A design decision-making in terms of style, nature, character, experience, and assessment.	Assessing the overall quality of the design.	Teachers conduct a student reflective evaluation for collecting student feedback regarding the learning activity and its design.

Quality	A design decision-making regarding materials, aesthetic norms, and standards.	Finding out the match/mismatch between aesthetic norms/standards and the particular proposed design artifacts.	Teachers discuss with the media specialists regarding the colors, visual representations, and texts in the online learning module.
Instrumental	A selection of tools or means that can be used for teaching and learning.	Selecting and using design tools/means to reach established design goals.	Teachers conduct a low-technology option for a learning activity because some students cannot get access to the internet at home.
Navigational	A complex and ill-structured design decision-making process considering different factors and directions.	Considering a path/direction to follow in completing a design task.	Teachers consider consulting with more subject content experts or media specialists to help them design and develop an online learning activity for mathematics learning.
Compositional	A decision-making process considering all elements and factors influencing the design project.	Bringing all elements of design together to form a whole.	Teachers map out all related elements for an online learning module, including learning objectives, subjects, grades, teaching standards, learning activities, and assessments to form a structure of an online learning module.
Connective	A design decision-making process considering a synthesis of different elements, informational perspectives, and its connections.	Making connections of objects together for the specific design situation.	Teachers map out how argumentation learning in mathematics aligns with that in science learning and develops some learning activities connecting the two concepts.

Core	A design decision-making process that relates to teachers' own values and beliefs.	Designer's own value or thinking that can lead to invoking all other design judgments.	Teachers decide to create an online discussion board because they believe that learning is collaborative and interactive.
Mediative	A balance between different alternatives and design judgments.	Not explicitly specified.	Teachers compare different digital tools considering the advantages and disadvantages, whether they contain collaborative features, etc., and decide to use a specific digital tool for a certain learning activity.

Specifically, framing judgment is mostly utilized at the beginning of the design process. It presents the problem framing process where practitioners make design judgments. Default judgment refers to practitioners' high-level decisions without too much mental efforts. Deliberated judgment is about the design decisions after a practitioner is familiar with a skill or a process. Appreciative judgment presents the prioritized decision based on the various options, perspectives, and information. Appearance judgment is about the design decisions in terms of the style, nature, character, and experience. Quality judgment is a matter of the choice of material. Instrumental judgment relates to the instrument design decisions, such as videos, technology tools, equipment, etc. Navigational judgment presents the design decisions in a complex and ill-structured situation. Compositional judgment requires practitioners to put things together with relationships and connections. Connective judgment asks for a series of synthesis of different options and informational perspectives. Core judgment is the deep and core judgment system in practitioners. Mediative judgment refers to how practitioners make a balance between different alternatives and design judgments (Nelson & Stolterman, 2012).

Prior studies have discussed design judgments in instructional design settings (e.g., Boling et al., 2017; Lachheb & Boling, 2018; Yanchar & Gabbitas, 2011). A recent study by Boling et al. (2017) examined the design judgment of eleven experienced instructional designers. This study indicated that design judgment is still a new topic in the field of instructional design. Through the analysis of instructional design judgements, the researchers suggested that more empirical studies investigating practitioners' design judgments and decision-making processes are needed. Another case study by Lachheb and Boling (2018) indicated the same concern. They suggested that educators should develop their design judgment knowledge and skills in real-life instructional design practices. Yanchar and Gabbitas (2011) theoretically discussed the design judgment and critical flexibility of instructional designers. They argued that conceptual design sense is critical in instructional designers' decision-making processes, since it entails a designers' beliefs, values, and assumptions through critical reflections. However, all the above studies exploring instructional design judgments did not explore teachers' design judgments in K-12 settings, thus teachers' instructional design judgments for their teaching and learning practices have not yet been fully investigated.

In Table 5, all the current studies discussing instructional design judgment and decision-making are presented. The research methods and the research contexts of the empirical studies exploring instructional designers' design judgment are also listed. Additionally, whether these empirical studies addressed decision-making strategies is presented in this table. None of the studies have been conducted in K-12 settings.

Table 5. *Studies exploring instructional designers' design judgments and decision-making.*

Authors	**Study design**	**Context**	**Instructional designers' design judgments**	**Decision-making strategies**	**Qualitative methods to identify design judgments (e.g., interviews)**	**Quantitative methods to identify design judgments (e.g., assessments)**	**Professional development or instructional design guidelines**
Boling et al., 2017	Multi case study	Instructional design	X		X		
Gray et al., 2015	Case study	Higher education	X	X	X		X
Honebein, 2019	Evaluation study	Instructional design	X			X	
Kim & Ryu, 2014	Case study	Instructional design	X	X	X		X
Lachheb & Boling, 2018	Mixed-methods	Instructional design	X	X	X	X	X
Smith & Boling, 2009	Literature review	Instructional design	X				
Yanchar & Gabbitas, 2011	Theoretical study	Instructional design	X	X			X
Zhu et al., 2020	Case study	Higher education (public health)	X	X	X		X

Factors influencing teachers' decision-making

A variety of factors influence teachers' decision-making while designing instruction. Prior studies have identified significant factors that can affect teachers' instructional decision-making, including teachers' beliefs (Ertmer, 1999, 2005; Hermans et al., 2008; Tondeur, van Braak, Ertmer, & Ottenbreit-Leftwich, 2017), teacher knowledge (Heitink et al., 2016; Kopcha et al., 2020), pedagogical reasoning (Boschman et al., 2015; Lee & Kim, 2017; Webb & Cox, 2004), and teachers' instructional design judgments (Boling et al., 2017; Boling & Gray, 2014; Gray et al., 2015; Nelson & Stolterman, 2012; Zhu et al., 2020).

Teacher beliefs

Teacher beliefs have been recognized as a critical factor influencing teachers' decision-making for technology use and pedagogical practices in the classroom (Ertmer, 2005). Scholars have yet to determine a definition of teacher beliefs, as "the difficulty in defining teacher beliefs centers on determining if, and how, they differ from knowledge" (Ertmer, 2005, p.28). Thus, how teachers' knowledge differs from their beliefs and the extent to which teachers' knowledge can impact their beliefs remain controversial (Pajares, 1992; Philipp, 2007). Pajares (1992) indicated that the term *belief* requires a clear and thorough discussion of the constructs within it. The difference between teacher beliefs and knowledge, according to Pajares (1992), is that teacher knowledge is often connected with consensus, while teacher beliefs lack validity, consensus, and consistency. Philipp (2007) explained that researchers could view teacher knowledge as "belief with certainty" (p.266). Therefore, teacher beliefs have something "core" in teacher belief systems that are valuable to be explored as psychological constructs in teacher education.

Ertmer (1999) indicated that teacher beliefs can present specific challenges for teachers' decision-making for technology integration. Ertmer (1999) explained first-order (external-) and second-order (internal) barriers that prevent teachers from developing technology-enhanced, student-centered practices in their classrooms. Specifically, first-order barriers include teachers' limited access to technology, time to learn or use technology, insufficient or ineffective professional training, and lack of resources or support. Second-order barriers consist of teacher beliefs, perceived values of technology, and lack of comfort or confidence in technology use. Scholars have argued that internal barriers, especially teacher beliefs, deserve to be further examined because of their relationship to teachers' attitudes toward students, classroom contexts, and their decisions about teaching practices (e.g., Ertmer et al., 2012; Shifflet & Weilbacher, 2015; Tondeur et al., 2017; Zhao et al., 2002).

Based on the prior study, Ertmer (2005) also thoroughly analyzed the pedagogical beliefs that played a critical role in teachers' decisions about technology use. She claimed that teachers' beliefs about technology integration are similar to their beliefs about classroom instruction more generally. That is, "if the technology is presented as a tool for enacting student-centered curricula, teachers with teacher-centered beliefs are less likely to use the tool as advocated" (Ertmer, 2005, p.31). Ertmer (2005) further identified three strategies to promote change in teacher beliefs about technology: personal experiences, vicarious experiences, and sociocultural influences. Specifically, personal experiences promote individual change in teachers' technology use and classroom goals, vicarious experiences build confidence and competence in teachers' technology integration and professional development, and sociocultural influences reflect the importance of professional communities and "the influence of the school environment" (Ertmer, 2005, p.35).

Ottenbreit-Leftwich et al. (2010) specifically discussed teacher value beliefs associated with using technology to promote student-centered learning. Teacher value beliefs refer to the belief constructs caused by value (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2008), that is, how teachers think that their judgments about "whether an approach or tool is relevant to their goals" can be achieved (Ottenbreit-Leftwich et al., 2010, p.1322). The study leveraged the hermeneutic phenomenology approach to uncover eight teachers' use of technology and their value beliefs about student needs. The result shows that teacher value beliefs can influence teachers' technology integration practices and their instructional decisions on technology use. Professional development initiatives can be more effective if they address technology uses that align with teacher value beliefs.

Meanwhile, Ertmer's research (1999, 2005) and Ottenbreit-Leftwich et al. (2010) have informed many other empirical studies to explore the relationship between teacher beliefs and teachers' decision-making for technology integration to provide suggestions for professional development. Some quantitative studies have employed various statistical methods to examine the relationship between teachers' beliefs and their use of technology (Bahcivan et al., 2019; Hermans et al., 2008; Inan & Lowther, 2010; Jung, Cho, & Shin, 2019; Pittman and Gaines, 2015; Sang et al., 2011; Tondeur et al., 2008).

For instance, Inan and Lowther (2010) conducted descriptive statistical examinations to determine the direct effect of teacher pedagogical beliefs on technology integration in K-12 classrooms. They developed a research-based path model to explain the causal relationship between teachers' individual characteristics and perceptions of environmental factors that influence their technology integration in the classroom. The statistical results provided significant evidence that the model can explain the relationships between the factors and technology integration.

Sang et al. (2011) used path modeling to explore the direct and indirect effects of the teacher beliefs on information and communication technology (ICT) K-12 classroom integration. They selected a K-12 classroom context to identify the combined impact of the variables related to teacher beliefs on teachers' technology integration. Comparably, Hermans et al. (2008) went into primary schools to identify how teacher beliefs affected computer use in classrooms. They collected quantitative data from both experimental and control groups of participant teachers to investigate the relationship between teacher beliefs and teachers' computer use in classroom settings. Another study by Pittman and Gaines (2015) examined the relationship between technology use factors (e.g., technology professional development) and teacher beliefs toward technology use in third-, fourth-, and fifth-grade classrooms. They utilized a *t*-test to compare teacher beliefs toward technology use and different factors about technology use. The study result showed that the strongest correlation with technology integration is teachers' attitudes toward technology.

Based on this body of quantitative research, the assumption that teacher beliefs (or simply teacher value beliefs) play a significant role in technology integration has been statistically supported in some studies (i.e., Bahcivan et al., 2019; Hermans et al., 2008; Inan & Lowther, 2010; Pittman & Gaines, 2015; Sang et al., 2011; Tondeur et al., 2008) but not confirmed in others (i.e., Jung, Cho, & Shin, 2019). Through the statistical analysis, Jung, Cho, & Shin (2019) conducted a case study exploring the relationship between all teacher-related variables and technology integration. This study confirmed the significant influence of teacher-related variables such as supportive culture, teachers' self-efficacy, and teacher knowledge on teachers' technology integration; however, teachers' pedagogical beliefs and technology integration did not have a significant relationship in this study.

Some qualitative studies also identified the relationship between teacher beliefs and decision-making for technology integration (Ding et al., 2019; Ertmer et al., 2012; Hsu, 2013; Shifflet & Weilbacher, 2015; Zhao et al., 2002). For example, Ding et al. (2019) identified the relationship between teachers' content-specific pedagogical beliefs and technology integration in English as a second language (ESL) classes by exploring lesson plan artifacts and focus group interviews with teachers. The researchers showed that teacher belief is "one of the dispositional factors that must be addressed in teachers' technology learning" (Ding et al., 2019, p.35). Hsu (2013) conducted surveys and interviews with pre-service teachers to examine changes in pre-service teachers' beliefs about technology integration during the student teaching semester. The findings indicated that pre-service teachers' beliefs about technology integration changed in two directions, positively and negatively. The study suggested that reflective activities for pre-service teachers can help teacher educators gain access to the teachers' decision-making processes.

A case study by Shifflet and Weilbacher (2015) followed a middle school social studies teacher to describe the complexities and difficulties of technology integration in her classrooms. The participants in this study were a 13-year veteran social studies teacher and the student intern who worked with the teacher. Through the use of interviews and observations, this study described teacher belief constructs and teaching practices in relation to the participants' viewpoints of technology use in the classroom. This study also confirmed the critical role of teacher beliefs in teachers' decision-making for technology-integrated classroom practices.

Table 6 presents the research methods of both quantitative and qualitative studies that have explored the relationships between teacher beliefs and teachers' decision-making for technology integration. Findings from most studies indicated that teacher beliefs play a critical role in teachers' integration of technology. Teachers may change or improve their pedagogical beliefs toward technology integration after they have identified the affordances of technology-integrated practices and the learning environment.

Table 6. *Studies exploring teacher beliefs and teachers' decision-making for technology integration.*

Authors	**Study design**	**Context**	**Types of technology**	**Positive relationship between teacher beliefs and teachers' decision-making for technology integration**
Bahcivan, Gurer, Yavuzalp, & Akayoglu, 2019	Quantitative study	Teacher education	Not reported	X
Ding, Ottenbreit-Leftwich, Lu, & Glazewski, 2019	Case study	K-12	Technology tools in K-12 settings such as Powerpoint	X
Er & Kim, 2017	Design research	Teacher education	Technology tools such as Powerpoint and Interactive WhiteBoard	X
Ertmer et al., 2012	Case study	K-12	Web 2.0 tools	X
Hermans, Tondeur, van Braak, & Valcke, 2008	Quantitative study	K-12	Computer use	X

Hsu, 2013	Case study	Teacher education	Not reported	X
Inan & Lowther, 2010	Quantitative study	K-12	Not reported	X
Jung, Cho, & Shin, 2019	Quantitative study	K-12	Not reported	
Kilinc, Tarman, & Aydin, 2018	Quantitative study	K-12	Technology tools in K-12 settings	X
Kim et al., 2013	Mixed-methods	Profession al developme nt	Web-based technology tools	X
Kimmons & Hall, 2016	Quantitative study	K-12	Technology tools in K-12 settings	X
Lee, Longhurst, & Campbell, 2017	Quantitative study	K-12	Not reported	X
Liu, Ritzhaupt, Dawson, & Barron, 2017	Quantitative study	K-12	Technology tools in K-12 settings	X
Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010	Qualitative study	K-12	Electronic portfolio	X
Pittman & Gaines, 2015	Quantitative study	K-12	Technology tools in K-12 settings	X
Sang, Valcke, van Braak, Tondour, & Zhu, 2011	Quantitative study	K-12	Instructional communication tools	X

Shifflet & Weilbacher, 2015	Case study	K-12	Technology tools in classroom settings such as SMART Board	X
Thieman, 2008	Mixed-methods	K-12	Technology tools such as presentation tools, Web tools, and computer/video tools	X
Tondeur, Hermans, van Braak, & Valcke, 2008	Quantitative study	K-12	Computer use	X
Zhao, Pugh, Sheldon, & Byers, 2002	Case study	K-12	Not reported	X

Teacher knowledge and pedagogical reasoning

Teachers' knowledge is another essential factor influencing teachers' decision-making for technology use (Jonassen, 1997). Teachers' knowledge base on technology integration and its relationship with their decision-making in practice have been discussed by some prior studies (Guzey & Roehrig, 2009; Heitink et al., 2016). Most empirical studies exploring the relationship between teacher knowledge and technology integration have used TPACK or the model of pedagogical reasoning as their theoretical frameworks (Voogt et al., 2013; Harris & Phillips, 2018; Willermark, 2018).

TPACK is a critical conceptual framework that encourages teachers to draw from their knowledge to design technology-integrated pedagogical practices for teaching (Koehler & Mishra, 2005; 2009). TPACK explains teachers' knowledge base of technology integration. This framework highlights technology integration as an equal-aligned component as content and pedagogy in teaching. Teachers who want to integrate technology are required to apply their knowledge base to synthesize content, pedagogy, and technology well together (Koehler & Mishra, 2009). The TPACK framework has been extensively employed by teachers to develop technology-integrated lesson plans and teaching practices (e.g., Guzey & Rochrig, 2009; Heitink et al., 2016; Koehler, Mishra, & Yahya, 2007; Voogt et al., 2013).

The development of TPACK is based on the concept of pedagogical content knowledge and pedagogical reasoning (Shulman, 1986, 1987). The term pedagogical content knowledge (PCK) and the model of pedagogical reasoning and action were firstly introduced by Shulman (1986, 1987). Shulman (1986) described the transformation process through which teachers transferred the knowledge base of content (CK) and pedagogy (PK) into classroom teaching practices. Based on the concept of PCK, Koehler and Mishra (2005, 2009) proposed the TPACK conceptual framework that categorizes teachers' knowledge into three equally aligned domains: content (CK), pedagogy (PK), and technology (TK) - and the interplay among the three domains. Accordingly, the TPACK framework captures how teachers transform their knowledge base into technology-enhanced teaching practices through pedagogical reasoning and instructional design. Frameworks similar to TPACK, such as information and communication technology (ICT)-related PCK (Angeli & Valanides, 2005) and technology-enhanced PCK (Niess, 2005), also recognize the impact of technological knowledge (TK) on teaching practices.

Thus, teachers' pedagogical reasoning has been recognized as critical to understanding teachers' decision-making regarding knowledge transformation and technology integration (e.g., Boschman et al., 2015; Webb & Cox, 2004). Prior studies have indicated that the investigation of teachers' pedagogical reasoning processes and teacher knowledge base contributes to the successful transformation of teacher knowledge into effective teaching practices (Heitink et al., 2016; Loveless, 2011; Starkey, 2010). Both TPACK and pedagogical reasoning should work as theoretical frameworks to understand how teachers make pedagogical decisions for technology integration.

Shulman's (1987) pedagogical reasoning framework explains the transformation process from teachers' knowledge to instructional practice, emphasizing teaching "as comprehension and reasoning," and "as transformation and reflection" (p.13). Shulman (1987) explained:

> When we examine the quality of teaching, the idea of influencing the grounds or reasons for teachers' decisions places the emphasis precisely where it belongs: on the features of pedagogical reasoning that lead to or can be invoked to explain pedagogical actions. … This image of teaching involves the exchange of ideas. The idea is grasped, probed, and comprehended by a teacher, who then must turn it about in his or her mind, seeing many sides of it. Then the idea is shaped or tailored until it can in turn be grasped by students. (p.13)

The pedagogical reasoning framework thus highlights the transformation of teachers' knowledge into the design and implementation of pedagogical practice. Accordingly, the literature reviews of TPACK from Voogt et al. (2013) and Harris and Phillips (2018) have both suggested that the pedagogical reasoning framework should be used together with TPACK to understand teachers' design decision-making process. Heitink et al. (2017) reinforced that teachers' pedagogical reasoning can elicit their technology pedagogical knowledge (TPK) when using ICT in practice. The reciprocal relationship between TPACK development and pedagogical reasoning can support teachers' instructional design for technology-enhanced practices (Heitink et al., 2017).

Gibson (1977) discussed the concept of affordances in a learning environment. He suggested that the information in the environment can be perceived by people, thus they are related to the action possibilities of decision-makers. Webb and Cox (2004) and Shafto et al. (2014) suggested that teachers should consider both teachers' and learners' perspectives in pedagogical reasoning. Approaching instructional design and technology integration from both viewpoints enables teachers to utilize the learning environment's affordances and accommodate the learning audience (Gibson, 1977; Webb & Coxx, 2004). Webb and Cox (2004) also developed a pedagogical reasoning framework for technology integration that requires practitioners to leverage both teachers' and students' knowledge and beliefs as well as the affordances within the learning environment. Accordingly, a thorough examination of teachers' pedagogical reasoning processes requires consideration for how teachers negotiate affordances from both perspectives and the learning environment.

Some empirical studies have explored teachers' development of TPACK and their decision-making for technology-enhanced teaching practices in classrooms. Both TPACK and pedagogical reasoning involve teachers' knowledge base and transformation of the knowledge into teaching practices related to technology integration (Koehler & Mishra, 2005, 2009; Shulman, 1987; Webb & Coxx, 2004). Below are some empirical studies that explored both TPACK and pedagogical reasoning in the context of teachers' decision-making for technology-enhanced teaching practices (e.g., Boschman et al., 2015; Guzey & Roehrig, 2009; Heitink et al., 2016; Koh, 2019).

For instance, Koehler, Mishra, & Yahya (2007) conducted an empirical study for the TPACK framework. This study investigated teachers' development of TPACK through a semester-long faculty development design seminar, where faculty members worked in groups to develop online courses. Through quantitative discourse analysis of 15-week field notes from two design teams, the authors found that faculty members gradually moved from three distinctive knowledge bases (i.e., CK, PK, and TK) to the emphasis on the connections among the three bases. This study finally suggested that the complex interrelationships between the three knowledge bases and the contexts in which they function well should be examined in future studies.

Guzey and Roehrig (2009) discovered that teachers' pedagogical reasoning and contextual factors greatly influence teachers' teaching performances and pedagogical decisions (Guzey & Roehrig, 2009). They examined the development of teacher knowledge (TPACK) in four in-service secondary science teachers as they participated in a professional development program in terms of technology integration in K-12 classrooms. Through data analysis on interviews, surveys, classroom observations, teachers' technology integration plans, and action research study reports, this study confirmed that science teachers' TPACK can be developed through effective professional development opportunities. Meanwhile, this study suggested that contextual factors and teachers' pedagogical reasoning affected teachers' ability to transform what they learned into their classroom teaching practices. More empirical studies examining experienced science teachers' pedagogical reasoning processes for technology integration are needed to inform the nature and development of TPACK.

Moreover, Boschman et al. (2015) investigated the instructional design process of a team of kindergarten teachers creating technology-supported teaching materials and activities. Teachers' collaborative design decisions related to TPACK and their pedagogical reasoning processes were examined (Boschman et al., 2015). The study used a holistic examination of teachers' design talk for technology integration. Findings of this study indicated that teachers' design talk contained some deeper level of inquiry about technology integration, and TPACK and PCK were mostly connected to the practical concerns. Although TPACK includes three distinct domains of knowledge, this study reflected that pedagogy was only addressed by teachers “not as a single knowledge domain, rather in conjunction with the other two domains” (p.250). This study suggested that TPACK itself may not be sufficient to address the collaborative design experiences of teachers; rather, teachers’ deeper level of inquiry in their design processes should be investigated thoroughly through more empirical studies.

Similarly, Heitink et al. (2016) examined teachers’ pedagogical reasoning and TPACK use in teachers’ instructional design processes. This study mainly focused on teachers’ reasoning about technology use in practice. Through video cases, the researchers investigated 157 teachers’ technology use in practice and their reasoning behind their actions. The results of this study showed that teachers’ transfer of knowledge in practice was reflected in half of the video cases. The alignment between reasoning and practice was explicitly addressed in some teachers’ reflections (but not others).

Another case study by Koh (2019) described teachers’ pedagogical changes using different TPACK design scaffolds, including lesson design heuristics, a meaningful learning rubric, and TPACK activity types. This case study addressed teachers’ challenges in designing technology-integrated lessons for student-centered learning. Using pre- and post-surveys, the impact of these TPACK design scaffolds on the TPACK confidence and lesson design confidence were statistically examined. The findings of this study indicated that these design scaffolds had positive effects on teachers’ TPACK confidence. Teachers’ lesson plan confidence could be enhanced through the promotion of teachers’ articulation of their pedagogical change in lesson designs. Both Heitink et al. (2016) and Koh (2019) confirmed that teachers’ use of

TPACK significantly affected teachers' pedagogical decision-making process for instructional design. These studies successfully recognized factors and instructional strategies supporting teachers' practical use of TPACK in design decision-making.

Additionally, some theoretical research has discussed systematic literature reviews about TPACK (e.g., Voogt et al., 2013; Harris & Phillips, 2018; Willermark, 2018). Voogt et al.'s (2013) literature review analyzed 55 studies (i.e., theoretical and empirical works) related to the TPACK framework. The researchers claimed that the practical use of TPACK is difficult to evaluate. Voogt et al. (2013) proposed that TPACK itself is not sufficient to analyze teachers' technology integration; both TPACK and teachers' decision-making/pedagogical reasoning should be examined to explore how technology has been integrated into instructional practice. Willermark's (2018) literature review examined 107 empirical studies about TPACK published from 2011 to 2016, finding that a mixed-methods approach may facilitate investigations into teachers' TPACK use in classrooms (p.338).

Another literature review by Harris and Phillips (2018) discussed new directions in future TPACK research through the descriptions of connections and differences between PCK and TPACK. Through examinations of theoretical works and empirical studies on both PCK and TPACK (e.g., Angeli & Valanides, 2009; Feng & Hew, 2005; Loveless, 2011; Mishra & Koehler, 2006; Niess, 2005; Shulman, 1987; Starkey, 2010), this literature review suggests that "teachers' knowledge is only used to provide the grounds for their choices and actions" (Harris & Phillips, 2018, p.2059). Although teachers' knowledge (i.e., TPACK) and their pedagogical actions "can change in fundamental ways when emerging technologies are incorporated," the process that leads teachers to make pedagogical decisions, typically *does not* change (Harris & Phillips, 2018). Teachers' pedagogical reasoning and decision-making process for technology integration needs to be further examined within the process that compromises teachers' knowledge transformation (i.e., TPACK development) (Harris & Phillips, 2018).

Thus, both the TPACK framework and Shulman's (1987) framework of pedagogical reasoning and action have been utilized to inform teachers' instructional decision-making and instructional design. At the same time, since both TPACK and Shulman's (1987) framework focus on teachers' knowledge and pedagogical reasoning related to technology integration, some researchers have claimed that teachers' instructional design of technology-enhanced pedagogical practices should embrace both teachers' and students' perspectives and the affordances of the learning environment during the decision-making process (Shafto et al., 2014; Webb & Cox, 2004). Central to instructional design decision-making and technology integration are considerations for the affordances of the learning environment and perspectives from both teachers and students (Stefaniak et al., 2021; Webb & Coxx, 2004). Teachers' pedagogical reasoning process and dynamic decision-making should be examined together in terms of how teachers have negotiated these two perspectives and the classroom context (Stefaniak et al., 2021).

Decision-making for instructional design and technology integration

This section will provide a systematic analysis of empirical studies exploring decision-making for instructional design and technology integration. As discussed above, instructional design can be viewed as a set of decisions made for instruction (Jonassen, 2012). Thus, teachers' decision-making processes directly influence the instructional design decisions governing their technology-enhanced teaching practices in the learning environment.

McKenney et al. (2015) developed an ecological framework for investigating teacher design knowledge for technology-enhanced learning. This theoretical study discussed the concept of *teachers as designers* through technical, phenomenological, and realist theoretical strands. Instructional design models and frameworks can be classified into technical strands since the primary emphasis is to guide teachers' design decision-making. Phenomenological strands emphasize teachers' designer experiences and consciousness. TPACK and Shulman's pedagogical reasoning framework can be categorized as realist strands because these frameworks reflect what practitioners do in actuality as well as how and why they do it. This ecological framework integrates critical concepts from each strand to specify how to examine teachers' design knowledge, design decision-making processes, and instructional design strategies for technology-enhanced instruction.

Some prior empirical studies have explored teachers' decision-making processes related to technology integration. For example, Greenhow, Dexter, and Hughes (2008) conducted a comparison study of in-service and pre-service teachers to examine teachers' abilities to apply knowledge about technology integration to instructional decision-making. They proposed a series of design guidelines for technology professional development based on their analysis of teachers' pedagogical decisions: (1) more professional development opportunities should be focused on the development of teachers' lesson planning and decision-making skills, especially "the importance of identifying and weighing options and articulating a well-justified instructional plan to students, parents, and administrators who may be wary of innovation" (p.22); (2) more emphasis should be put on how teachers provide formative feedback on students' decision-making performances, thus teachers themselves can develop a nuanced understanding of the complexities and dynamics within their decision-making processes; and (3) the reflective and inquiry-oriented approach to technology integration should be applied in the professional development opportunities to develop teachers' reflective decision-making knowledge and skills.

Kopcha et al. (2020) examined teachers' decision-making and proposed a process model (TRM) related to technology integration in K-12 contexts. This model emphasized the dynamics and evolution during teachers' decision-making processes. The researchers also called for more empirical studies investigating teachers' decision-making *process* for the integration of technology rather than products to facilitate teaching and learning in technology-enhanced contexts (Kopcha et al., 2020).

Cviko, McKenney, and Voogt (2013) used mixed methods to explore the decision-making of six kindergarten teachers when re-designing technology-enhanced teaching practices in kindergarten classrooms. This study suggested that re-designing technology-enhanced activities supported teachers' decision-making due to "teacher experiences of co-ownership" (p.466). More empirical studies exploring what kind of involvement appeals to teachers and encourages teachers to participate into the (re-)design processes are needed in the field. Comparably, Boschman et al. (2015) conducted a multi-case qualitative study to understand kindergarten teachers' design decision-making when designing and developing a technology-rich learning environment for young children. Here, the research team found both teacher knowledge and teacher beliefs play an important role at the start of their instructional design process.

Ertmer and Cennamo (1995) discussed strategies to improve teachers' decision-making skills in instructional design practices. An apprenticeship model based on a cognitive apprenticeship approach (Collins, Brown, & Newman, 1989) was described in Ertmer and Cennamo's (1995) theoretical study. The researchers provided descriptions of the pedagogical features mentioned in the cognitive apprenticeship approach including situated learning, modeling, coaching, reflection, articulation, and exploration, and discussed how to conduct corresponding teaching practices in instructional design contexts. This apprenticeship model recognizes the problem-solving process teachers face when designing instruction and emphasizes the value of real-world learning design environments for novice instructional designers.

In addition, prior empirical studies have also examined pedagogical strategies and professional development practices to support teachers' instructional design decision-making processes. For example, Blackwell and Pepper (2008) utilized a statistical analysis to investigate the effect of concept mapping on pre-service teachers' pedagogical decision-making in reflective practice. Their quantitative results indicated that concept mapping can be perceived as an effective tool to enhance pre-service teachers' reflective process for pedagogical decision-making.

Bennet et al. (2002) explored the design of authentic learning practice to improve pre-service teachers' decision-making, looking at both personal accounts and original design documents. The study found that the focus on authentic learning and opportunities to practice instructional design can stimulate teacher-learners' understanding of real-life situations. Pre-service teachers can also benefit from the design learning process as well as their exploration of multiple perspectives and issues emerging from real-world design cases.

McKenney et al. (2016) examined the conversations taking place when teachers collaboratively design technology-enhanced learning practices for early literacy classrooms. This study suggested that the design decision-making process for teacher-learners can be supported by process scaffolding, subject matter scaffolding, visualization, and teacher collaboration. Another qualitative case study by Bennett et al. (2017) analyzed 30 university teachers' instructional design processes. After examining teachers' design and re-design work, the researchers presented a top-down, iterative, descriptive model for teachers to use in their instructional design process.

Table 7 presents the empirical studies that have investigated teachers' decision-making processes related to technology integration and instructional design pertaining to K-12 settings. Relevant instructional methods promoting teachers' design decision-making processes are also listed.

Table 7. *Empirical studies investigating teachers' decision-making for instructional design and technology integration.*

Authors	**Purpose**	**Context**	**Recommended instructional method(s) to promote design decision-making in teachers/practitioners**
Agyei & Voogt, 2012	To explore four pre-service mathematics teachers' development of TPACK through collaborative design.	Teacher education	Teacher reflection. Collaborative design practice.
Blackwell & Pepper, 2008	To investigate the effect of concept mapping on teachers' reflective pedagogical decision-making processes.	Teacher education	Concept mapping. Reflective activities.
Bennet et al., 2002	To explore how pre-service teachers design authentic learning opportunities through multimedia technology.	Higher education	Authentic learning design practices.
Bennett et al., 2017	To examine university teachers' instructional design work to understand their iterative design process for instructional planning.	Teacher education	Iterative design process.
Boschman et al., 2015	To investigate how teachers use TPACK during design talk for technology-rich early literacy activities.	Kindergarten	Collaborative design. Procedural and subject-matter support.

Boschman et al., 2016	To investigate the role of content knowledge of kindergarten teachers during collaborative curriculum design for technology-enhanced learning.	Kindergarten	Subject matter expert support.
Cviko et al., 2013	To examine teachers as re-designers of technology-integrated activities for early literacy instruction.	Kindergarten	Teacher reflection. Teacher collaboration.
Greenhow et al., 2008	To compare the abilities of in-service and pre-service teachers in terms of how they apply instructional knowledge about technology integration in decision-making.	Teacher education	Assessment of teacher knowledge. Field experience to promote contextual considerations.
Gyabak, Ottenbreit-Leftwich, & Ray, 2015	To examine how teachers use design thinking as they design online courses for K-12 students.	K-12	Community of practice. Process support. Constant feedback.
Heitink et al., 2016	To investigate teachers' reasoning about their technology use in practice.	Teacher education	Coherence between technology use, subject matter, and pedagogy. Alignment between reasoning and practice.
Hoard et al., 2019	To explore expert and novice instructional designers' multimedia development knowledge and their design decisions when engaged in instructional design.	Instructional design	Support regarding media tool selection and relevant analysis.

Holmberg et al., 2018	To explore teachers' reframing of practice in digital contexts by analyzing teachers' pedagogical reasoning processes.	Teacher education	Exploration of teachers' pedagogical reasoning and TPACK development.
Hollands & Escueta, 2019	To identify the role of research in instructional decisions about acquiring and using technology for teaching and learning in higher education.	Higher education	Personalized learning.
Koh, 2019	To describe how teachers' pedagogical change can be supported through TPACK design scaffolds.	Teacher education	Lesson design rubrics. Multiple TPACK scaffolds supporting TPACK analysis. Contextualization of TPACK.
Lee & Kim, 2014	To develop an instructional design model for pre-service teachers' learning of TPACK in multidisciplinary technology-integrated courses.	Teacher education	Real-life learning experiences. Role-playing.
Lee & Kim, 2017	To elaborate on the TPACK-based instructional design model by investigating pre-service teachers' contextual analyses and descriptions of technology integration.	Teacher education	Instructor support. Role-playing. Evaluation of student-centered, technology-integrated lesson plans.
McKenney et al., 2016	To investigate the nature and content of teacher talk when designing technology-enhanced learning for early literacy classrooms.	Kindergarten	Team engagement. Process support. Subject matter support. Visualization of classroom enactment.

Nguyen & Bower, 2018	To discuss how to prepare novice teachers' technology-enhanced learning design capabilities through silent pedagogy.	Teacher education	Tutor support. Group collaboration. TPACK development.
Nichols & Meuleman, 2017	To explore educational designers' reflections on their decision-making processes through narrative inquiry.	Instructional design	Reflections.
Smith, Parker, McKinney, & Grigg, 2018	To explore the decision-making processes of elementary teachers as they design and implement an integrated STEM curriculum in their classrooms.	Elementary school	Examination of lesson elements. Exploration of tools and teacher knowledge to enact STEM curriculum with fidelity.
Thieman, 2008	To examine work samples and reflections of elementary and secondary pre-service teachers to explore the extent to which they integrate technology into their instructional planning for K-12 students.	Teacher education	N/A

Summary

Both classroom teaching and instructional design involve teachers' decision-making. However, limited empirical evidence has shown *how* and *why* teachers make decisions about technology-enhanced instruction and instructional design. None of the prior studies exploring design judgments have put their focus on K-12 settings and teachers' dynamic decision-making processes for instructional solutions. Teachers' dynamic decision-making processes, design judgments, as well as pedagogical reasoning for technology integration and instructional design have not been extensively investigated.

As a result, more scholarship is needed to unpack precisely how teachers are engaged in dynamic decision-making, design judgments, and pedagogical reasoning while designing instruction and integrating technology for their K-12 educational settings. It is also needed to explore what factors are influential in shaping the instructional design decision-making processes and design judgments employed by teachers. The present study, therefore, will investigate teachers' dynamic decision-making, design judgments, and pedagogical reasoning surrounding technology integration. By taking a deeper investigation on how teachers are involved in technological design decision-making, design judgments, and pedagogical reasoning, we can identify the potential connections reflecting the relationship between teachers' design decision-making processes and the design challenges they encounter, thereby proposing appropriate professional development strategies to support teachers' design decision-making knowledge and skill development.

CHAPTER 3

METHODS

This chapter describes the research methods used for this study and theoretical concepts related to the research design. The details related to the research design, including the research setting, participants, data collection methods, and data analysis procedure will be discussed in this chapter.

Purpose of the Study

The purpose of this study is to explore how teachers apply dynamic decision-making, design judgments, and pedagogical reasoning while designing instruction and integrating technology in their educational contexts (i.e., K-12 contexts). Participant teachers were asked to describe their dynamic decision-making processes regarding a (or multiple) technology-integrated instructional activity(ies) they have designed for their teaching contexts. This study employs the critical decision method (CDM) to have teachers explicitly explain internal and external factors such as their knowledge, experiences, values, perceptions towards different technology, and affordances of the learning environment that have influenced their dynamic decision-making processes, design judgments, and pedagogical reasoning for technology integration. During which, teachers' negotiation and navigation among multiple factors influencing their dynamic decision-making, design judgments, and pedagogical reasoning around technology integration were investigated.

Specifically, teachers participated in this study outside of a class. Participant teachers were recruited from learning, design, and technology programs across the United States. Teachers firstly completed a survey to describe how they have designed and implemented technology-integrated activities for their own classrooms or learning environments. Then, teachers participated in a follow-up *critical decision method* (CDM) interview to explicitly describe their dynamic decision-making processes for instructional design and technology integration. The interview questions were developed based on the critical incident technique (CIT) to elicit teachers' dynamic decision-making processes and pedagogical reasoning for specific events (Crandall et al., 2006).

The research questions for this study are:

- How do teachers engage in dynamic decision-making processes and pedagogical reasoning while designing instruction and integrating technology?
- What is the relationship between teachers' design judgments and their dynamic decision-making processes for instructional design and technology integration?

Research design

This exploratory case study employed a qualitative design to gain insight into teachers' dynamic decision-making processes, design judgments, and pedagogical reasoning while designing instruction and integrating technology in their teaching contexts. The research design would mainly employ the *critical decision method* (CDM) approach and utilize CDM interviews as the primary data source. Teachers participated in CDM interviews to discuss their dynamic decision-making processes for a technology-integrated instructional activity they have designed for their own instructional contexts (i.e., K-12 classrooms). A pre-survey regarding teachers' dynamic decision-making and instructional design for technology integration was distributed before the CDM interviews to exclude participants who did not meet the inclusion criteria.

The first phase of the study involved participant teachers identifying multiple technology-integrated instructional activities designed for their own classrooms. Participants initially completed a pre-survey in terms of their instructional design and technology integration practices in their K-12 contexts. After exclusion of the participants who did not meet the inclusion criteria or did not complete the survey, the second phase engaged participants in CDM interviews to indicate *how* they have engaged in dynamic decision-making, design judgments, and pedagogical reasoning by explicitly describing a variety of internal factors and external factors affecting their design decisions while designing instruction and integrating technology. Based on the technology-integrated learning activity(ies) identified, participants were required to conduct a systematic reflection of their own instructional activities and instructional design decision-making processes for technology integration, including how they made instructional design decisions for technology integration, changes they have made according to different contextual factors, and challenges they have encountered during the process. The semi-structured CDM interview questions helped the researcher explicitly describe relevant factors that have affected teachers' dynamic decision-making for technology integration and instructional design (Ertmer et al., 2008; Tessmer & Richey, 1997). The last phase involved data analysis for the CDM interview data and member checking procedure (Candela, 2019). Figure 1 presents the research design.

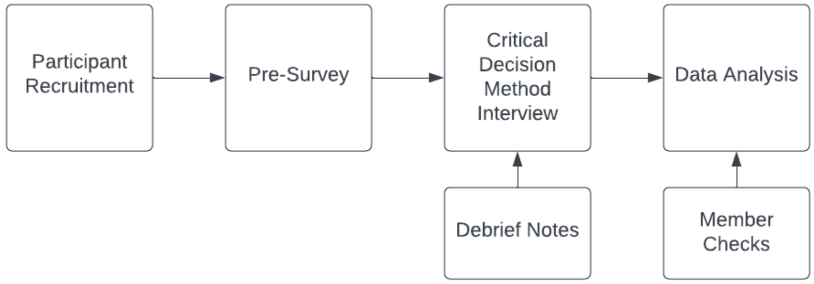

Figure 1. Research Design

Qualitative methods were employed to understand teachers' dynamic decision-making, design judgments, and pedagogical reasoning for integrating technology. Specifically, the pre-survey, teacher's interview data, and researchers' notes on teacher interviews were analyzed to explain the dynamic decision-making processes and pedagogical reasoning of teachers while designing instruction and integrating technology. The present study asked participant teachers to participate in the CDM interviews to discuss their decision-making and thinking processes regarding technology integration and instructional design for their classrooms/students. Through thematic coding analysis for the interview data (Nowell et al., 2017), a better understanding of how teachers have perceived dynamic decision-making and pedagogical reasoning while designing instruction and integrating technology can be gained, as well as their potential strategies used to navigate through different factors to develop instructional practices pertaining to the learning audience and learning environment. Meanwhile, Nelson and Stolterman's (2012) design judgment framework (see Table 4) guided the thematic coding analysis for the interview data.

Instrument: *Pre-survey about teachers' technology integration situations*

One data collection instrument was a pre-survey designed to identify teachers' technology integration for designing instruction in their current classrooms (see Appendix B).

The pre-survey asked participants to share their demographic information as well as their self-reported data regarding their technology integration situations while designing instruction for their current teaching. Specifically, the demographic information questions collected information regarding the participant teachers' teaching grade levels, subjects, years of teaching experience, and frequencies of using technology in their classrooms. The information about teachers' grade levels, subjects, and teaching experiences can help identify their expertise continuum (Ericsson et al., 1993). The frequencies of using technology can help us identify if the participant teachers have access to technology or have the habits of using technology in their classrooms.

Teachers were asked to provide a few examples of what and how they have done to integrate technology in their classrooms (see Appendix B). The sample scenarios provided as examples in the pre-survey were retrieved and adapted from conceptual papers in terms of technology integration and instructional design (Jonassen et al., 2003; Welsh et al., 2011). These scenarios were written in neutral tone with general terms, so that participant teachers were not misguided or misled to a desired response. From this section, some basic information regarding teachers' decision-making regarding technology integration and instructional design can be identified and explored.

Instrument: *Critical Decision Method (CDM) Approach*

The Critical Decision Method (CDM) approach is a cognitive task analysis (CTA) method derived from Flanagan's (1954) *critical incident technique* (CIT) to identify decision-making or problem-solving behaviors that are critical for task performances.

The CDM approach guides the major research design (see Figure 2). The CDM approach has been widely used to examine cognitive processes and ill-structured problem-solving (Jonassen, 2010; Klein, 2000). This approach allows researchers to use probing questions to elicit how teachers as decision-makers have leveraged their knowledge in diverse domains and applied them systematically in instructional design decision-making (Klein, 1989).

The CDM involves multiple retrospective questions that enable teachers to articulate their cognitive and dynamic decision-making processes for their performances (Hoffman et al., 1998). This method requires the participant to think of a single (or multiple) critical incident(s) that is either a success or a failure of a task. Based on the context of the critical incidents, the semi-structured interview consists of a series of probing questions that seek to reveal how decision-makers respond to critical incidents. Decision-makers' actions to critical incidents and their explanations of thinking processes can be analyzed to reflect their dynamic decision-making processes for instructional design and technology integration. The goal of the CDM approach, according to Crandall, Klein, & Hoffman (2006), is to leverage the critical incidents to analyze how practitioners or experts make decisions through their reasoning during an ill-structured complicated situation.

Normally, a four-step interview procedure is followed to identify teachers' dynamic decision-making processes based on their specific events (Crandall et al., 2006; Hoffman et al., 1998; Klein & Armstrong, 2004): (1) selecting an event/incident, (2) constructing a timeline, (3) deepening, and (4) "what if" queries. In this study, the first step requires participants to describe a technology-integrated instructional activity they have recently designed for their classrooms. Based on teachers' detailed descriptions regarding the activities and how they have approached their activities, the second step consists of probing questions that ask participants to create a timeline of their design decision-making processes. From teachers' descriptions and responses to the interview questions, teachers' perceptions of different possible factors that influence their dynamic decision-making for instructional design and technology integration can be examined.

The ‘deepening’ and ‘what if’ questions allow for certain points of interest to be clarified or elaborated.

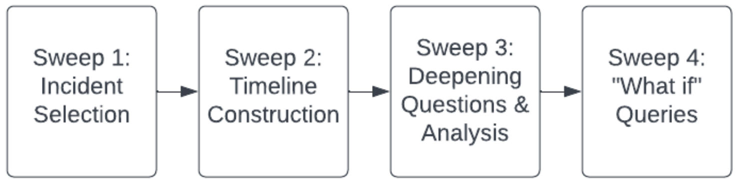

Figure 2. The Critical Decision Method Approach

Three major data sources can be collected through the CDM method: interviews, self-reports, and observation. According to Desimone (2009), observation and interviews are the most appropriate research methods because they can “capture in-depth and nuanced constructs such as critical reflection and depth of focus” (Desimone, 2009, p.190), while observation data itself may not be adequate when the task is not routine or the timing of the activity cannot be predicted (Flanagan, 1954). Thus, interviews have been recognized as the most accurate data collection method for CIT. The CDM interview data enables researchers to understand non-verbal information and communication from the participants, thus interviewers can bring up more probing and follow-up questions that can elicit in-depth responses. Flanagan (1954) proposed that the interview may entail additional prompts to help participants explain implicit knowledge and cognitive processes applied in the incidents. Rous and McCormack (2006) recommended a series of potential probing interview questions and techniques that can be used for additional prompts and in-depth data collection.

The CDM approach, Dynamic decision-making, and Reflection-in-action

The CDM has been widely used to seek out information about dynamic decision-making (Hoffman et al., 1998). This method has provided novices with a systemic view of decision-making practices in different contexts, such as communication, medicine, psychology, and social studies (e.g., Hoffman et al., 1998; Yates & Early, 2007). Some empirical studies have also encouraged researchers to leverage the CDM approach to understand teachers' real-world design decision-making processes. For instance, a case study by Dan (2014) utilized the CDM approach to identify mathematics teachers' decision-making in the contexts of mathematics classrooms. It emphasized that CDM mainly focused on incidents that were "non-routine and challenging in the eyes of the interviewee" (p.306). This kind of non-routine incident will call for teachers to "rely less on automatic responses" and "be better able to recall what they were actually thinking during the incident".

The key to accessing a critical decision moment in teachers' memory, according to prior literature about CDM (e.g., Hanson & Brophy, 2012), is to elicit participants to recall something extreme (e.g., most successful, most recent, most important, most challenging) in their minds. This is called a memory prompt. In the present study, the researcher asked participant teachers to think of a single or multiple technology activities they have designed for their teaching contexts. These technology-integrated activities that teachers described provided an example where the teacher has something unsure about and relies less on automatic reactions - teachers' dynamic decision-making processes and design judgments can be captured to understand the situations where teachers had to rely on different domains of information to make corresponding instructional design decisions. Thus, the present study comprises the following memory prompts provided to the participants (see Appendix C):

1. Think of the *most recent* technology that you have used on purpose for your classrooms/students.
2. Think of a *most successful* technology-integrated activity you have done with your students.

3. Think of a *most challenging* moment where you tried to integrate technology into your lessons.

The steps of constructing timeline and asking "deepening" probing questions are based on constructivism, metacognition, and the notion of pedagogical reasoning (Veal & MaKinster, 1999; Wilson, 1997). Some prior studies of teacher education have used reflective activities to develop teachers' instructional planning and decision-making skills for teaching (Blackwell & Pepper, 2008; Lim et al., 2003; Zeichner & Liston, 2013). Similarly, the CDM approach contains the reflective step that helps teachers explicitly describe their dynamic decision-making processes and pedagogical reasoning "prompts" that influence their instructional design judgments.

Reflection-in-action is a theoretical concept that addresses how decision-makers think about their decisions and actions when they complete a task (Schön, 1987). This concept has been elaborated and utilized as a research method to help researchers collect data regarding different perspectives about people's decision-making or problem-solving processes (e.g., Ge et al., 2005; Tracey & Hutchinson, 2018). Comparably, reflection-on-action refers to the retrospective contemplation of practice that helps researchers speculate how a situation might have been handled differently based on specific knowledge. Both conceptions were applied in the CDM interviews to help elicit participants' dynamic decision-making and pedagogical reasoning processes when designing instruction and integrating technology.

Prior studies have used reflective practices to develop teachers' decision-making and pedagogical reasoning knowledge and skills. For example, Zeichner and Liston (2013) provided empirical evidence to indicate that pre-service teachers who utilized reflective activities in their teaching tend to pay more attention to their instructional decisions for planning and teaching.

They also came up with a series of real-life examples to show people how to implement reflective activities for teacher education and professional development. Similarly, Penso, Shoham, & Shiloah (2001) indicated the inner correlations between reflective activities and teachers' teaching skills. Findings of this study acknowledged that reflective activities could help develop teachers' critical thinking, thereby enhancing their decision-making and teaching skills. Another study by Lim et al. (2003) explored kindergarten teachers' reflective decision-making. This study showed that reflective semantic mapping could promote teachers' instructional decision-making on lesson planning.

Blackwell and Pepper (2008) is another critical study that discussed the use of reflective concept maps in the development of teachers' pedagogical reasoning and decision-making skills. Their quantitative results indicated that concept mapping can be perceived as an effective tool to enhance pre-service teachers' reflective process for pedagogical decision-making. The authors suggested that more empirical studies exploring the use of reflective activities and teacher education should be conducted to verify the causal relationship between teachers' reflections and their decision-making knowledge and skills.

Appendix C comprises the semi-structured CDM interview questions used for this study. Besides the listed structured interview questions based on their memory prompts, some follow-up "deepening" reflective probing questions that are not listed in the interview protocol were asked to help clarify some activities the researcher observed. Through these CDM interview questions, teachers' dynamic decision-making and pedagogical reasoning can be identified.

Flanagan (1954) considered data analysis from the CDM interviews to be the most important and most difficult step. Many prior literature works have discussed ways for data analysis and interpretation with CIT data. Thematic coding has been used as a traditional way of interpreting CIT data (Nowell et al., 2017). Meyer and Booker (2001) recommended the use of initial analysis of the data to identify the major features. Schluter et al. (2008) proposed inductive analysis with the data that can lead to two levels of interpretation. The first level is an iterative review of the individual interviews for thematic coding. The second level involves grouping segments of different interviews based on similarities or differences (Hanson & Brophy, 2012). A case study by Crawford and Signori (1962) successfully applied inductive analysis with their CIT data. Flanagan (1954) also pointed out all the overarching themes and subthemes included at the end need to have a significant contribution to the activity or task performance.

Participants and Research Site

The participants of this study were K-12 in-service teachers with at least one year of active teaching experience in classroom settings in the United States. Participants were recruited from learning, design, and technology programs that aim to engage teachers and practitioners from multiple disciplines and build their knowledge and skills in instructional design and educational technology. Participation in this study was not tied to a particular course at a university. Teachers were asked to reflect upon their dynamic decision-making processes for instructional design and technology integration.

The participants were selected according to the following inclusion criteria:

1. Participants needed to have some formal training in learning, design, and technology (i.e., a graduate degree, certificate, or currently enrolled in a course) in the United States.
2. Participants needed to be in-service, experienced teachers in K-12 contexts.
3. Participants needed to have at least one year of active teaching experience in school settings.
4. Participants needed to have basic skills and experiences in technology use.

A total of 31 teachers attempted to participate in this study. Nine teachers did not complete the pre-survey. Four teachers did not meet the inclusion criteria. The rest 18 participants completed the pre-survey. Among the 18 teachers, eight participants provided limited information in the survey or did not respond to follow-up interview invitations. Thus, the survey results and follow-up interview invitations acted as a filter to exclude some participants who did not provide enough technology integration experiences through their descriptions or did not want to attend follow-up interviews. Ten participants teachers who met the selection criteria were thereby chosen for the follow-up CDM interviews.

Ten participant teachers participated in the CDM interviews. Five of the participants were elementary school teachers; two were middle school teachers; three were high school teachers. All the participants were currently enrolled in a master's degree program in Learning, Design, and Technology at a university in the United States. They were all having some knowledge, skills, and experiences in technology integration and instructional design. Table 8 summarizes the demographic information of the interview participants. This table presents data on the participants' genders, number of years in teaching, geographical location, their current teaching grades, subjects, and their self-reported technology use frequencies.

Table 8. *Interview participants' pseudonyms and demographic information.*

N	Pseudonyms	Gender	Years of teaching experience	Geographical region	Grade(s)	Subjects	Frequency of technology use
1	Abby	Female	16-20 years	Northwest US	7, 8	Math, science	Several times a day
2	David	Male	3-5 years	Southeast US	9, 10, 11, 12	Math, science, social studies, music	Several times a day
3	Judy	Female	6-10 years	Southeast US	2	Math, science, language arts, social studies	Several times a day
4	Kate	Female	6-10 years	Southeast US	2	Math, science, language arts, social studies	Several times a day
5	Lan	Female	1-2 years	Southeast US	1	Language arts	Several times a day
6	Linda	Female	3-5 years	Southeast US	1, 2, 3, 5	Science	Once a day
7	Melanie	Female	16-20 years	Northeast US	6, 7, 8	Math, science, special education	Several times a day
8	Stephen	Male	11-15 years	Northeast US	2, 3	Math, science, social studies	Several times a day
9	Tom	Male	6-10 years	Central US	10, 11, 12	Technology enrichment, computer science, AP courses	Several times a day
10	Yasmin	Female	6-10 years	Southeast US	12	Language arts	Several times a day

Below are descriptions of the ten participants' major school contexts of technology integration and instructional design. All the following descriptions were double-checked with the participants for validity (see Table 9).

Table 9. *Ten participant teachers' contexts of technology integration and instructional design.*

N	Pseudonyms	Contexts of technology integration and instructional design
1	Abby	A private middle school. She teaches math and science to 7th and 8th graders. She has about 70 students. The school highly supports technology in classrooms, and all in-service teachers (including her) are required to take technology-based training (including LMS and technology tools) every year on professional learning days. Her students' technology literacy is high. Thus, she implements various technology-integrated lessons in science learning.
2	David	A public high school. He teaches 9-12th grades math, science, social studies, and music (band) classes. The largest class has nearly 90 students. The school is extremely supportive of innovative technology. Every student is assigned a Chrome book. The classroom has Smartboard, a high-resolution web-camera system, and an iPad.
3	Judy	A public elementary school. She teaches 2nd graders language arts, math, science, and social studies. Her current project working with 2nd graders is integrating block-based coding into science learning. Some students do not have internet access or laptops at home; thus, she needs to help students complete the coding project in computer labs.
4	Kate	A public charter elementary school. She teaches 2nd graders all subjects including language arts, math, science, and social studies. She has about 45 students. She teaches all her classes virtually due to the pandemic. The school supports teachers to use an online asynchronous self-directed curriculum developed by Pearson, and Adobe Connect for synchronous meetings (group and one-on-one).

5	Lan	A public elementary school. She teaches 1st graders language arts. Every student is assigned a Chrome book. She only uses Epic Books for individual reading assignments (every day) and ClassDojo for classroom management. She prefers in-person interactive classroom activities with young learners. Thus, she does not integrate technology much in classroom settings.
6	Linda	A public elementary school. She teaches science to 1st, 2nd, 3rd, and 5th graders. The school does not promote technology integration. Every student is assigned a Chrome book. She mainly uses technology to present information (such as YouTube videos and PowerPoints).
7	Melanie	A public middle school. She works as a special education teacher who teaches 6th, 7th, and 8th graders math and science. Because of special education students' learning needs, she mostly uses technology to design interactive puzzles (Pear deck and Nearpod) or video-embedded presentations. No high-level implementation or synthesization of technology integration was done.
8	Stephen	A public elementary school. He works as an instructional technology coach and helps 2nd and 3rd grade classroom teaching in math, science, and social studies. His recent project is to co-teach science by using Minecraft VR games with two other science teachers. Every student is assigned a Chrome book. The school supports all teachers to have professional development in technology integration two times a year.
9	Tom	A public high school. He teaches 10-12th graders computer science and AP classes in technology enrichment. The school provides basic technology equipment such as computers and projectors. Some students do not have internet access at home. Thus, he has to adjust his meaningful technology-integrated lessons to accommodate student needs and provide low-tech classroom activities.
10	Yasmin	A private high school. She teaches AP classes and creative writing. The school is supportive of technology, so every teacher is assigned with an iPad for classroom management. Every student has a laptop. She uses Google Suites tools for some classroom activities and group activities.

Procedure

Before conducting the study, the Institutional Review Board approval was confirmed. A research request was sent to the potential research participants. Meanwhile, an informed consent document was sent to all potential participants to explain the purpose of this study and ask for their voluntary participation. After receiving the consent forms from the participants, the URL of the survey was distributed to the participants. Participants firstly completed a pre-survey to self-report their technology integration in their current classrooms (see Appendix B). Potential participants who did not meet the inclusion criteria were excluded based on their responses to the survey questions.

Before the CDM interviews, several rounds of informal engagement and communication with the teachers were implemented to help gain some in-person ethnographic information about teachers. Because of the pandemic, most communications happened through emails and synchronous meetings. After establishing connections with the participant teachers, the in-depth CDM interviews were conducted. The CDM questions firstly provided teachers with memory prompts to help them recall an incident (or several incidents): an overview of the technology-integrated learning activity, learning objectives, subject, grade, standards, assessments, and technology use. Teachers then articulated aspects such as how they have applied their decision-making processes for technology integration and instructional design, what design changes they have made for the technology-integrated teaching activity, and how they approached different factors that have influenced their dynamic design decision-making processes. The semi-structured CDM interviews employed several open-ended or "what if" questions, such as "How do you know/approach …?" "What if [condition] changed, what would you do?" "Can you tell me more about …?" and "Why do you think …?" All the interview questions were designed to explore teachers' dynamic decision-making processes while designing instruction and integrating technology.

A typical CDM conversation happened in this way: after a participant teacher described a technology-enhanced instructional activity they designed for their students, he/she was asked to elaborate on what the instructional activity was in general, what learning objectives were addressed, whether the learning content was age-appropriate according to the state or national standards, how the technology-integrated learning activity was implemented, how they had learners navigate through the instruction, what challenges were happened, and how they solved them, etc. Flexibility was adopted to allow for insights and new information reflecting their dynamic thinking or contextual analysis for the affordances of the learning environment. The researcher did not impose any personal agenda and biases into the CDM interview processes. The interview data were collected and analyzed through thematic coding analysis to identify factors influencing teachers' dynamic decision-making processes, instructional design judgments, and pedagogical reasoning for the integration of technology. Each interview lasted around 30 to 40 minutes.

Table 10 presents an overview of the research questions, corresponding data collection methods, and data analysis approaches in the instructional design practice.

Table 10. *The alignment of research questions, data collection methods, and data analysis approaches.*

Research questions	**Data collection methods**	**Data analysis**
1. How do teachers engage in dynamic decision-making processes and pedagogical reasoning while designing instruction and integrating technology?	- CDM interviews - Observation notes (interview notes)	Using Nelson and Stolterman's (2012) conceptual framework and Lachheb and Boling's (2021) judgments in instructional design contexts, a priori thematic coding analysis of open-ended responses to the CDM probing questions.
2. What is the relationship between teachers' design judgments and their dynamic decision-making for instructional design and technology integration?	- CDM interviews - Observation notes (interview notes) - Pre-survey	Using Nelson and Stolterman's (2012) conceptual framework and Lachheb and Boling's (2021) judgments in instructional design contexts, a priori coding analysis of open-ended responses to the CDM probing questions and researchers' notes was conducted. Descriptive analysis of survey results.

Pre-survey results

A web-based pre-survey developed by Qualtrics was distributed to the participants initially (see Appendix B) after participant recruitment. The purpose of this pre-survey was to have a general understanding of in-service K-12 teachers' technology integration, dynamic decision-making, and instructional design judgments in their educational settings. The first six questions in the pre-survey collected participants' demographic information as well as their self-reported data regarding technology integration situations while designing instruction for their current classrooms. Specifically, the first set of questions collected information regarding the participant teachers' name, gender, teaching grade levels, subjects, and years of teaching experience; the sixth question asked about participant teachers' frequencies of using technology in their classrooms that can help identify if the participant teachers have access to technology or have the habits of using technology in their classrooms. The options for frequencies of using technology included never, monthly, weekly, once a day, and several times a day.

With the purpose to elicit teachers' examples of how they integrated technology into their instructional contexts, a spectrum showing different levels of technology integration was presented to participant teachers after the six demographic questions. The spectrum was developed based on Ertmer's (1999) and Jonassen et al.'s (1998) different levels of technology integration. Teachers were asked to provide brief descriptions of three distinct examples of what and how they have done to integrate technology in their classrooms (see Appendix B). The sample scenarios were presented under the lowest level of technology integration (point A) and the highest level of technology integration (point C). Some basic information regarding teachers' decision-making for technology integration and instructional design can be examined from the survey.

During the CDM interviews, all participant teachers were initially asked to provide more details on their technology integration experiences they indicated in the survey. They were asked to describe what, when, where, and how their technology integration experiences happened as within a 'timeline'. They were then asked why they made certain instructional design decisions for technology integration. Teachers then articulated aspects such as how they have applied their dynamic decision-making processes for technology integration and instructional design, what design changes they have made for the technology-integrated teaching activity, and how they approached different factors that have influenced their dynamic design decision-making and pedagogical reasoning processes. Some open-ended questions were asked during the process to clarify their dynamic decision-making process and pedagogical reasoning for technology integration and/or instructional design. Then, participant teachers were asked to address any other technology integration experiences they could recall besides the survey responses or any challenges they have encountered with the instructional design of technology integration. The last question to conclude the interview was about how these teachers approached technology integration in general. The longest interview was with David that lasted 67 minutes, and the shortest interview was with Lan that lasted 31 minutes.

Data analysis

This exploratory case study used interpretive data analysis that has been well established in the traditions of qualitative research and critical inquiry. All qualitative data (i.e., survey, teachers' interview data, researcher's notes) was transcribed for thematic analysis. Thematic analysis is a method of "examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights" (Nowell et al., 2017, p.2). This method's general procedure involves: (1) becoming familiar with the data and developing initial codes, (2) coding data, (3) generating themes, (4) reviewing themes, (5) defining and naming themes, and (6) writing up the report (Braun & Clarke, 2006). This procedure was followed to identify factors influencing teachers' dynamic decision-making processes and pedagogical reasoning.

Lachheb and Boling's (2021) interpretations of Nelson and Stolterman's (2012) classifications of design judgments in instructional design provided some initial codes for the priori thematic coding process. Table 11 presents those definitions and examples of each judgment from this study. Meanwhile, Flanagan's (1954) recommendations for CIT data analysis and the iterative review and coding processes discussed in Meyer and Booker (2001) and Schluter et al. (2008) were incorporated into qualitative data analysis as the complimentary codes. The coding process mainly focused on participants' descriptions concerning their instructional design decision-making processes, design judgments, and pedagogical reasoning for technology integration and instructional design.

Table 11. *Design judgments and examples in this study.*

Design judgment	**Definition** (Nelson & Stolterman, 2012)	**Judgments in instructional design** (Lachheb & Boling, 2021)	**Example of design judgment in this study** (Teacher quotes can be found in Chapter 4)
Framing	A problem framing process that defines the boundaries of the design project.	Defining the boundaries of the design project by emphasizing its focus and outcomes.	The participant teacher, David, defined how he designed a math learning activity for ninth-grade students considering the learning objectives and student learning needs.
Default	An automatic decision-making process without too much mental efforts.	Generating "automatic" response to a situation without hesitation, and without too much thinking.	The participant teacher, Kate, planned and designed supplementary online routine meetings for her students during the regular professional planning meetings every week.
Deliberated off-hand	A recall of prior experiences or successful instructional design cases.	Recall of previous successful default judgments, consciously.	The participant teacher, Abby, actively recalled her professional learning experiences with some technology tools and then crafted her science learning activity.

Appreciative	A prioritized design decision-making based on an emphasis on certain aspects of a design, considering various options, perspectives, and information.	Emphasizing certain aspects of a design, and backgrounding others.	The participant teacher, Judy, appreciated interactions and student engagement in technology integration, thus she designed multiple learning activities using the ViewSonic Board.
Appearance	A design decision-making in terms of style, nature, character, experience, and assessment.	Assessing the overall quality of the design.	The participant teacher, Melanie, perceived her use of Google Meet and Google Classroom worked well for the hybrid learning environment, thus she decided not to integrate more types of technology tools into her instructional activities.
Quality	A design decision-making regarding materials, aesthetic norms, and standards.	Finding out the match/mismatch between aesthetic norms/standards and the particular proposed design artifacts.	The participant teacher, Kate, purposefully used Nearpod because it has various age-appropriate functions where students can draw, speak, and interact with each other.
Instrumental	A selection of tools or means that can be used for teaching and learning.	Selecting and using design tools/means to reach established design goals.	The participant teacher, Judy, worked with their media center specialists and came up with a number of lesson plans integrating robotics and Scratch.
Navigational	A complex and ill-structured design decision-making process considering different factors and directions.	Considering a path/direction to follow in completing a design task.	The participant teacher, Yasmin, decided to use Google Suite tools in trying to figure out a balance between digital literacy development and effective content teaching.

Compositional	A decision-making process considering all elements and factors influencing the design project.	Bringing all elements of design together to form a whole.	The participant teacher, David, designed a COVID-related project by synthesizing different sources of information including learning objectives, student needs, authentic learning experiences, and content teaching.
Connective	A design decision-making process considering a synthesis of different elements, informational perspectives, and its connections.	Making connections of objects together for the specific design situation.	The participant teacher, Stephen, transferred his Minecraft design for mathematics to the context of social studies by integrating different learning objectives and content teaching.
Core	A design decision-making process that relates to teachers' own values and beliefs.	Designer's own value or thinking that can lead to invoking all other design judgments.	The participant teacher, Melanie, would like her students to become active meaning-makers through technology use rather than passive users of technology.
Mediative	A balance between different alternatives and design judgments.	Not explicitly specified.	The participant teacher, Melanie, made design decisions for technology integration according to various factors: the hybrid learning environment, student needs during the pandemic, lack of technical support, and her daily workload.

An example of how teachers' descriptions of their design judgments and dynamic decision-making processes were thematically coded is provided below (see Table 12). Because dynamic decision-making is a complex and ill-structured process where multiple design judgments were often invoked together (Lachheb & Boling, 2021), more than one type of design judgment may be coded for a single excerpt from a participant teacher to indicate its complexity. Sometimes participants revisited different design judgments while these judgments were intertwined, thus the table only presented teachers' prioritized design judgments indicated in their discussions. Meanwhile, a case profile of each teacher and their frequencies of design judgments were created to understand the complexity of their dynamic decision-making processes, design judgments, and pedagogical reasoning for different technology integration and instructional design incidents, while the frequencies of design judgments in each teacher can help identify the participant teacher's tendency of making design judgments and dynamic decision-making processes.

In Table 12, a brief explanation of why and how the excerpt was coded with multiple types of design judgments was provided. The quotes are from Melanie who described how she leveraged different technology tools to engage her students in both classroom settings and digital learning settings. She described why she decided to utilize Google Meet, Google Slides, and Google Classroom in her contexts, how these tools helped her engage students and implement learning activities, what her workload looked like, and her challenges and feelings behind her dynamic decision-making and instructional design judgments for technology integration.

Table 12. *An example of the priori thematic coding process using instructional design judgment constructs.*

Sample transcripts from Melanie	**ID judgments**	**Rationale for assigned codes**
"… I wanna say probably half my classes were in the building, the other half were at home. So as hybrid from the school building, we would have to tap into the Google Meet. I would get everything up and running… I was able to even, I'm trying to think it was a template that I found on, I think it was slide something carnival.com that I was able to make a vocabulary test using Google Slides, which was really neat …"	Framing design judgment Instrumental design judgment	The teacher decided to use Google Meet and Google Slides to engage students from both the classroom setting and digital learning environment. The teacher defined what the hybrid learning environment (i.e., design context) was, and made framing design judgment and instrumental design judgment based on her prior experiences of technology use and the learning environment.
"...We still were mandated to uphold all of our paperwork. So we had to schedule IEP meetings. We had to draft all the documentation. We were responsible for ensuring that evaluations and reevaluations would go smoothly. At the end of the school year, there were so many professional members that I have learned more this year about digital technology, digital competency than I have learned in the last ten, fifteen years of my career. They all mentioned stepping out of the comfort zone because we needed to figure out how to get through this. So a lot of times it was really on the fly. I don't know how to do this. You don't know how to do what you don't know. You gonna get them (i.e., students) to try and specify what the issue is and then we are troubleshooting…"	Appearance design judgment Navigational design judgment	The teacher perceived her overall technology integration experience in the past year as a trial-and-error experience. The teacher made appearance design judgments based on her current situation and decided to solve the unforeseen challenges of technology integration. The teacher also made navigational design judgments by navigating through a variety of factors in the learning environment and solving any design problems appeared in the context.

"… I think right now their (i.e., students') capacity is more of on a passive event where they are just a user and they really need to be a producer of it… We need to get them there, to just saying, okay, well, I', gonna take this all in and I'm just going to take care of what I need to. But, how do you produce something? How do you make a project? How do you show your knowledge? I see through the use of digital technology, and I think we need to start going in that direction."	Core design judgment	The teacher made core design judgment to indicate her preference for technology use. The teacher reflected her attitudes toward technology integration, that is, to have students become producers of technology tools rather than passive users of technology.

Table 13 presents a sample teacher's profile, Melanie, with different types of instructional design judgment addressed in her discussion. The codes were given based on Melanie's descriptions and her prioritized design judgments. It is essential to emphasize that teachers' design judgments were intertwined and connected, such as core design judgment is connected to every type of design decision (Lachheb & Boling, 2021). The sample teacher profile can provide us with a holistic picture of how Melanie navigated the complexity of her design problems, engaged in dynamic decision-making, and made different and intertwined design judgments for technology integration.

Table 13. *A sample teacher profile showing the complexity of design judgments and dynamic decision-making for technology integration and instructional design.*

Teacher #7: Melanie	
Instructional design judgments and quotes	**Other design judgments involved**
Framing design judgments	
"… I wanna say probably half my classes were in the building, the other half were at home. So as hybrid from the school building, we would have to tap into the Google Meet. I would get everything up and running… I was able to even, I'm trying to think it was a template that I found on, I think it was slide something carnival.com that I was able to make a vocabulary test using Google Slides, which was really neat …"	Instrumental
Appearance design judgments	
"...We still were mandated to uphold all of our paperwork. So we had to schedule IEP meetings. We had to draft all the documentation. We were responsible for ensuring that evaluations and reevaluations would go smoothly. At the end of the school year, there were so many professional members that I have learned more this year about digital technology, digital competency than I have learned in the last ten, fifteen years of my career. They all mentioned stepping out of the comfort zone because we needed to figure out how to get through this. So a lot of times it was really on the fly. I don't know how to do this. You don't know how to do what you don't know. You gonna get them (i.e., students) to try and specify what the issue is and then we are troubleshooting… I think once we become familiarized with it (certain technology tools), that you become accustomed to it, it is a lot easier. It is very fun. I think it could be very laborious and tedious because it is just a lot of prep work on the front end, but once you have got that machine going, you just have to keep oiling the gears and it could keep going."	Navigational Instrumental Core

Navigational design judgments	
"... So a lot of times it was really on the fly. I don't know how to do this. You don't know how to do what you don't know. You gonna get them (i.e., students) to try and specify what the issue is and then we are troubleshooting…"	
"We eventually went back into the building, and some were in the building, some were still home to try and get the engagement. Those student polls really came into play because it worked so well in like hybrid teaching settings. I could take care of both student groups at the same time by getting information from both of them. However, I'm not gonna lie. It was really challenging trying to appease both parties and students at home. Literally it is a very unstructured setting so you have to pay attention to, like kids turning off cameras and we would try to engage them…"	
Instrumental design judgments	
"… I wanna say probably half my classes were in the building, the other half were at home. So as hybrid from the school building, we would have to tap into the Google Meet. I would get everything up and running… I was able to even, I'm trying to think it was a template that I found on, I think it was slide something carnival.com that I was able to make a vocabulary test using Google slides, which was really neat …"	Framing
"So when I'm interacting with the kids, I do have a Google Classroom. We still utilize Kami for them to do open-ended note taking. We also utilize Google Meet, to meet with the kids. So typically everyone, even like students in the classroom go into Google Meet to meet with the online students and communicate together."	
Core design judgments	
"… I think right now their (i.e., students') capacity is more of on a passive event where they are just a user and they really need to be a producer of it… We need to get them there, to just saying, okay, well, I', gonna take this all in and I'm just going to take care of what I need to. But, how do you produce something? How do you make a project? How do you show your knowledge? I see through the use of digital technology, and I think we need to start going in that direction."	

Mediative design judgments	
"So unfortunately we didn't have enough prep time. For example, how many kids are going to be in the building? How many aren't? What materials are we giving these kids? How do we take this material, make it into a reproducible digitally? And that's where that one website came into play with my worksheets. I really wish I could have the website…"	Compositional
"We didn't have much (technology support), I was using my home computer when we were at home. It is unfortunate because we weren't given any stipends. There were no grants. I have to, you know, my husband helped me take the closet of our guest room and made it into a functional, like mini office for me so that I could do the work… It was not working while they eventually mid-year got us a second monitor so that we could put the kids that were joining remotely up on that screen. But it is a challenge because you are really dividing your attention into two. And you are having to engage with the kids at home, make them feel like they are a part of things…"	Instrumental

As shown in Tables 12 and 13, Melanie's design judgments were intertwined and interconnected. Although these design judgments were overlapping, codes were assigned based on Melanie's prioritized design judgments during her discussion about the technology integration experiences. For example, mediative and compositional design judgments were assigned to the second to last excerpt shown in Table 13, when Melanie had to make balanced instructional design decisions for technology integration according to a variety of factors: lack of preparation time, lack of technical support, a hybrid learning environment that requires her to engage both face-to-face and digital students, the learning objectives, communication and interactions with the students, and the capacity of her classrooms. It resulted in her compositional and mediative design judgments as she had to synthesize different sources of information and made balanced design decisions considering all elements influencing the design context. Although her design decisions were also connected to instrumental design judgments (that represent the technology tools she decided to use) and/or core design judgments (that reflected her beliefs and attitudes toward technology integration), these codes were not assigned there because they were not Melanie's prioritized design judgments during her discussion at that moment.

Trustworthiness

To enhance the trustworthiness of the data analysis results (Lincoln & Guba, 1985a), several techniques were used to increase the validity and reliability of this study. The following techniques were applied in this study:

Triangulation of data. Different data collection methods and sources were used to identify teachers' dynamic decision-making, instructional design judgments, and pedagogical reasoning for designing instruction and integrating technology. Both interviews and pre-surveys were distributed to the participants. All interviews were audio-recorded and transcribed. Each teacher was assigned a pseudonym and a participant code to protect participants' identities and confidential information. To enhance the validity and reliability of data analysis and interpretation, a second researcher was involved in the data analysis process to verify whether the codes and transcription notes are agreed upon. No disagreements or doubts appeared between the two members of the research team.

Member checks. Member checks were conducted after the data analysis phase to enhance participant validation. This technique can help explore the credibility of data analysis results. Specifically, the original data and its data analysis results were sent back to participants to check for accuracy and resonance with their experiences. If disagreements or doubts appear, some follow-up informal interview questions were asked to help clarify or solicit reactions of the participants as to confirm the validity of the data analysis results.

CHAPTER 4

RESULTS

This study explored how teachers apply dynamic decision-making, instructional design judgments, and pedagogical reasoning while designing instruction and integrating technology in their instructional solutions in K-12 settings. This qualitative case study had 18 participants who completed the pre-survey. Ten participant teachers were chosen upon meeting the study's inclusion criteria for the follow-up critical decision method (CDM) interviews. During the CDM interviews, participants described their technology integration practices, instructional design decision-making process, and the contextual factors that have influenced their design judgments and dynamic decision-making regarding technology integration.

Teachers were interviewed using a semi-structured interview protocol (see Appendix C). All interviews were video-recorded and transcribed. Codes were defined before the data analysis as a priori thematic coding analysis approach. Nelson and Stolterman's (2012) conceptual framework of design judgments (Table 4) provided the types of design judgments used for a priori thematic coding (see Table 11). Lachheb and Boling's (2021) interpretations of design judgments in instructional design contexts were utilized to offer the adapted definitions of these design judgments for the priori thematic coding processes.

Some data were coded under multiple design judgment constructs because instructional design judgments were often invoked together and not isolated (Lachheb & Boling, 2021). Through this study, participant teachers' dynamic decision-making, instructional design judgments, and pedagogical reasoning process that they were involved in when they integrated technology and designed instruction for their teaching contexts were examined. Participant identities were kept confidential in the reporting of the study results through the use of pseudonyms.

To enhance the validity and consistency of data analysis, two rounds of priori thematic coding analysis were completed. Member checks were conducted after the data analysis phase to enhance participant and data validation. No disagreements or doubts about data analysis appeared during member checks.

Results of data analysis

Nelson and Stolterman (2012) and Lachheb and Boling (2021) offered eleven kinds of design judgments that were used for a priori thematic coding analysis for this study. In this section, the results of data analysis are reported through the eleven constructs of design judgments. The tables at the end summarized participants' design judgments and frequencies of design judgments based on the number of times a particular keyword/factor was prioritized by participant teachers during the CDM interviews. Lachheb and Boling (2021) indicated that instructional design judgments were often invoked together. Thus, the teacher quotes in this section may consist of one or multiple types of instructional design judgments. Although the way teachers' design judgments and dynamic decision-making were presented based on the type of design judgments, it is still worth noting that some data may involve multiple types of instructional design judgments due to the complexity of the dynamic decision-making process and instructional design judgments. Teachers' prioritized design judgments during the interviews were what this study was focused on.

Framing design judgment

Framing design judgment refers to how practitioners or teachers make design judgments at the beginning of the design process. It often consists of a problem framing process to define the design boundaries where teachers make corresponding design decisions based on their students and classroom contexts. Eight out of ten participants talked about their framing design judgments for their classrooms and/or students. An example of framing design judgment from Abby was:

> *… so we (teachers) are together to plan for activities, and it is kind of a real-time activity. For science, I have been using a couple of sites. One is called Gizmos and one is called, simulations out of Colorado. They have a lot of science, not really experiments, but the kids kind of play around with different science concepts and they are able to move things on the screen and interact with it. So those are some of the simulations, and I try to incorporate those into introductory activities. Say like, we need to introduce a new topic, and I'm gonna have you explore this simulation and then we will come back to the simulation and see how it ties into whatever we are learning…*

As Abby said, the framing instructional design judgments allow teachers to think of technology integration resources they currently have at their hands, analyze the learning content, define the learning objectives, situate and fit the technology into the learning context(s), and make corresponding instructional design decisions for their students and the learning environment. Teachers often make framing design judgments with instrumental design judgments together because teachers need to select and leverage technology tools to reach their instructional design goals. Here, Abby's framing design judgment came together with her instrumental design judgment that reflected the technology tools she decided to use. Another example came from David, who shared how he made framing instructional design judgments for technology integration -- he described a technology-integrated meaningful math learning activity for his ninth-grade students:

> *… I had a lot of ninth-grade boys, and you know, if you don't keep them engaged, they will drive you insane. … This project was meant to give students an opportunity to explore what it might be like to be an architect. So as I planned that we would spend a month and they would cover all the stuff that is related to being an architect. We would learn about like measuring the area of a room… you have to show it on this piece of paper, and then make a 3D floor plan using a website. Is it floorplanner.com? … So there is a lot of numeracy involved and I decided that rather than just have them design blueprints… students loved it and they were so proud of their final projects…*

David explained why he used a 3D floor planning tool to accommodate ninth graders' curiosity and learning needs to design a student architect project in his math classrooms. He also decided to have students spend a whole month of time exploring different learning aspects related to the real-world project, including measuring, calculation of areas, 2D and 3D transformation, and floor planning. He also made framing design judgment along with instrumental design judgment.

In addition, David described how he made framing design judgments to situate his math learning project under the post-COVID context. He re-defined the learning objectives of his design project based on the special contexts and student needs, made framing design judgments by re-designing and developing his instructional activities, and re-framed his rationale supporting the design-based project by applying authentic learning principles. Here, his framing design judgments came together with his compositional design judgments:

> *… I was told by my administrators that is the purpose of my class was to have students explore different careers. I changed the (architect) project accordingly and made it, and this was post COVID. I made it like, how would you design a COVID-proof school and just posed open-ended questions to the students… It was a really, really interesting tool to have them use to experiment with that kind of three-dimensional thinking space and then throwing the COVID layer on top…*

A variety of contextual factors were considered in teachers' dynamic decision-making and pedagogical reasoning when they made framing design judgments for technology integration. These contextual factors include teachers' prior teaching experiences, students' demographic information and socioeconomic status, technological support, and environmental factors such as the pandemic that has hugely affected teaching and learning in students.

For example, Tom noted that when he planned for meaningful learning experiences for his tenth graders, he referred back to his prior teaching experience working with the same grade level and his knowledge regarding students' backgrounds/socioeconomic status within the school district. As he explained, despite the school district equipping every classroom with a computer and a projector, some students in his class do not have stable internet access or personal laptops at home. These students had to go to fast-food restaurants or coffee shops for free Wi-Fi to complete their technology-integrated course projects. He knew well about students' technical challenges and decided to design technology-integrated practices that could be completed in classroom settings as much as possible: *"… I decided to make a class based through research activity, so we get as much done in class as possible. And when they go home, they can think* *about it. They can write notes to themselves, they can look at their phone and practice…".* Tom's framing design judgments came together with his navigational design judgments within the design context, and it also reflected his core design judgments that promoted meaningful learning experiences in students.

Teachers also considered technological support as a factor that influenced their framing design judgments. Both Abby and Kate discussed how they communicated with subject matter experts (SME) and technological specialists at the beginning of every semester to plan for their technology-embedded activities. Abby talked about how she worked on learning objectives with the experts during her instructional design process and then defined what she could do in her classes. Kate met with a group of teachers and SMEs and made framing design judgments for her online learning activities for second-grade students.

Melanie shared her framing design judgments and decision-making processes affected by the pandemic that had hugely changed the learning environment. Her school had a group of students learning online and another group of students came to classrooms. Thus, she and her colleagues were required to teach through Google Classroom and Google Meet on a daily basis and to engage both face-to-face and online students simultaneously in a hybrid learning environment. As she said, *"…I wanna say probably half my classes were in the building, the other half were at home. So as hybrid from the school building, we would have to tap into the Google Meet. I would get everything up and running… I was able to make a vocabulary test using Google slideshow, which was really neat… We also used a lot of Kahoot. We used Quizlet, that produce math for supplemental work for fun…"* Melanie's framing design judgments were made together with her instrumental design judgments.

In summary, eight teachers discussed their framing design judgments and dynamic decision-making processes regarding technology integration and instructional design. It is worth emphasizing again that these framing design judgments were what the participant teachers prioritized during the interviews. Meanwhile, framing design judgments of teachers were closely related to their instrumental design judgments, that is, how teachers decided to use technology tools for their instructional contexts.

Default design judgment

Default design judgment refers to practitioners' high-level decisions that do not require too much mental effort. It allows teachers or practitioners to generate 'automatic' responses to a situation without hesitation or too much thinking. Teachers' regular professional planning time on technology integration is a typical context where teachers make default design judgments. Two typical cases emerged from the data that reflect the default design judgments of teachers.

The first case was from Kate, a second-grade teacher. Kate is a teacher working in a public charter school. She is the only participant who teaches all subjects virtually to her second-grade students. Her school provided teachers with a complete online curriculum developed by Pearson, thus all teachers at that school were only required to build add-in content based on student needs and plan for synchronous group or one-on-one meetings. Kate also leveraged the ready-to-use curriculum for student assessment. Specifically, she made default design judgments when planning for supplementary online meetings for her students during the regular professional planning meetings:

> *… So on a normal week, we actually have a team of second-grade teachers that work together, so it is not as overwhelming as it sounds, and we all have similar training and so we will break it (i.e., four subjects) up. Teams of teachers will*

plan math and teams will plan reading, and then we will come together and share the procedure. And so, everyone knows what to expect…

Kate did not need to spend too much mental effort on her regular class planning such as scheduling regular virtual meetings or sending reminders to parents. In addition to this example, Stephen, an instructional technology coach in a public elementary school, also shared his experience of making default design judgments. He worked with teachers who need technological support and/or advice on technology integration in lesson planning and practice implementation. He made default design judgments whenever he found any available or useful technology tools that could be integrated into classroom settings. As Stephen said, whenever he had any ideas on technology integration, he would reach out to teachers: *"... I might be sitting in a meeting with them and listening to them, talking about what they are planning and I might have an idea of something they could do related to what they are planning, and I would make a suggestion. ... If I had an idea, I would reach out to someone and say, hey, what do you think about trying this? ..."* Stephen already knew who he would come to and what procedure it would be whenever he had some ideas about technology integration.

Meanwhile, default design judgments may result in a new set of framing design judgments. As teachers worked together or implemented some routine technology-embedded activities in their learning contexts, they may come up with new possibilities for technology integration for their students or classrooms. As Stephen indicated, after he communicated with his colleague regarding a Minecraft math learning activity, *"We had the students kind of demonstrate their knowledge about the fractions by exploring some existing examples of fractions using Minecraft blocks and then they would have to create their own examples to represent fractions...It's always taking something they (students) are interested in, and giving* *them the opportunity to be creative and work as part of a team…"* He reflected back on his instructional design decisions for this math learning activity and worked with his colleague to develop some new possibilities in the context of social studies: *"Social studies… and content connection. I then worked with a couple fourth-grade teachers, and we had the students navigate through a Minecraft world…"* As reflection-in-action refers to the internal dialogue that designers have when they try to solve a particular design problem (Schön, 1983), teachers' default design judgments and their following framing design judgments were affected by designers' reflections on student needs and the learning environment.

Thus, three teachers in this study discussed their default design judgments that led to their automatic responses to the design contexts. Default design judgments in teachers may lead to a new set of framing design judgments.

Deliberated off-hand design judgment

Deliberated off-hand design judgment is about the design decisions after a practitioner is familiar with a skill or a process and generates automatic decisions. The difference between deliberated off-hand design judgments and default design judgments is that the deliberated off-hand judgments put more emphasis on teachers' self-consciousness on the recall of the prior experiences and design decisions for their technology integration (Lachheb & Boling, 2021).

An example of deliberated off-hand design judgments is from Kate's technology integration experiences. She described how the professional development resources at her school provided her with sufficient training and resources on technology integration:

> *… So when you first are hired at my school, we have a whole bank of training that we go through as far as learning our platform and how to utilize our Adobe Connect, lesson structure, and the curriculum. And they also provide us a one-on-*

one trainer, which is a teacher who has been with the school for several years, that we can ask questions to. And then through our state requirements, we also have to complete a 70 hours of PD (professional development). I wanna say it is 120 hours. I may be wrong on my number there. So, we continuously engage in PD as well before we teach.

Kate indicated that she enjoyed her online teaching experience because of the sufficient technological support and professional development she had received from her school. *"I would say about three quarters of our training is based on technology or new platforms we are using for integration. And then there is about a quarter of that PD that would focus on content since we are responsible for teaching the content."* Even though she admitted that she still had some challenges to engage second-grade learners in the online learning environment, she purposefully made deliberated off-hand judgments by recalling her skills and successful technology integration experiences she gained from professional development and support: *"I love the technology training. I mean it (the training content) is changing all the time… Although there it isn't a whole lot new changing right now and how to teach math or how to teach reading, finding ways to teach them effectively in our platform is what we focus on. And I appreciate that. I think that number is just right, at least for me."*

Meanwhile, Abby provided another good example of deliberated off-hand design judgments. She indicated that whenever she needed any help in lesson planning on technology integration, she would reach out to the technology department at her school. The school motivated teachers to come to their technology department by earning extra clock hours. From the professional learning experiences, she got familiar with the system and a number of technology tools that can be used in her classroom settings. She reflected back on her prior technology integration experiences and described her deliberate off-hand design judgments. As she commented:

> *… So you could go through everything, go at your own pace, and learn all those tools…. And so I tried to pull some of those in and over the last year… I have tried to pull in some tools. And when I use the technology, I always keep in my mind, the rationale is okay, then what is the purpose? Can I do it better with pencil paper or just talking? Will it be more engaging on the computer? …*

To summarize, deliberated off-hand design judgments were closely related to teachers' prior successful experiences related to technology integration or instructional design, their knowledge and skills, and the professional development training they have obtained in relation to technology integration and instructional design. Two teachers in this study discussed their deliberated off-hand design judgments.

Appreciative design judgment

Appreciative design judgment presents the prioritized decision based on the various options, perspectives, and information. It often reflects how teachers emphasize certain aspects of a design and background others during their decision-making process (Lachheb & Boling, 2021). For instance, Stephen designed and developed several technology-embedded activities with his colleague teachers. He made appreciative design judgments because he appreciated the collaborative instructional design opportunities working with the teachers. Stephen reached out to teachers to understand the learning needs of students and teachers' preferences for technology tools. He also modeled the technology-integrated lessons for his colleagues. As he mentioned, *"So I would try to meet with the teacher to kind of get an idea of what they were looking to do. I would, you know, if it was something new they were learning, I would try to demonstrate, do* *some demonstration or help them kind of get an idea of what will happen, like what this technology will do. I would try it at all possible to offer, to be there with them in the classroom when they are first starting to, or to model the lesson for them."* His appreciative design judgments considered teachers' instructions and teachers' knowledge and skills of technology integration as the priority; thus, he could coach and help his colleague teachers implement the technology-embedded instructional activities in classroom settings.

Judy offered another typical example of appreciative design judgments. She is a second-grade teacher who teaches math, science, social studies, and language arts in a public elementary school. As a big fan of technology, she couldn't help to express her love to integrate different types of technology in her classrooms. *"... We just got it this year. They are called ViewSonic Board. So they are very very interactive, like a newer version of, like, Smartboard. So it is kind of a stand-alone board. If that makes sense, but it has got a lot of really great interaction capabilities. And it got its own software, kind of like smart note wise. So I use that everyday. Like when I do my mini lessons, a lot of times I use it when we are doing reading mini lessons, because I can actually write on it..."* Judy acknowledged that technology had helped her implement lessons and engage students, thus she loved technology integration and worked closely with their media center specialists to make various kinds of technology-embedded activities. She made appreciative design judgments because of her enthusiasm for technology integration: *"I want to make it meaningful. I want it to, I mean, obviously there is value in doing things like having kids simply type, you know, using Google Docs or Google Slides. But I want it to be when I look to integrate technology, I want it to be a meaningful way."*

Five out of ten teachers discussed how they made appreciative design judgments for instructional design and technology integration. Appreciative design judgments in teachers were more focused on what teachers prioritized and emphasized in their design. Appreciative design judgments in teachers are closely related to teachers' core design judgments since both their appreciative design judgments and core design judgments reflect teachers' beliefs and attitudes towards technology integration.

Appearance design judgment

Appearance design judgment is about prioritized design decisions in terms of the style, nature, character, experience, and assessment. It often relates to how teachers perceive the overall quality of the technology integration and/or instructional design practices for their students and learning environments. In this study, three of the ten teachers shared their appearance design judgments for technology integration and instructional design. For example, Abby perceived her design of robotics class as a successful case of technology integration:

> *… I teach an elective class that's a robotics class and to give them a lot of introduction. I usually give them a hyperlink document with their team. They are supposed to go click on this link and fill out this thing with their team and then check their knowledge or go explore this site, and then come back to the hyperlink document and fill out this Google Form. So there is also something they can proceed through it at their own pace… and there's something like evaluative that they have to turn in, like the Google Form, so I can see if they actually went to the different places…*

Abby made appearance design judgments for her robotics class based on her own perceptions of the use of self-directed interactive hyperlink documents and the collection of Google Forms as student performance assessments worked well in her contexts. She examined the overall quality of student learning experience in her instructional design and believed that it was a successful experience for both her students and her. She also mentioned the underlying reason for her successful technology-embedded practices: *"... so there are a lot of tech companies up here and I think there are a lot of kids in our area whose parents work in that (area)…".* She indicated that her students' digital literacy knowledge and skills were high, *"A good handful of the kids that were in my robotics class had some experience with coding… So like we would do, you know, I would just have them go on and play around with the site. And a lot of kids knew Scratch. They were very familiar with block-based coding and that is the kind we use in our robotics class."* Abby made appearance design judgments based on her positive work experience for technology integration and her students' overall performance of technology use in classrooms. Her appearance design judgments were made together with her instrumental design judgments.

Another example of appearance design judgments was brought up by Melanie, who explained her use of technology integration in her classroom settings. Melanie was the one who used Google Meet and Google Classroom in her classes due to the hybrid learning environments. Even though the school provided all teachers with professional learning opportunities on various technology tools and technology-integrated activities every Tuesday night, she did not have time or strong willingness to attend these training sessions due to her exhausting workload at school. As she said, *"... we still were mandated to uphold all of our paperwork. So we had to schedule IEP meetings. We had to draft all the documentation. We were responsible for ensuring that evaluations and reevaluations would go smoothly… So a lot of times it was really on the fly. I don't know how to do this. You don't know how to do what you know. You gonna get them (students) to try and specify what the issue is and then we are troubleshooting."* Melanie had been getting tired of teaching in hybrid learning environments because she had to plan for both ways of lesson planning every day, set up the technology in advance, and engage all her students including face-to-face students sitting in the classroom, online students joining from Google Meet, and special education students through her design of interactive activities. She examined her overall design decisions for technology integration, perceived her experiences as a trial-and-error experience, and decided not to integrate more technology tools other than Google Classroom and Google Meet. Her appearance design judgments relied heavily on her current technology-integrated pedagogical practices and a variety of contextual factors such as technological support and student needs in the hybrid learning environment. As she commented:

> *I think once we become familiarized with it (certain technology tools), that you become accustomed to it, it is a lot easier. It is very fun. I think it could be very laborious and tedious because it is just a lot of prep work on the front end, but once you have got that machine going, you just have to keep oiling the gears and it could keep going.*

Here, Melanie's appearance design judgments came together with her core design judgments. Thus, appearance design judgments are related to how teachers value their own design of teaching practices, their current teaching and learning environment, and several contextual factors. Those contextual factors play a critical role in affecting teachers' overall teaching experience and how they examined the quality of technology integration and instructional design.

Quality design judgment

Quality judgment is a matter of the choice of materials, aesthetic norms, and standards. It refers to technical choices of technology integration and instructional design, such as colors, standards, functions, and visual representations. Teachers did not provide many examples of their quality design judgments in this study – only one out of ten teachers, Kate, shared her experience of making quality design judgments along with instrumental design judgment:

> *… We found Nearpod to be really successful. So that we have used it a lot this year, just because it has functions where they can draw, they can speak. We can also do fluency passages and reading and hear them and see them. We can see their math and thinking that can literally write out the problem and solve it for us.*

Kate specified that her design judgments of using Nearpod for her students were based on the interactive features of the tool. This technology tool enables students to listen, draw, write, and speak when they would like to communicate with the rest of the class. Kate made her quality design judgments by applying Nearpod in her online classrooms for second graders.

Thus, quality design judgments were often related to instrumental design judgments. Although teachers in this study discussed limited quality design judgments, it did not mean that K-12 teachers did not make quality design judgments in general. The results only present what the participants prioritized when discussing their design judgments and dynamic decision-making processes for technology integration during their interviews.

Instrumental design judgment

Instrumental judgment relates to the instrument design decisions, such as videos, technology tools, equipment, etc. It acts as one of the most critical design judgments that teachers made for their instructional design and technology integration (Lachheb & Boling, 2021). Instrumental design judgments of teachers help us understand what technology the teachers selected for their teaching, why they decided to leverage certain tools, and teachers' underlying attitudes and rationale for using certain type(s) of technology. This type of design judgment often comes with framing design judgments because both design judgments reflect how teachers reflect on their dynamic decision-making and instructional design processes for technology integration.

Kate described her instrumental design judgments as shown below. As a teacher who did online teaching for second-grade students, Kate emphasized her instruction of typing and basic computer skills for her students. At the beginning of every semester, she leveraged more than a week of synchronous meetings to model the lessons for students, develop students' typing skills, and engage her second-grade learners in the online learning environment. As she described,

> *… I have been doing this (i.e., training in typing for kids) for a while. So now, you know, with the emergence of kids with cell phones or using tablets, they are a little more proficient than they have been in the past. But as far as like formal typing skills or proper grammar, sometimes that's still pretty tricky, because at the stage they are using mainly sight words or sounding out words, So it can be a little bit harder then there.*

Kate had full awareness of the cognitive capacity of second-grade students. Thus, she decided not to integrate high-level or complex technology tools into her supplementary online meetings. Instead, she developed some basic technology skills in students that *"everyone should acquire"*. Meanwhile, she would like her technology use can *"further student learning or boost engagement"*. Her instrumental design judgments reflected certain types of technology she had integrated into her online sessions and her rationales for doing so.

In addition to Kate's experiences, David addressed how he made instrumental design judgments in his instructional design. He explained why he decided to utilize 3D floor planning for his design of the authentic learning project for math learning:

> *… Technology is hard for some of these students to use. They grew up on phones, they know Instagram, they know Snapchat, but when you put them in front of a computing device and suddenly the digital generation who's supposed to be better at computers and everybody, they break down because it is not that they are better at technology than anybody else. They just have a whole lot of experience with the phone, and a lot of them just struggled with the complexity of, like I have a mouse now, and I have to drag, and it is not a touch screen.*

David also explained his use of instructional videos in math classes and Flipgrid, a video-making tool that allows users to develop a safe learning community through communication via videos. He said, *"I need another way for the students to see problems solved step by step in the way that they had seen the last time when they failed the class, hoping that might jog their memory in help. So I basically went to YouTube and found lots of step-by-step videos from professors who were much more eloquent than I was… Students could pause and replay… (I also used) a website that my school subscribes to called Flipgrid. And I just repurposed Flipgrid so that I could tell my students, hey, you need to go home… By the end of the week, I need a video of you playing it so that I can assess it…"* David selected some online learning community technology tools such as Flipgrid to promote self-directed learning and communication among students. It also helped him complete individualized assessments. Both David and Kate made instrumental design judgments to achieve the learning objectives they set for their students. They also considered their selection of specific technology had successfully helped them reach their established instructional design goals, that is, framing design judgments.

In addition, Judy offered another example to indicate her preference and decision-making toward a particular type(s) of technology: *"My kids will do actually a computer science segment* *once a week ... It is the coding. It is not always brought in with a certain subject. But it is actually like, that is the main focus. So, they are learning the problem, solving the critical thinking problems, developing skills like how to think through a problem step-by-step. And they are learning those basic, like at second grade, they are learning those basic codes…"* Judy acknowledged the critical role of coding and critical thinking in elementary education, thus she has worked with their media center specialists and came up with a number of lesson plans that "*use robotics to support math learning*". She mentioned that although she had not had a chance to apply all of them in class, she thought she *"got a lot of ideas and the knowledge ... I have also done a few activities where we use Scratch and other online coding programs where my students have done like research projects, like a unit where we studied like famous women in history. They (students) would do Scratch with the two characters such as Mars Rover and do an interview…"* When I asked her whether she had challenges implementing coding-related lessons to second graders, she said, *"It takes a little work. But second grade is when you can start moving them from Scratch. There is Scratch Junior and there is regular Scratch, so at second grade is when you can start introducing them to more complex coding using block codes… Some of my lower kids seem to do really well with that".* Judy was fully aware of second graders' knowledge and their cognitive level, thus she made appropriate instrumental design judgments by selecting relevant online platforms for block-based coding and integrating them into her teaching practices.

In short, instrumental design judgments were closely related to framing design judgments and core design judgments. Because technology integration was the focus of this study, participant teachers tended to prioritize their discussions on instrumental design judgments during the interviews.

Navigational design judgment

Navigational judgment presents the design decisions in complex and ill-structured situations. It often relates to how teachers filled in an identified gap and offered certain directions to solve the design problem. Lachheb and Boling (2021) addressed that navigational design judgments always consist of a certain path or direction in completing a design task, such as inviting an external SME to provide knowledge and expertise to fill a content gap that instructional designers or teachers identified. Six out of ten participant teachers indicated their consultation with SMEs or technology specialists for technological troubleshooting and/or instructional design problems.

For instance, Kate and Abby shared their navigational design judgments where they had technology issues with online teaching or technological issues. Kate said, *"we all have mentor teachers that should be helping with things like content, technology troubleshooting, or classroom management. Our state requires all public schools, which we fall under the umbrella of, to provide a mentoring and supportive person for every new teacher…"* Kate also expressed her feelings towards technological support and professional development offered at her school, *"I appreciate that… Like I said, I definitely find it easier virtually and at least in the place I am right now. We have a lot of creative liberty to try different programs and talk with others, teachers, and collaborate, and dig into those. Whereas in the brick and mortar, if we didn't have devices or the computers were older, that did not allow for as much integration."* Kate knew where to go for help whenever she encountered technological issues or challenges in technology integration, thus her navigational design judgments for technology integration enabled her to have an enjoyable technology integration experience in online educational settings.

Yasmin also talked about how she navigated through different elements/factors in her learning environments to support her instruction design for technology integration: *"I'm trying to figure out the balance. I mean, although we don't have to provide our rationales to our administrators. They just kinda leave it up to us. And I know I definitely do it a little bit differently than my co-teachers or my colleagues that teach the same level of writing. Uh, I do a little bit more, I think with the kids interactive in the Google Classroom with their computers. So the kids, you know, they could pretty much do everything online."* Yasmin leveraged Google Suite tools and purposefully interacted with her students in the digital learning environment to develop students' digital literacy knowledge and skills. Her navigational design judgments allowed her to explore her own approach to ensure great communication with students and effective content teaching with the support of technology.

Thus, navigational design judgment is relevant to the design space and the learning environment where teachers made specific instructional design decisions for their teaching practices. A variety of contextual factors such as technological support, professional development resources, classroom settings, student groups, and teaching content may affect teachers' instructional approaches and their navigational design judgments. Navigational design judgments in teachers were mostly related to compositional design judgments and mediative design judgments, since all these three types of design judgments emphasized the critical role of dynamic decision-making processes and contextualized instructional decisions for technology integration.

Compositional design judgment

Compositional design judgment entails practitioners putting things together with relationships and connections. Teachers who designed higher-order technology-integrated practices such as synthesizing and analyzing information from different sources often made compositional design judgments.

David's technology-embedded COVID-related project provided us with a good example of compositional design judgments. He aimed to develop students' design thinking as well as empathy from his instructional design practice. Thus, he designed and developed the student-centered COVID-situated project and asked his students to synthesize different sources of information to complete this technology-integrated project: *"I just wanna make my kids wear masks ... If you wanted students to not wear masks, they made their design process difficult and they got to experience that others were like, this design process is too hard… My kids are wearing masks now and they got to understand a little bit more about why my school was mandating them and why schools had closed when they did, and why there is a risk ... So not only did they learn numeracy and three-dimensional thinking and presentation skills in front of fancy adults, but also some research stuff, some inquiry staff. And they got to experience it in a setting that was embedded in the current world that was happening around them. Super fun."* In addition to the complexity of this project itself, David's instructional design decisions for this technology-integrated project also required him to synthesize different sources of information, such as learning objectives, student needs, situated learning, authentic learning experiences, and technology integration.

Another interesting finding of compositional design judgments is that some teachers specifically indicated that they did not have experiences or did not like to make compositional design judgments for higher-order technology-integrated practices. Linda and Lan were two participants who specifically shared their concerns about technology integration. They only used technology to present information and/or manage classrooms when necessary. Their explanations, as Linda said, were, *"I don't know why we need to use technology that often… And there are sometimes where it is like, okay, this is much easier with a pencil and a piece of paper… Kids were also excited about it because it came up and they had a leaderboard and everything like that. And they wanted to do it again. You know, I kind of try to balance it out because I think the kids, there are a lot of tools that we could use, but not a lot of tools for the job, you know, the purpose that I'm trying to use in my classroom."* Compositional design judgments require teachers or practitioners to put together all elements of design for meaningful learning technology-embedded practices in the educational contexts. It is essential for teachers to analyze and synthesize various information based on their expertise and experiences.

In total, eight teachers in this study discussed compositional design judgments that required them to synthesize information from different sources and came up with design decisions for higher-order technology-integrated practices.

Connective design judgment

Connective design judgment asks for a series of syntheses and connections of different options and informational perspectives. For example, a teacher makes a connective design judgment when he/she "considers how a design of a lecture in an academic course is related to another learning activity/assessment, and whether there is a connection and/or alignment between these two design objects" (Lachheb & Boling, 2021).

For example, after Stephen developed his Minecraft activity for mathematics learning, he decided to transfer it into a social studies project: *"Social studies... We came up with a finishing project where they (students) had to recreate the Jamestown Fort. So we spent some time with the students outside of Minecraft kind of planning and brainstorming. Okay, we are gonna do this… what different kinds of jobs did they have? The students would say, well, they had farmers,* *and then we would need people to actually build the thing. And then we gather all the materials we need…"* Stephen discussed how he made connective design judgments along with his instrumental design judgments by aligning his math learning Minecraft activity with the social studies learning objectives and content. Students also loved this technology-integrated activity through the recreation and development of their individual, meaningful scenarios via Minecraft.

David explained his connective design judgments and instructional design decision-making processes for technology integration where he synthesized different sources of information and made comparative analyses: *"… I usually start off with just whatever is traditional, normal, and regular because I am a very safe-in-the-box kind of person. … I'll run into some problem-solving where something isn't working good enough for me or something is really boring. Those are usually my two (reasons) to go look for a (technology) tool… If something is inefficient, I'm gonna look for a technology tool."* David's connective design judgments were closely related to his core design judgments and framing design judgments.

In summary, connective design judgments were discussed by two teachers in this study. They both explicitly discussed what connections and syntheses they addressed when they designed technology-integrated practices for certain contexts.

Core design judgment

Core judgment is the deep and core judgment system in practitioners. It reflects teachers' beliefs and attitudes toward technology integration and their approaches to instructional design decision-making. Besides framing design judgments and instrumental design judgments that are critical to practitioners' decisions for technology integration, core design judgment is a type of design judgment that "stems from designers' own values or thinking that can be revealed through 'why' questions" (Lachheb & Boling, 2018, 2021). Every teacher makes their core design judgments if they design and develop technology-integrated practices in their learning environments.

A typical example of core design judgments came from David, who brought up several technology-integrated practices he had implemented with his high school students. He acknowledged how he selected certain type(s) of technology for his math and science classes: "*I want them (students) to use the tool because it is something that, I mean, it is not like actual architects use it, but it uses a lot of industry standard terms and design principles. And I want them to be exposed to that."* David wanted his students to get involved in real-world meaningful learning projects that integrated with technology. Similarly, Tom integrated technology with the premise that his students must be engaged in meaningful learning projects in authentic learning settings: *"I always start with the learning objectives. I always start with the goal in mind and then find the technology that fits because I really can't stand it when you start with a tech tool and say, how can I use this tech tool? … Good teaching is good teaching, so my way is to know your content and focus on the learners. For me, everything and education comes down to relationships. Forming a meaningful relationship with students and with colleagues and with administrators. Students will work harder for you. They will rise and do better work if you ask them to do better work."*. Besides designing individual, meaningful learning experiences for students, Tom also emphasized that his design decisions for technology integration should enhance his relationships and communication with students.

In addition, Kate indicated her successful core design judgments for technology integration in online settings: *"I feel like I get to know my students better virtually than I did in brick and mortar. Because I'm seeing them often. I get to know their likes and dislikes. There is a lot more conversation as well as engaging their family. And that second piece is more of a selfish* *reason. It is very flexible. So having a family and being a student as well as myself, I can teach anywhere time and I can be a little more creative too, just because there are so many different tools at my disposal…"* Kate preferred to teach online rather than in face-to-face settings because online learning environments allowed her to get to know her students in a flexible and individual way.

Both Stephen and Abby claimed that they would use technology as long as technology worked as a tool to achieve their learning objectives. Stephen mentioned, *"… so I definitely want to have, you know, the content comes first and then find the technology that would go with that and be appropriate for meeting the goals of the lesson and what they are trying to have the students do"*. Abby addressed a similar comment for her technology-integrated practices: *"I have tried to pull in some tools. There are so many, but when I use the technology, I always keep in my mind, the rationale seems okay, what is the purpose? Can I do this better with the tools? Will it be more engaging on the computer?"*

In addition, David and Yasmin addressed that modeling and teacher scaffolding are critical to student learning. David expressed his concern about group and collaborative work when he integrated technology into his teaching practices: *"Groups don't share work very well in ninth grade. They need some training on how to share workloads evenly. And even with the older students, a group of more than three people, it is kind of not feasible to share the work out. And I basically had to make sure that my kids were busy for those six weeks. If they were sharing work, there would be days where they didn't have enough to do."* David believed that technology integration is challenging enough for students to grasp the content knowledge with the use of technology, thus teacher modeling and scaffolding play a critical role in student learning performances. Yasmin also mentioned that it is essential for students to get appropriate guidance and support from the teachers before having students complete their technology-integrated projects.

Two other teachers also expressed their concerns about the role of technology in education. Both Abby and Melanie said that they would like their students to become active meaning-makers through technology rather than users of technology. Their core design judgments affected their technology-integrated teaching practices as well. Abby said,

> *… They (students) can use the technology to Google stuff. They can use the technology to find appropriate YouTube videos. They can use technology to Google their favorite musician or whatever, or listen to music, or play little games. But a lot of kids need kind of that redirection, like, you know, kind of a step-by-step thing… I think we make a lot of assumptions about kids using technology, students using technology. They are not, they are not that great at it when we want them to produce something. You know, they need instruction on that.*

A similar comment came from Melanie: "*I think right now their capacity is more of on a passive event where they are just a user and they really need to be a producer of it. And we need to get them there. To just saying, okay, I'm gonna take this all in and I'm just going to take care of what I need to too. How do you produce something? How do you make a project? How do you show your knowledge? I see through the use of digital technology, and I think we need to start going in that direction.*"

In addition, it deserves to address that all teacher quotes and their descriptions in this chapter reflected their core design judgments, that is, the designer's core value or thinking that can invoke all other design judgments. This section only presents the quotes when teachers explicitly discussed why they made certain design decisions based on their beliefs and attitudes toward technology integration.

Mediative design judgment

Mediative design judgment refers to how practitioners make a balance between different alternatives and design judgments. It reflects a combination or a balance of different types of design judgments. All constructs of design judgments are not isolated units, thus instructional designers and teachers always invoke a number of design judgments together unconsciously (Lachheb & Boling, 2021). However, analyzing these constructs from teachers' dynamic decision-making process is necessary to reflect how teachers leveraged different contextual factors within the design space and make instructional design decisions that either benefit themselves or their students.

A good example of mediative design judgments came from Judy. Judy preferred to design and develop her technology-integrated practices meaningful for students and applicable in real-world settings. Judy indicated, *"...so I try to make sure I'm integrating it in a meaningful way. I don't want it to, I mean, obviously there is value in doing things like having kids simply type, you know, using Google Docs or Google Presentation. But I want it to be, when I look to integrate technology, I want it to be a meaningful way. So I want it to mimic something that is gonna be applicable in real life. I want it to teach the critical skills, or, you know, help build skills that will transfer into other subjects."* Judy made a balance between her core design judgment that values the role of technology and student-centered meaningful learning experiences, framing and appreciative design judgments that allowed her to make instructional design decisions within the design space, and instrumental design judgment that integrates certain type(s) of technology into her pedagogical practices. She is the one who strongly advocated computational thinking and robotic education. As she mentioned, *"Like with math, for example, like that problem-solving is so imperative for math and it is just right as a skill that is built into robotics"*, Judy made mediative design judgments for her computational thinking activities.

Other typical comments reflecting teachers' mediative design judgments include:

- *We didn't have much (technology support), I was using my home computer when we were at home. It is unfortunate because we weren't given any stipends. There were no grants. I have to, you know, my husband helped me take the closet of our guest room and made it into a functional, like mini office for me so that I could do the work… It was not working while they eventually mid-year got us a second monitor so that we could put the kids that were joining remotely up on that screen. But it is a challenge because you are really dividing your attention into two. And you are having to engage with the kids at home, make them feel like they are a part of things… (by Melanie).*
- *I always start with the learning objective. I always start with the goal in mind and then find the technology that fits because I really cannot stand it when you start with a tech tool and say, how can I use this tech tool? Unfortunately, sometimes you get that as a K-12 teacher. Sometimes you have to do this when the department or a school purchases, like it is a software and you have to use it… (by Tom).*
- *I am a big fan of technology and think it has a very important role in education. I think it opens the doors and provide opportunities for students to learn in new ways that weren't possible before, and possibly give them opportunities to learn or express their ideas or connect with other people that might not be possible without it… so I would try to meet with the teacher to kind of get an idea of what they were looking to do. I would, you know, if it was something new they were learning, I would try to do some demonstration*

to help them kind of get an idea of what will happen, like what this technology will do. I would try it at all possible to offer, to be there with them in the classroom when they are first starting to, or to model the lesson for them… (by Stephen).

All the above discussions reflect teachers' mediative design judgments and their balanced design decisions based on a couple of other design judgments such as framing design judgments, instrumental design judgments, navigational design judgments, and/or compositional design judgments. All the ten teachers shared how they made mediative design judgments in this study. It emphasized how teachers discussed their balanced design decisions considering a variety of elements influencing their dynamic decision-making processes for technology integration. It also reflected what teachers prioritized when they had to consider all the contextual factors and made balanced instructional design decisions.

Two tables are presented below to provide the summarized information from the data analysis. Table 14 shows if participant teachers mentioned particular type(s) of design judgments during their interviews. Table 15 presents the frequency of design judgments addressed in teachers' discussions. Although the numbers in the tables could suggest teachers' preferences or prioritization in discussing their design judgments for technology integration, it did not mean that these participant teachers did not make certain design judgments (or make certain design judgments than other types) in real-world settings.

Table 14. *Participants' design judgment(s) for instructional design and technology integration.*

Design judgment	**Definition** (Nelson & Stolterman, 2012)	**Definition** (Lachheb & Boling, 2021)	**Participant(s) (N)**
Framing	A problem framing process that defines the boundaries of the design project.	Defining the boundaries of the design project by emphasizing its focus and outcomes.	Abby, David, Judy, Kate, Melanie, Stephen, Tom, Yasmin (n=8)
Default	An automatic decision-making process without too much mental efforts.	Generating "automatic" response to a situation without hesitation, and without too much thinking.	Abby, Kate, Stephen (n=3)
Deliberated off-hand	A recall of prior experiences or successful instructional design cases.	Recall of previous successful default judgments, consciously.	Abby, Kate (n=2)
Appreciative	A prioritized design decision-making based on an emphasis of certain aspects of a design, considering various options, perspectives, and information.	Emphasizing certain aspects of a design, and backgrounding others.	David, Judy, Melanie, Stephen, Tom (n=5)
Appearance	A design decision-making in terms of style, nature, character, experience, and assessment.	Assessing the overall quality of the design.	Abby, David, Melanie (n=3)
Quality	A design decision-making regarding materials, aesthetic norms, and standards.	Finding out the match/mismatch between aesthetic norms/standards and the particular proposed design artifacts.	Kate (n=1)

Instrumental	A selection of tools or means that can be used for teaching and learning.	Selecting and using design tools/means to reach established design goals.	Abby, David, Judy, Kate, Lan, Linda, Melanie, Stephen, Tom, Yasmin (n=10)
Navigational	A complex and ill-structured design decision-making process considering different factors and directions.	Considering a path/direction to follow in completing a design task.	Abby, David, Judy, Kate, Melanie, Yasmin (n=6)
Compositional	A decision-making process considering all elements and factors influencing the design project.	Bringing all elements of design together to form a whole.	Abby, David, Judy, Kate, Melanie, Stephen, Tom, Yasmin (n=8)
Connective	A design decision-making process considering a synthesis of different elements, informational perspectives, and its connections.	Making connections of objects together for the specific design situation.	David, Stephen (n=2)
Core	A design decision-making process that relates to teachers' own values and beliefs.	Designer's own value or thinking that can lead to invoke all other design judgments.	Abby, David, Judy, Kate, Lan, Linda, Melanie, Stephen, Tom, Yasmin (n=10)
Mediative	A balance between different alternatives and design judgments.	Not explicitly specified.	Abby, David, Judy, Kate, Lan, Linda, Melanie, Stephen, Tom, Yasmin (n=10)

Table 15. *Frequencies of design judgment(s) participant teachers addressed.*

Design judgment	**Participants**										**Total**
	Abby	David	Judy	Kate	Lan	Linda	Melanie	Stephen	Tom	Yasmin	
Framing	2	4	2	2	0	0	2	5	4	2	23
Default	1	0	0	1	0	0	0	2	0	0	4
Deliberated off-hand	1	0	0	1	0	0	0	0	0	0	2
Appreciative	0	2	1	0	0	0	1	1	3	0	8
Appearance	1	1	0	0	0	0	1	0	0	0	3
Quality	0	0	0	1	0	0	0	0	0	0	1
Instrumental	3	5	3	2	1	2	5	2	3	2	28
Navigational	2	2	2	3	0	0	4	0	0	1	14
Compositional	1	1	1	2	0	0	2	1	2	1	11
Connective	0	3	0	0	0	0	0	1	0	0	4
Core	4	3	2	4	2	2	4	3	7	3	34
Mediative	1	1	1	1	2	1	7	1	2	1	18
Total	16	22	12	17	5	5	26	16	21	10	

Lachheb and Boling (2021) emphasized that teachers often invoke a number of design judgments together; thus, it is difficult to isolate any instructional design judgment unit from a series of design judgments addressed in teachers' descriptions of their technology integration experiences. As a result, one technology integration story shared by a participant may consist of different constructs of instructional design judgments. This study only presented what teachers prioritized for making design judgments and dynamic decision-making processes during their interview discussions. Meanwhile, the purpose of Table 15 is to present the complexity of teachers' dynamic decision-making and the different types of instructional design judgments teachers made throughout the process. The numbers in this table did not mean to count or tally.

Additionally, Lachheb and Boling (2021) claimed that the most important three types of design judgments are framing design judgment, instrumental design judgment, and core design judgment. It is interesting to note that these three types of design judgments are what teachers most frequently addressed in CDM interviews, as shown in Table 15. Framing design judgments were addressed 23 times by the teachers in this study; instrumental design judgments were discussed 28 times, and core design judgments were discussed 34 times.

Another important thing to note is that the design judgments reflected in Table 14 and Table 15 did not suggest that these teachers did not make other type(s) of design judgments in real-world contexts. All the design judgments indicated in Table 14 and 15 simply reflected what the teachers emphasized or prioritized in their CDM interviews. For example, Melanie tended to discuss her mediative design judgments for technology integration other than other types of design judgments during the interview. It was very possibly due to the teaching and learning contexts during the pandemic where Melanie had to make a variety of balanced design decisions considering multiple factors such as the hybrid learning contexts, student needs, technological support, and subject content. David liked to share how he made framing design judgments and instrumental design judgments during the interview. It might result from David's prioritization in dynamic decision-making processes for technology integration where his design conjectures and his selection of technology tools were appropriately aligned with the learning objectives, student needs, and design contexts. Tom preferred to discuss his core design judgments during the interview because he would like to share his beliefs and attitudes toward technology integration, that is, why he made certain design decisions rather than how he made design decisions for technology integration. Lan and Linda addressed the least number of design judgments for technology integration during the interviews. It reflected that Lan and Linda might not favor instructional design decision-making for technology integration in general.

The purpose of this chapter was to present the results of the data analysis. As shown above, the study revealed multiple teachers' prioritized design judgments during their dynamic decision-making processes and pedagogical reasoning for technology integration. It is essential to note again that the data analysis and teachers' prioritized design judgments were only based on the interviews. The next chapter provides a discussion of the results.

CHAPTER 5

DISCUSSION & CONCLUSION

This study explored how teachers engaged in dynamic decision-making, design judgments, and pedagogical reasoning while designing instruction that integrates technology in their instructional solutions. This chapter provides a summary of findings regarding (1) how teachers are engaged in dynamic decision-making processes, pedagogical reasoning, and design judgments for instructional design and technology integration; and (2) how teachers perceive different factors regarding instructional design and technology integration when they are involved in the dynamic decision-making process for their design practices, that is, the relationship between teachers' design judgments and their dynamic decision-making processes for instructional design and technology integration. The limitations of this study and implications for future research will also be discussed.

Instructional design decision-making for technology integration is a complex, ill-structured, and multi-leveled process that allows teachers to make decisions based on their experiences, expertise, and contextual factors within the design space (Ertmer & Koehler, 2014; Stefaniak & Xu, 2020). To date, few empirical studies have explored teachers' dynamic decision-making processes, pedagogical reasoning, and instructional design judgments for technology integration (Kopcha et al., 2020; Stefaniak et al., 2021). This study leveraged a multi-case design to explore how K-12 teachers applied dynamic decision-making processes and design judgments while designing instruction and integrating technology in their educational contexts.

This study implemented a pre-survey about instructional design and technology integration and used a critical decision method (CDM) interview technique with every participant to understand how teachers were involved in the complicated dynamic decision-making processes for technology integration and make instructional design judgments for their design decisions. Nelson and Stolterman (2012)'s research has led to the characterization of eleven design judgments. These judgments were further contextualized for instructional design by Lachheb and Boling (2021). Lachheb and Boling's (2021) judgment characteristics (see Table 11) were used to guide thematic data analysis for this study.

The findings of this study revealed that teachers' dynamic decision-making processes were complicated and complex. Design judgments were overlapping and interconnected in teachers' design decisions. It is important to note that the majority of the judgments reported by the teachers did not occur in isolation; many occurred in tandem with other design judgments. It is also important to note that the judgments reported in this study did not reflect every judgment made during the teachers' design projects; they were judgments that the teachers' prioritized in their interviews during this study. The findings of this study offered insights into how teachers navigated the complexities of dynamic decision-making processes and instructional design judgments for technology integration.

Additionally, teachers' design judgments highly depended on teachers' perceptions of different factors in the educational environments and their contextual analysis results when they were engaged in dynamic decision-making for technology integration. In this study, teachers prioritized different contextual factors in the learning environments when they made instructional design decisions for technology integration; it is significant to identify the interconnections and relationships of teachers' dynamic decision-making processes, instructional design judgments, and teachers' perceptions of multiple contextual factors that affect the learning environment. The examination between these factors and teachers' instructional design judgments could inform potential strategies to develop teachers' dynamic decision-making skills for technology integration.

The results showed that three types of instructional design judgments were predominant in teachers' discussions about their instructional design decisions for technology integration: framing design judgments, instrumental design judgments, and core design judgments (see Table 14). The finding of the three prioritized types of design judgments in teachers' discussions supported Lachheb and Boling's (2021) claim of the most important design judgments in teachers' instructional design practices. They proposed that the three types of design judgments were imperative in instructional design practices among eleven types of design judgments: core design judgments stemmed from practitioners' own values and thinking that were behind every other design judgment; instrumental design judgment allowed designers to decide on which design or technology tools to use or not, as well as how to use them for technology integration; framing design judgment helped define the goal of practitioners' design projects and/or technology-integrated practices. These three types of design judgments were significant because they played a substantial role in teachers' dynamic decision-making processes to evoke their design decisions for technology integration (Lachheb & Boling, 2021).

As reflected in this study, core design judgments in teachers were related to teachers' beliefs and attitudes behind their instructional design decisions. Instrumental design judgments in teachers helped them decide what technology tools can be utilized to solve the design problem and/or benefit student learning in their contexts. Framing design judgments in teachers allowed them to define the design context and make the following design decisions/judgments for teaching and learning. These three types of design judgments were what the participant teachers in this study most frequently recalled and described (see Table 15).

Meanwhile, the relationship between teachers' dynamic decision-making processes and their design judgments was investigated. Some themes were identified through the investigation of teachers' dynamic decision-making processes and their interconnections with teachers' prioritized design judgments. The findings indicated that teachers prioritized student-centered pedagogy when designing instruction and integrating technology. The use of technology, on the contrary, was not prioritized over subject matter content and students' needs in the teachers' dynamic decision-making processes and design judgments. It is critical to have teachers reflect on their dynamic decision-making processes because it allows teachers to make situated and timely adjustments to their design judgments and pedagogical practices. The findings also indicated that continuous, sufficient, and consistent technology support and training positively influenced how teachers make instructional design judgments and decisions for technology integration.

The findings of this study also suggested that digital learning environments provided students with individualized learning experiences and teachers with flexibility. K-12 teachers enjoyed the flexibility and student engagement resulting from technology-integrated practices, while they disliked or felt frustrated with the workload and technical challenges it entailed. Thus, a flexible design workload with sufficient technological support was the key to sustaining teachers' successful dynamic decision-making processes and pedagogical reasoning for instructional design and technology integration. The understanding of how teachers perceived dynamic decision-making and instructional design judgments could provide insights into instructional design decision-making and teachers' prioritized design judgments within the process.

It is important to note that this study was conducted during a global pandemic that has greatly affected K-12 education and student learning experiences. The increased attention on instructional design during this time provides opportunities for further exploration of dynamic decision-making for instructional design and technology integration has become increasingly important for K-12 teachers. This study revealed that the pandemic has influenced how teachers prioritized their design judgments when engaging in dynamic decision-making processes for technology integration.

During the pandemic, a number of fast-changing factors such as digital and hybrid learning environments affected teachers' perceptions of instructional design and technology integration; thus this unexpected global health crisis has influenced and reconstructed teachers' dynamic decision-making processes, design judgments, and instructional practices for technology-integrated pedagogical practices. Mediative design judgments, along with a set of framing design judgments, became prevalent in teachers' discussions about dynamic design decision-making for technology integration during the pandemic. It is very much likely that teachers' different sets of prioritized design judgments were a result of their consideration and navigation among a variety of fast-changing factors and their perceptions of the affordances of the learning environment. Teachers' prioritized design judgments helped define the boundaries of instructional design projects and satisfy the urgent needs during the pandemic to come up with a series of balanced design decisions for technology integration.

Teachers' dynamic decision-making and pedagogical reasoning when making instructional design judgments for technology integration

The first research question explored how teachers make instructional design decisions when they are involved in dynamic decision-making processes, pedagogical reasoning, and design judgments for technology integration. Dynamic decision-making emphasizes ill-structured situations where decision-makers consider a variety of factors and transform their analysis and reasoning results into decisions and actions within a short time frame (Jonassen, 2012; Klein, 2008). Pedagogical reasoning addressed the role of teacher knowledge and the transformation from the teacher knowledge base to pedagogical practices (Shulman, 1987; Starkey, 2010). Instructional design judgments represented why certain design decisions were made for technology integration (Lachheb & Boling, 2021). This study showed that when teachers made design judgments and integrated technology into their learning environments, they considered multiple factors during their dynamic decision-making processes and pedagogical reasoning for their instructional design practices within the context. These factors included learning objectives, subject matter content, technology availability, technological support, student learning needs, the affordances of the learning environment, and school policy. Teachers' design judgments considering and prioritizing these factors reflected how teachers navigated through different contextual factors when engaged in dynamic design decision-making for technology integration. Through the examination of teachers' prioritized design judgments, the findings suggest what teachers prioritized while engaging in dynamic decision-making processes and pedagogical reasoning to integrate technology.

As discussed in Chapter 4, every participant teacher addressed a series of complicated and interconnected design judgments resulting from their dynamic decision-making processes for technology integration. The understanding of how teachers engaged in dynamic decision-making processes and instructional design judgments for technology integration can inform how K-12 teachers perceived these factors related to technology integration and why some design decisions were made. A majority of studies have placed emphasis on instructional products resulting from teachers' decision-making rather than their decision-making processes. The findings of this study provide insights into the understanding of teachers' dynamic decision-making processes for technology integration in instructional design contexts.

This study investigated teachers' frequencies of design judgments addressed in their discussions (Table 15). Lachheb and Boling (2021) indicated that the most important instructional design judgments are framing design judgments, core design judgments, and instrumental design judgments. The results showed that three types of instructional design judgments were predominant in teachers' discussions regarding the instructional design decisions for technology integration: framing design judgments (n=8), instrumental design judgments (n=10), and core design judgments (n=10) (see Table 14).

Framing design judgments allowed teachers to define the design context and make the corresponding design judgments for teaching and learning (Lachheb & Boling, 2021). Lachheb and Boling (2021) emphasized that framing design judgments can help instructional design practitioners define the boundaries of the design project or the design problems; thus, it was one of the most prioritized three types of design judgments by teachers. In this study, teachers made framing design judgments to help them define the design contexts and identify critical aspects they needed to consider when making design decisions for technology-integrated practices. Teachers in this study liked to describe their framing design judgments because their framing design judgments guided them to understand the dynamic nature of the design problems in relation to technology integration. The teachers considered a variety of factors such as learning objectives, subject matter content, student needs, and educational contexts (face-to-face, online, and hybrid) when making framing design judgments for technology integration. Teachers' framing design judgments in this study offered information on how K-12 teachers engaged in their dynamic decision-making processes by defining the design boundaries pertaining to the technology-integrated project.

Meanwhile, the study showed that teachers' framing design judgments were closely related to teachers' instrumental design judgments. Instrumental design judgments allowed teachers to select certain technology tools to reach their instructional design goals. The interconnection between these two types of design judgments suggested that teachers' framing design judgments and instrumental design judgments informed each other and collectively shaped teachers' design decisions for technology integration. The selection of technology tools was not only a result of dynamic decision-making processes for technology integration, but also a representation of teachers' instrumental design judgments. Both instrumental design judgments and framing design judgments of teachers helped teachers decide how to leverage certain technology tools for their contextualized design problems.

Additionally, both instrumental design judgments and core design judgments were identified in all ten teachers' discussions regarding their dynamic decision-making processes and pedagogical reasoning for technology integration. Core design judgments reflected teachers' beliefs, values, and attitudes toward their design decisions and practices. Because core design judgments were the root of every kind of design decision (Lachheb & Boling, 2021), all types of design judgments addressed by the teachers, including framing and instrumental design judgments, could be tied back to teachers' core design judgments, that is, teachers' values and attitudes toward the design problems.

This study showed that teachers tended to discuss their framing design judgments and their instrumental design judgments along with core design judgments related to integrating technology. It suggested that teachers' dynamic decisions regarding the selections of technology tools as well as how they defined the design projects were ultimately embedded in their beliefs and attitudes toward instructional design for technology integration. All the three kinds of prioritized design judgments (i.e., framing, core, and instrumental) during teachers' dynamic decision-making processes for technology integration reflected how these teachers perceived technology integration and their technology-integrated practices in their learning contexts.

In addition, the design judgments reported in Table 15 helped identify teachers' complexities in dynamic decision-making processes as well as their prioritized design judgments when teachers described their design decisions and pedagogical reasoning for technology integration. From Table 15, it can be identified that four out of ten teachers discussed core design judgments most frequently in their technology integration practices, which reflected their rationales and attitudes toward technology integration. Four out of ten teachers addressed instrumental design judgments regarding the selection of technology tools most frequently; it indicated that it is critical for teachers to select appropriate technology tools and ensure the alignment of technology integration and their design or instructional goals. Three out of ten teachers mentioned framing design judgments most frequently in their discussions; it reflected teachers' emphasis on defining design problems and contexts. These design judgments, although prioritized in teachers' discussions, were often connected with other types of design judgments and teachers' design decisions. Two out of ten teachers invoked mediative design judgments most frequently, which indicated how these teachers leveraged multiple sources of information and factors to make balanced decisions for technology integration through their negotiations and dynamic decision-making processes.

Contextual factors influencing teachers' design judgments and dynamic decision-making

Learning objectives and content analysis

The first contextual factor that influenced teachers' dynamic decision-making processes, pedagogical reasoning, and design judgments for instructional design and technology integration is the learning objectives and subject matter content. Five teachers in this study explicitly discussed the role of the learning objectives and subject matter content when they made instructional design decisions for technology-integrated practices. These teachers emphasized how the learning objectives and their subject matter content expertise supported them to determine the technology tools and the design rationale of the learning activities when engaging in dynamic decision-making processes in the learning contexts.

The learning objectives and subject matter content were related to teachers' multiple types of instructional design judgments because teachers often invoked a series of instructional design judgments simultaneously (Gray et al., 2015; Lachheb & Boling, 2021). This study showed that learning objectives and subject matter content were relevant to the following types of teachers' instructional design judgments: framing design judgments, instrumental design judgments, compositional design judgments, connective design judgments, and mediative design judgments. Some teachers in this study explained their framing design judgments and instrumental design judgments by addressing how they purposely aligned their technology integration design decisions with the learning objectives and subject matter content.

This study also revealed that teachers prioritized the teaching and learning objectives and subject matter content ahead of the use of technology tools when making framing design judgments to define the technology-integrated learning activities and instrumental design judgments to make decisions for their selection of technology. As Lachheb & Boling (2021) informed, framing design judgments often happen at the beginning of an instructional design process, and it often comes together with other types of design judgments such as instrumental design judgments, core design judgments, and compositional design judgments. In this study, several teachers prioritized learning objectives and subject matter content when they defined the goal of their overarching design context and project as they made framing design judgments. Based on teachers' pedagogical reasoning toward learning objectives and the analysis of subject matter content, these teachers decided what technology tools they could utilize for their instrumental design judgments and situated the content and technology into their learning environments for their compositional design judgments, connective design judgments, and/or mediative design judgments.

The study exhibited that two out of ten teachers contextualized learning objectives and subject matter content based on student learning needs and technology availability as they engaged in dynamic decision-making processes and pedagogical reasoning for designing their course. The teachers came up with the design of innovative technology-embedded practices based on specific learning objectives, student needs, and subject matter content analysis throughout their dynamic decision-making processes, considering the affordances of the learning environment and technology integration. One teacher, as an example, contextualized her science learning objectives and subject matter content by integrating specific science learning simulations and age-appropriate touch-screen platforms into her learning environment. Jonassen

(2012) claimed that teachers' instructional decisions for technology integration are closely related to teachers' contextual analysis, such as student needs and learning environments. The results of this study approved that teachers' considerations of learning objectives and subject matter content directly affected teachers' dynamic decision-making processes and instructional design judgments when they made design decisions for technology integration considering learners and learning contexts. By contextualizing learning objectives and subject matter content into the learning environment, the teachers aligned these factors with student needs and their selection of technology tools (i.e., instrumental design judgments) and made a set of interconnected design judgments (e.g., framing design judgments, connective design judgments, compositional design judgments) for their design practices. Teachers were then aware of what they should prioritize when making design decisions for technology integration.

Technology availability and support

Technology availability and support directly affected teachers' dynamic decision-making processes, pedagogical reasoning, and instructional design judgments for instructional design and technology integration (Heitink et al., 2016; Stefaniak et al., 2021). This study showed that teachers required sufficient and sustainable technical support from the school and/or professionals to assist them with technology integration and instrumental design decision-making. All ten teachers discussed what technology support they had acquired from the school and how it had sustained their dynamic decision-making processes and instrumental design judgments. Three out of ten teachers specifically discussed their navigational design judgments and mediative design judgments during the dynamic decision-making processes for technology integration; they negotiated between different factors such as technology availability and support, student needs, and classroom contexts, and then made corresponding interconnected design judgments for the learning environment.

All ten teachers in this study explained their rationale for technology-integrated practices. Teachers' dynamic decision-making skills in designing instruction for digital learning environments, according to Stefaniak et al. (2021), have become an essential skillset for teachers. This study endorsed Stefaniak et al.'s (2021) claim that all teachers in this study who utilized different technology tools in digital learning environments were required to synthesize multiple sources of information in dynamic decision-making processes to make a series of instructional design judgments, especially when teachers addressed mediative design judgments for their learning contexts. It also suggested that it is crucial for schools and/or administrators to provide adequate technical support and resources to sustain teachers' instructional decision-making processes for the design of technology-embedded pedagogical practices.

Meanwhile, according to the study, some teachers' framing and instrumental design judgments considered student needs and scaffolding as essential factors that affected their dynamic decision-making processes for technology integration. For example, one teacher described how she adjusted her design decisions (i.e., framing and instrumental design judgments) by comparing the workload between face-to-face teaching and online teaching with different technological challenges and ways of scaffolding. It suggested that teachers' scaffolding for technology integration needed to be aligned with student needs, the learning content, and the learning environment. Sufficient technological support could sustain not only teachers' design decision-making for technology integration, but also student learning experiences in digital learning environments.

Student socioeconomic backgrounds and learning needs

Student socioeconomic backgrounds and learning needs served as another critical aspect that teachers prioritized when they engaged in dynamic decision-making processes and pedagogical reasoning for instructional design and technology integration (Boschman et al., 2014; Lowenthal & Dennen, 2017). In this study, four out of ten teachers reported how they perceived students' digital literacy levels when they made instructional design decisions for technology-embedded practices. One another teacher in this study drew on his previous teaching experience with similar groups of students and made corresponding design judgments based on his knowledge of student backgrounds and learning needs within his dynamic decision-making processes for designing and developing meaningful learning experiences for technology integration.

Seven types of instructional design judgments were related to student learning needs and learner analysis, including framing design judgments, default design judgments, appearance design judgments, quality design judgments, navigational design judgments, compositional design judgments, and mediative design judgments. These design judgments may derive from one or multiple instructional design activities because design judgments were often invoked together and interconnected (Gray et al., 2015; Lachheb & Boling, 2021).

Teachers were engaged in dynamic decision-making for technology integration by utilizing the information around them to make design decisions (Stefaniak et al., 2021). Teachers' perceptions of their students' socioeconomic backgrounds and learning needs, as well as their prior experiences working with similar groups of students, directly affected their dynamic decision-making processes for technology integration. The dynamic decision-making processes then led teachers to decide how to utilize technology tools and how these tools can be best integrated into the student-centered learning activities, which also informed their interconnected design judgments such as framing design judgments and instrumental design judgments.

Tessmer and Richey (1997) presented a series of contextual factors pertaining to contextual analysis in instructional design. They specifically discussed the importance of systemic analysis concerning learners' needs, the immediate environment with respect to teaching and learning, and the organization comprising all teachers and learners. This study revealed that the teachers were concerned with learner backgrounds when making instructional design judgments for technology integration. Five of the teachers explicitly described how they prioritized student learning needs, their backgrounds, as well as students' technological knowledge and skills when they addressed framing design judgments, instrumental design judgments, and navigational design judgments in their discussions for technology integration. Meanwhile, this study demonstrated that all ten teachers were able to recognize the role of contextual analysis of learners and make corresponding design judgments and decisions for integrating technology in their learning contexts.

Time, space, and learning environments

Learning environments consist of digital learning environments, face-to-face learning environments, and hybrid learning environments. Design space refers to how teachers make a balance among multiple factors influencing the learning environment when designing instruction (Ertmer & Koehler, 2014; Stefaniak et al., 2021). Different learning contexts and design spaces may lead to different teachers' dynamic decision-making processes, pedagogical reasoning, and instructional design judgments for technology integration.

According to this study, six types of design judgments made by teachers were closely associated with time, space, and different learning environments, including framing design judgments, appreciative design judgments, appearance design judgments, instrumental design judgments, connective design judgments, and mediative design judgments. The different and intertwined types of design judgments suggested that teachers' dynamic decisions and design judgments for technology integration varied in complexity when they were engaged in different contexts.

For example, there were two teachers in this study who taught at the same grade level and had sufficient professional training for technology integration as they reported. However, these two teachers' teaching environments, student backgrounds, and design contexts were totally different, and thereby their dynamic decision-making processes, pedagogical reasoning, as well as their types of design judgments involved were different in essence. It also reflected that although teachers' demographic backgrounds might be similar to each other, their design judgments, prioritized factors, and their dynamic decision-making processes might be different due to the differences in their decision-making knowledge and skills, attitudes toward technology integration, the technological support they could acquire, and the learning environments.

When teachers were engaged in dynamic decision-making and pedagogical reasoning when designing instruction and integrating technology, their time, design contexts, and learning environments would all play a critical role in teachers' instructional design judgments and design decisions for technology-embedded pedagogical practices. It is thereby essential to provide as much detailed information as possible regarding teachers' design and learning contexts when exploring their instructional design and dynamic decision-making processes for technology integration.

School policy

Some other external factors also influenced teachers' dynamic decision-making, instructional design judgments, and pedagogical reasoning for instructional design and technology integration, such as the school policy, the structure of the course/program, and assessments. For example, five out of ten teachers believed that they had received sufficient support, encouragement, and assistance from school administration when making instructional design judgments and decisions for technology integration. The supportive school policy and complete assessment systems resulted in default and/or deliberated off-hand design judgments in teachers.

Supportive school policy, assessment, and relevant administrative support also played a significant role in teachers' dynamic decision-making processes for technology integration. According to this study, the supportive school policy and complete administrative systems led to teachers' default design judgments and deliberated off-hand design judgments. Because both default and/or deliberated off-hand design judgments emphasized teachers' automatic or conscious recall of their prior successful design decisions for technology integration, supportive school policy and relevant resources may lead to teachers' fast-paced and successful dynamic decision-making processes and design judgments for technology integration.

However, teachers who suffered from their teaching experiences during the pandemic adjusted their instructional design judgments and design decisions based on the contexts. According to one participant's description, many in-service teachers have resigned from the schools in recent times because of the heavy workload, lack of support from the school, and the hybrid learning environments where teachers needed to engage both face-to-face and online students simultaneously. To maintain the teaching quality and regular communication with the students, the teacher had to make design decisions by considering an extra set of factors such as using personal computers and much more personal time to complete their work, creating extra sets of lesson plans suitable for the hybrid learning contexts, developing technology-embedded assessment materials, and tackling technical issues for their technology-integrated practices. These contextual factors derived from the pandemic hugely changed teachers' prioritized design judgments and their dynamic decision-making processes and pedagogical reasoning for instructional design and technology integration. This study showed that teachers would make a great number of mediative design judgments for technology-embedded practices because of the complicated, dynamic, and changing factors resulting from the teaching and learning contexts. It suggested that a sustainable system of school policy and relevant resources dealing with the impacts of the pandemic is urgently needed to facilitate teachers' dynamic decision-making processes and instructional design judgments for technology integration.

Emphasis on student-centered learning

Prior research concerning teachers' dynamic decision-making process and pedagogical reasoning rarely discussed the role of students' voices in affecting teachers' instructional design decisions for technology integration (Xu & Stefaniak, 2021). This study identified that eight out of ten teachers emphasized student-centered pedagogical practices when they were engaged in dynamic decision-making processes and instructional design judgments for technology integration. As Greenhow et al. (2008) described, teachers were concerned with "articulating a well-justified instructional plan to students who may be wary of innovation." The eight participant teachers in this study put student needs and learner-centered design as their priority when they made instructional decisions for their learning contexts. These teachers, no matter if they appreciated technology integration or not, emphasized student-centered instruction in their descriptions of decision-making and pedagogical reasoning for design practices.

Student-centered design was related to seven types of instructional design judgments: framing design judgments, default design judgments, appearance design judgments, quality design judgments, navigational design judgments, compositional design judgments, and mediative design judgments. Framing design judgments stood out from the seven types because student-centered design often influenced how teachers defined their instructional design contexts and practices for technology integration. In this study, five out of the eight teachers explicitly described how they approached student-centered design in their dynamic decision-making and pedagogical reasoning for instructional design and technology integration. They analyzed student needs, reflected within their own design spaces (i.e., bounded rationality), and then made corresponding design decisions for technology integration and instructional design according to student needs.

Iterative self-reflection to accommodate student needs and learning environments

This study identified that teachers' constant and iterative self-reflection influenced teachers' dynamic decision-making processes, pedagogical reasoning, and design judgments. Dynamic decision-making emphasized short time frames and prompt design decisions for the learning contexts. A couple of teachers in this study explicitly mentioned that they gained knowledge about technology integration from the school or relevant professional training, knew 'what to do' when they faced design problems in their contexts, and recognized their self-reflection processes for their instructional design judgments.

Pedagogical reasoning is a process where teachers refer to their knowledge base and transfer it into pedagogical practices through the reasoning process pertaining to the affordances of the learning environment (Shulman, 1987; Starkey, 2010; Stefaniak et al., 2021). Dynamic decision-making emphasized how teachers approached both teachers' and learners' perspectives in the contexts and made corresponding instructional design decisions to accommodate the affordances of the learning environment and the learners (Stefaniak et al., 2021; Webb & Cox, 2004). McKenney et al. (2015) addressed that teachers' self-consciousness of their instructional design experience is critical in developing teachers' dynamic decision-making skills and pedagogical reasoning for technology integration and instructional design practices. Boling (2020) discussed how design precedents as a form of knowledge influenced dynamic decision-making processes and pedagogical reasoning when teachers made design decisions for their learners and learning environments.

This study coincides with McKenney et al.'s (2015) and Boling's (2020) findings. A majority of the teachers were conscious of and benefited from their self-reflective process to accommodate student needs and a variety of contextual factors through pedagogical reasoning based on the teachers' knowledge and design precedents when they were engaged in dynamic decision-making processes and design judgments for designing instruction and integrating technology. Multiple teachers' descriptions of navigational design judgments, compositional design judgments, and connective design judgments reflected how these teachers referred to their knowledge, navigated among different factors within their design space, and made contextualized decisions based on student needs and the learning environment.

In addition, this study identified that teachers' self-reflection processes may not lead to design decisions for higher-order technology-integrated practices. Through reflection-in-action, teachers could engage in reflective conversations and interacted with design contexts to determine whether their design decisions worked or not (Stefaniak et al., 2021). One teacher in this study explicitly expressed that her reflection towards the current “abuse” of technology in classroom settings inhibited her design decisions for technology use in classrooms. Thus, her core design judgments and mediative design judgments did not support her to implement higher-order technology-embedded practices in her students. It was then critical to identify how to utilize digital tools (i.e., instrumental design judgments) to inspire or support teachers’ dynamic decision-making processes as well as their self-reflection processes for achieving better design decisions for technology integration.

Therefore, besides teacher knowledge regarding technology integration and instructional design, teachers’ constant and iterative self-reflection processes regarding their pedagogical reasoning and environmental analysis also played a critical role in teachers’ dynamic decision-making process and interconnected design judgments for technology-integrated pedagogical practices. Teachers leveraged their reflection-in-action to reason their pedagogical reasoning and justify their dynamic decision-making processes and instructional design judgments (Schön, 1991; Stefaniak et al., 2021; Tracey et al., 2014). It is thereby important to examine how teachers perceive student needs and other environmental factors within their dynamic decision-making processes and make corresponding adjustments for their design practices through self-reflective practices.

Teacher beliefs and attitudes toward technology integration and core design judgments

Teacher beliefs and attitudes on technology integration are closely associated with teachers’ decision-making process and their core design judgments (Ertmer, 2005; Lachheb &

Boling, 2021). Kopcha et al. (2020) addressed that teachers' decision-making for technology integration is a value-driven and dynamic process according to teacher beliefs and teachers' perceptions of technology integration. Teacher beliefs, values, and attitudes toward technology integration are rooted in teachers' dynamic decision-making processes, pedagogical reasoning, and design judgments for technology-integrated design practices.

Lachheb and Boling (2021) indicated that all design decisions and judgments were the results of teacher beliefs, values, and attitudes toward technology integration. Core design judgments, specifically, acknowledged why teachers made certain instructional design decisions and their rationale behind all decisions and actions. As teacher beliefs and values of technology integration were reflected in teachers' core design judgments, it was the major type of design judgments that led to a set of intertwined design judgments such as instrumental design judgments, compositional design judgments, and/or mediative design judgments.

In this study, all ten teachers addressed core design judgments in their discussions. While most teachers shared their positive values and attitudes toward technology integration, two out of ten teachers in this study explicitly expressed their concerns about technology integration in classroom settings. They only used technology to present information and/or manage classrooms when necessary. Thus, when teachers' core design judgments reflected their negative beliefs and attitudes regarding technology integration and technology-integrated practices in classroom settings, it warrants further exploration of how to utilize teachers' core design judgments and dynamic decision-making processes to support their technology integration practices. It also deserves to discuss in what way core design judgments for technology integration in teachers can be changed or developed during their dynamic decision-making processes.

Teachers' perceptions and assumptions of their instructional design judgments and practices directly impact teachers' dynamic decision-making process for instructional design and technology integration. Teachers' perceptions of technology integration connect teacher beliefs (i.e., core design judgments), their dynamic decision-making process, pedagogical reasoning, and contextual analysis that are related to technology-integrated practices and affordances of the environment (Shafto et al., 2014; Webb & Cox, 2014). Thus, teachers' perceptions and assumptions act as a bridge to help teachers synthesize various information and transform them into their technology-integrated pedagogical decisions (Kopcha, 2012), which resulted in multiple types of design judgments such as core design judgments and mediative design judgments in teachers.

In this study, all ten teachers discussed their perceptions and/or assumptions of their instructional design practices. Teachers' perceptions and/or assumptions of their design practices led them to make the following design judgments: core design judgments, navigational design judgments, compositional design judgments, connective design judgments, and mediative design judgments.It is thereby crucial to analyze teachers' perceptions and assumptions of their instructional design practices to understand how teachers leveraged different contextual factors within the design space and make corresponding instructional design decisions.

Drawing from prior success

Teachers' prior experiences were closely related to framing design judgments, default design judgments, deliberated off-hand design judgments, appearance design judgments, connective design judgments, and mediative design judgments. As Rowley (2005) stated, common design practices can help teachers or practitioners improve their expertise. It suggested that the more positive personal experiences for technology integration and instructional design a teacher had, it would be more likely for the teacher to make effective and successful instructional design judgments and decisions (Gray et al., 2015).

This study showed that teachers' prior experiences greatly influenced their behaviors and design judgments in the learning environment. Teachers' teaching experiences, especially their successful experiences with technology integration and instructional design, were helpful for their dynamic decision-making and pedagogical reasoning when they made instructional decisions for technology integration (Ertmer et al., 2008, 2009). This study provided several examples to indicate when teachers' prior experiences were not that successful regarding technology integration, teachers were less likely to make appropriate design judgments for technology integration in their educational settings.

To summarize, teachers' intertwined design judgments reflected how teachers perceived a variety of conditions during the dynamic decision-making process (Lachheb & Boling, 2021; Smith & Boling, 2009). Teachers' multiple types of design judgments highly depend on teachers' perceptions of both teachers' and learners' perspectives, the teaching and learning environment, and some other contextual factors regarding instructional design, technology integration, and the design space (Kopcha, 2012). This study provided some evidence for a set of factors and themes teachers were concerned with when they were involved in dynamic decision-making processes, pedagogical reasoning, and design judgments for instructional design and technology integration.

A relationship between teachers' design judgments, dynamic decision-making, and technology integration

The findings of this study identified a relationship between teachers' design judgments and their dynamic decision-making processes for instructional design and technology integration. When teachers engaged in dynamic decision-making and pedagogical reasoning for instructional design and technology integration, they made a series of interconnected design judgments according to their perceptions of factors within the learning context (Boling, 2020; Nelson & Stolterman, 2012). Below, the major findings and possible reasons regarding the relationship between teachers' dynamic decision-making processes, instructional design judgments, and technology integration are discussed.

According to this study, teachers prioritized student-centered practices when designing instruction and integrating technology. It is mostly related to teachers' framing design judgments that helped teachers define the boundaries of the design context, core design judgments that reflected teachers' beliefs and attitudes toward technology integration, and mediative design judgments that required teachers to negotiate between a variety of information and factors and make a balanced design decision.

Technology integration, on the contrary, was not that prioritized compared with learning objectives, learning content, and student needs in teachers' dynamic decision-making processes, pedagogical reasoning, and instructional design judgments for technology integration. As Ertmer et al. (2008) and Perez and Emery (1995) indicated, experienced teachers and instructional design practitioners are normally better at making instructional design decisions for technology integration because they could take into consideration numerous factors based on their expertise and personal experiences. This study showed that some experienced in-service teachers prioritized student needs and their technical knowledge and skills when making instructional design judgments for technology-integrated pedagogical practices in the learning environment.

Teachers' design judgments, learner-centered practices, and dynamic decision-making that helped teachers contextualize their design practices in the learning environment would benefit student learning experiences regarding technology integration.

Meanwhile, teachers' prioritization of student-centered design practices and technology integration helped teachers make design decisions and a series of design judgments, including framing design judgments, core design judgments, instrumental design judgments, and mediative design judgments. These design judgments were overlapping and interconnected according to teachers' discussions of their technology integration practices and dynamic decision-making processes.

Although teachers' instructional design judgments and dynamic decision-making processes were concerned with several contextual factors in the learning environment, technology integration never played as teachers' instructional priorities when teachers engaged in instructional design judgments for their educational contexts. None of the teachers in this study expressed that they made instructional design decisions solely based on the features of technology tools or technology availability in their educational settings (even quality design judgments made by the teacher). The study suggested that teachers' instructional decisions and judgments were focused on student needs and learning objectives rather than technology integration.

Although technology integration was not prioritized in some teachers' design judgments and dynamic decision-making processes, continuous and consistent technology support and training still had an impact on how teachers made instructional design judgments and dynamic decisions for technology integration. As teachers needed to be taught how to engage in pedagogical reasoning and dynamic decision-making processes by developing a full awareness of a variety of conditions that influence the learning environment (Kali et al., 2011; McKenney et al., 2015), this study suggested that whenever teachers would like to design and develop an appropriate learning activity/practice to integrate technology, they would require sufficient and consistent technical support to help them justify their design decisions considering internal and external factors within the design context. Teachers' design judgments, dynamic decision-making, and pedagogical decisions were influenced by the technological support and resources offered by the school administration or other sources.

Meanwhile, technological support and professional training may improve teachers' design judgments and their knowledge and skills for technology integration, especially framing design judgments and core design judgments in teachers. As Gray et al. (2015) claimed, teachers and practitioners can be trained to develop their instructional design decision-making knowledge and skills for technology integration. Teachers who do not favor technology integration may change their negative stereotypes of technology-integrated practices if provided with effective technical support and training. Then, these teachers would possibly make better instructional design decisions for the design of their technology-integrated practices (i.e., framing design judgments, core design judgments) if they were offered sufficient and consistent technology support and professional training in terms of technology integration.

Dynamic decision-making allows teachers to adjust accordingly for their design judgments

This study explored how dynamic decision-making allowed teachers to make situated and timely adjustments for their design judgments and pedagogical practices (Klein, 2008). Some teachers in this study were fully aware of their dynamic decision-making processes for technology integration. This was demonstrated in how they had perceived and prioritized a variety of unstructured and fast-changing factors through their constant and iterative reflection-in-action process for technology integration (Klein, 2008; Tracey & Hutchinson, 2018). They often prioritized student needs and educational purposes when they invoked a series of instructional design judgments for technology-integrated pedagogical practices and then made adjustments to their design judgments accordingly based on the environmental factors. It suggested that teachers' framing design judgments, compositional design judgments, navigational design judgments, and instrumental design judgments were closely related to how these teachers perceived the environmental factors and made certain adjustments to their design practices.

This finding also coincides with other studies that suggest that teachers' dynamic decision-making and pedagogical reasoning should acknowledge both teachers' and students' contributions to the learning environment (Shafto et al., 2014; Voogt et al., 2013). Some researchers have claimed that central to instructional design decision-making and technology integration are considerations for the affordances of the learning environment and perspectives from both teachers and students (Stefaniak et al., 2021; Webb & Coxx, 2004). This study sustained that it is important to examine instructional design judgments, dynamic decision-making processes, and pedagogical reasoning together in terms of how teachers negotiate these perspectives and the classroom context when making instructional design decisions (Stefaniak et al., 2021).

It is critical to note that the characteristics of design practices may affect teachers' design judgments and dynamic decision-making processes for technology integration as well. These characteristics include the learning objectives, subject matter learning content, technology platforms, technological support, and professional training teachers have gained either from the school or from other resources. As the teachers engaged with students in the learning contexts, they established affordances for the learning activities. These affordances are the results of the negotiations between the teachers' and students' knowledge, beliefs, and values (Webb & Cox, 2014). When teachers engage in dynamic decision-making processes, it would be critical to investigate how teachers make adjustments according to their perceptions of multiple factors and the affordances of the learning environment.

Teacher needs may be as important as student needs when teachers make multiple design judgments for technology integration. This study showed that even though teachers prioritized student needs when they made instructional decisions such as framing design judgments and instrumental design judgments, they would be easily frustrated with their design of technology-embedded design practices if teachers themselves did not get sufficient support during the design decision-making processes for technology integration. It also reflected that instrumental design judgments in teachers could inform how teachers perceived the role of technology support, as well as how to improve technological or administrative support to facilitate teachers' instructional design judgments and dynamic decision-making processes for technology integration.

Additionally, some teachers' experiences suggested that teachers may not be able to consider all the factors systematically if they were provided limited time, resources, or design spaces when engaged in dynamic decision-making processes and instructional design judgments for their technology-integrated practices. Thus, it is beneficial to help teachers self-reflect on their design judgments and dynamic decision-making processes for technology integration, so they would recognize the complexities and multiple factors involved in dynamic decision-making, what design judgment should or should not be evoked, and how to make better design judgments as “deliberate reflection” on their design practices and decisions (Lachheb & Boling, 2021).

Implications for exploring dynamic decision-making

It is important to recognize the role of dynamic decision-making and instructional design judgments for technology integration, the complexity and interconnections within these constructs, and the relationship between teachers’ design decision-making, design judgments, and a variety of contextual factors.

Teachers need to navigate the complexities of their instructional design judgments and dynamic decision-making processes for technology integration. They need to consider multiple constructs and factors that contribute to their dynamic decision-making processes for instructional design and technology integration. Currently, although the participant teachers in this study addressed different factors supporting their instructional design judgments, they did not have a complete awareness of the different types of intertwined instructional design judgments, how these design judgments were evoked and interconnected, as well as what contextual actors they have prioritized during their dynamic decision-making processes for technology integration. Teachers should be aware of these processes and factors from a systematic perspective, and understand the interconnections between their instructional design judgments, dynamic decision-making processes, and pedagogical reasoning for technology integration. Teachers could benefit from their self-reflections and reasoning processes regarding how they leveraged different sources of information/factors to make decisions, what design judgments have been evoked or not evoked, and how to embrace the uncertainty and ill-structured processes within their dynamic decision-making processes and pedagogical reasoning for technology integration.

The second implication is that it is imperative for teachers to be able to rationalize their dynamic decision-making processes and pedagogical reasoning when they make instructional design judgments for technology integration. In this study, teachers addressed their framing design judgments, core design judgments, and instrumental design judgments as the most frequent three types of design judgments in technology integration practices. It is essential to develop teachers' iterative and deliberate self-reflection on their dynamic decision-making processes and their interconnected instructional design judgments, so that teachers would get used to rationalizing their design judgments and be able to apply their dynamic decision-making knowledge and skills to any ill-structured situations.

Meanwhile, this study shed some light on the significant role of the dynamic decision-making processes for technology integration. Dynamic decision-making emphasizes how teachers make prompt design decisions based on the ill-structured design context. This study proposed that teachers should develop a better understanding of how they engage in dynamic decision-making and design judgments in their specific contexts. Additionally, the exploration of dynamic decision-making processes and its relationship with instructional design judgments allowed teacher educators to think about how to leverage learner designers' self-reflections to develop design decision-making skills for both pre-service teachers and in-service teachers.

Limitations

It is important to note some limitations of this study. Firstly, this qualitative study only recruited ten in-service teachers and examined their dynamic decision-making processes, pedagogical reasoning, and design judgments for instructional design and technology integration. The participant teachers who were involved in this study were those who completed the pre-survey and met the inclusion criteria. More data can be retrieved from a larger group of K-12 teachers to examine teachers' dynamic decision-making processes, pedagogical reasoning, and instructional design judgments for technology integration. This study's generalizability can be improved if we enroll more teachers in this study.

Another limitation is the validity of the study. The validity of the study could be improved by having more types of data from the teachers in terms of their dynamic decision-making processes and design judgments. Due to the pandemic, it was challenging to conduct informal observations with the teachers. The validity of the study can be enhanced by having more data such as observation of teachers' classrooms and teaching, student feedback of teachers' technology-integrated practices, and/or collection of teachers' design journals.

Third, the analysis of design judgments and dynamic decision-making processes for technology integration was mainly based on teachers' self-reported data on their technology integration experiences and instructional design decision-making. The design judgments reported were limited to what the participant teachers prioritized in their discussions. Because design judgments were interconnected and did not occur in isolation (Lachheb & Boling, 2021), it was difficult to capture and disclose every aspect of the teachers' dynamic decision-making processes and their pedagogical reasoning through teachers' self-reported data. It deserves further exploration and discussion on how to conduct effective data collection and data analysis for the investigation of teachers' dynamic decision-making processes and intertwined design judgments for technology integration.

Future Research

This study suggested that future studies can approach teachers' dynamic decision-making process and instructional design judgments from a multi-construct perspective. It deserves to further unpack teachers' dynamic decision-making processes, pedagogical reasoning, and instructional design judgments for technology integration by exploring their interconnections, their relationships, and what role different contextual factors play within the process. It would also be interesting to examine how teachers perceive the entire process, their reasoning process, and their prioritized design decisions when making instructional design judgments for technology integration.

Due to the complexity and interconnection within the design judgments in teachers' dynamic decision-making processes and pedagogical reasoning for instructional design and technology integration, this study also suggested that more empirical studies that aim to examine teachers' dynamic decision-making, instructional design judgments, and pedagogical reasoning with a multi-construct perspective are needed in the field. It is critical to gain a better understanding of teachers' decision-making processes and how teachers prioritize different contextual factors when making instructional design judgments for technology integration. Some professional guidelines that can develop teachers' dynamic decision-making knowledge and skills for instructional design and technology integration are also needed in the field.

Additionally, it would be interesting to identify if teaching with technology informs how these K-12 in-service teachers approach instruction. It deserves future research to investigate if teachers' different levels of technology integration contribute to their design judgments, dynamic decision-making, and pedagogical reasoning for instructional design. The examination of the relationship between lower or higher-order technology integration practices, teachers' perceptions of technology integration, and their dynamic decision-making processes for instructional design judgments would provide more information to understand teachers' attitudes and their behaviors. It could also inform potential ways to develop teachers' knowledge and skills in technology integration and instructional design.

Moreover, it is also essential to further understand teachers' decision-making process and come up with some professional guidelines to develop teachers' decision-making knowledge and skills for instructional design and technology integration. Future studies with different teaching and learning contexts and groups of teachers can lead to more validated guidelines for teachers' professional learning in technology integration and design decision-making.

During the pandemic, a number of fast-changing factors such as digital and hybrid learning environments have hugely affected teachers' perceptions of instructional design and technology integration (Polly et al., 2021). Some teachers' experiences and design judgments suggested that this unexpected global health crisis has influenced and reconstructed teachers' dynamic decision-making processes, pedagogical reasoning, and instructional practices for technology-embedded pedagogical practices. In this study, one teacher described her frustration since many environmental factors influencing dynamic decision-making and instructional design judgments had changed. Mediative design judgments were addressed as the most frequent type of design judgments in this teacher's discussion of technology integration experiences. Thus, it suggested that mediative design judgments mostly happened due to a variety of fast-changing, ill-structured, and uncertain factors within the teaching and learning environment. This study also indicated that teachers' expertise and experiences sometimes could not fully support them to make good decisions addressing various factors during the pandemic. Thus, more empirical studies that aim to investigate the influence of the pandemic on digital or hybrid learning environments, as well as teachers' dynamic decision-making processes, pedagogical reasoning, and intertwined design judgments are needed in the field.

Conclusion

This qualitative multi-case study provided researchers with insights into how teachers are engaged in the dynamic decision-making process, pedagogical reasoning, and design judgments when designing instruction for technology integration. This study successfully identified multiple factors and themes in relation to teachers' dynamic decision-making processes and instructional design judgments for technology integration. The relationship between teachers' instructional design judgments, dynamic decision-making, and technology integration was also discussed.

To date, there have not been any empirical studies exploring dynamic decision-making, instructional design judgments, and pedagogical reasoning for technology integration in K-12 teachers. This study successfully unpacked teachers' dynamic decision-making processes and interconnections among instructional design judgments for technology integration in teachers. It also informs future studies to further explore teachers' dynamic decision-making processes and instructional design judgments for technology integration from a multi-construct perspective.

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APPENDIX A

Recruitment Letter and Consent Form

Recruitment letter
Recruitment: Invitation to participate in a Study

Hello,

You are invited to participate in a research study that aims to investigate dynamic decision-making processes while designing instruction and integrating technology.

If you agree to join the study:

You will be asked to complete a pre-survey regarding your technology integration and instructional design experience.

You will potentially have an interview with the researcher. In this interview, you will be asked to describe some stories or incidents about your technology integration and instructional design experiences. You will share with us how you design the technology-integrated activity and what factors influence your decisions. The whole session will take around 30 to 40 minutes.

It is ensured that participation/non-participation in this study does not affect your performance assessment. If you have any questions, feel free to contact Dr. Jill Stefaniak or Meimei Xu.

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Consent Form

Researcher's Statement
You are invited to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. This form is designed to give you information about the study. If you have any questions, feel free to contact the principal investigator, Dr. Jill Stefaniak, or the co-investigator, Meimei Xu. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called "informed consent".

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Purpose of the Study
This study aims to explore how teachers apply dynamic decision-making, design judgments, and pedagogical reasoning while designing instruction and integrating technology in their instructional solutions.

Study Procedures
If you agree to participate, you will be asked to ...

- Participate in a pre-survey in terms of your technology integration and instructional design experiences. The researchers anticipate that you should be able to complete this survey in less than 10 minutes.
- Potentially participate in an audio-recorded interview in which we ask about your technology integration and instructional design experiences, and your thoughts about your experiences. The interview will take about 30 to 40 minutes.

Risks and Discomforts
Foreseen risks that may cause discomfort for participants are:
Psychological risks:

- Unlikely but a fear that it will influence their performance assessment by the instructor(s).
- A discomfort when being audio-recorded during interviews.

We do not anticipate any other risks from participating in this research.

Benefits

There may not be any direct or immediate benefits from participating in this study. Through survey and interview questions, some study participants may develop a better understanding of their dynamic decision-making processes for technology integration and instructional design experiences. Through teachers' participation in this research, our research team will develop an understanding of teachers' reasoning processes regarding technology integration and instructional design, thereby developing professional development strategies that can help educators and teachers make appropriate dynamic design decisions for instructional solutions regarding technology integration.

Incentives

Participants will have chance to win one of five $30 gift cards.

Privacy/Confidentiality

This study aims to explore how teachers apply dynamic decision-making, design judgments, and pedagogical reasoning while designing instruction and integrating technology in their instructional solutions. Data gathered during this study will not disclose your personal information or school information. A code will be created to hide your identity and only the researchers will be able to identify you. The findings of this research might be subject to future journal or conference publications and presentations.

Your personal information will not be included and will be kept confidential. A pseudonym will be used if the data of an individual is used as an example. Audio files will be destroyed after transcription is complete. Participants will be provided an opportunity to review the transcripts and provide any feedback to the researchers prior to analysis through email. The research may involve the transmission of data over the Internet. Every reasonable effort has been taken to ensure the effective use of available technology; however, confidentiality during online communication cannot be guaranteed.

Taking part is voluntary

Your involvement in the study is voluntary. Your decision to participate or to not participate will not affect your evaluation, your grades, or class standing. You may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to withdraw from the study, the information that can be identified as yours will be kept as part of the study and may continue to be analyzed, unless you make a written request to remove, return, or destroy the information.

If you have questions

The main researcher conducting this study is Jill Stefaniak, an associate professor of Learning, Design, and Technology at the University of Georgia, and Meimei Xu, a Ph.D. candidate of Learning, Design, and Technology. Please ask any questions you have for now. If you have questions later, you may contact Dr. Stefaniak at jill.stefaniak@uga.edu. You can also direct your questions to Meimei Xu, the primary point of contact for this study, at meimei.xu@uga.edu. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

APPENDIX B

Instructional Design Dynamic Decision-Making Pre-Survey

The following survey is to help us understand your instructional design and technology integration experiences. Please respond to each of the questions as accurately as possible. The data gathered from the responses will be used to examine how teachers apply dynamic decision-making while designing instruction and integrating technology.

Please indicate the following information:

1. Name:

2. Email:

3. Years of teaching experience:

Less than a year	1-2 years	3-5 years	6-10 years	11-15 years	16-20 years	More than 20 years

4. Where do you currently teach?

Elementary school	Middle school	High school

4.1. What grade level(s) do you currently teach? (A dropdown menu)

Elementary school: K, 1, 2, 3, 4, 5

Middle school: 6, 7, 8

High school: 9, 10, 11, 12

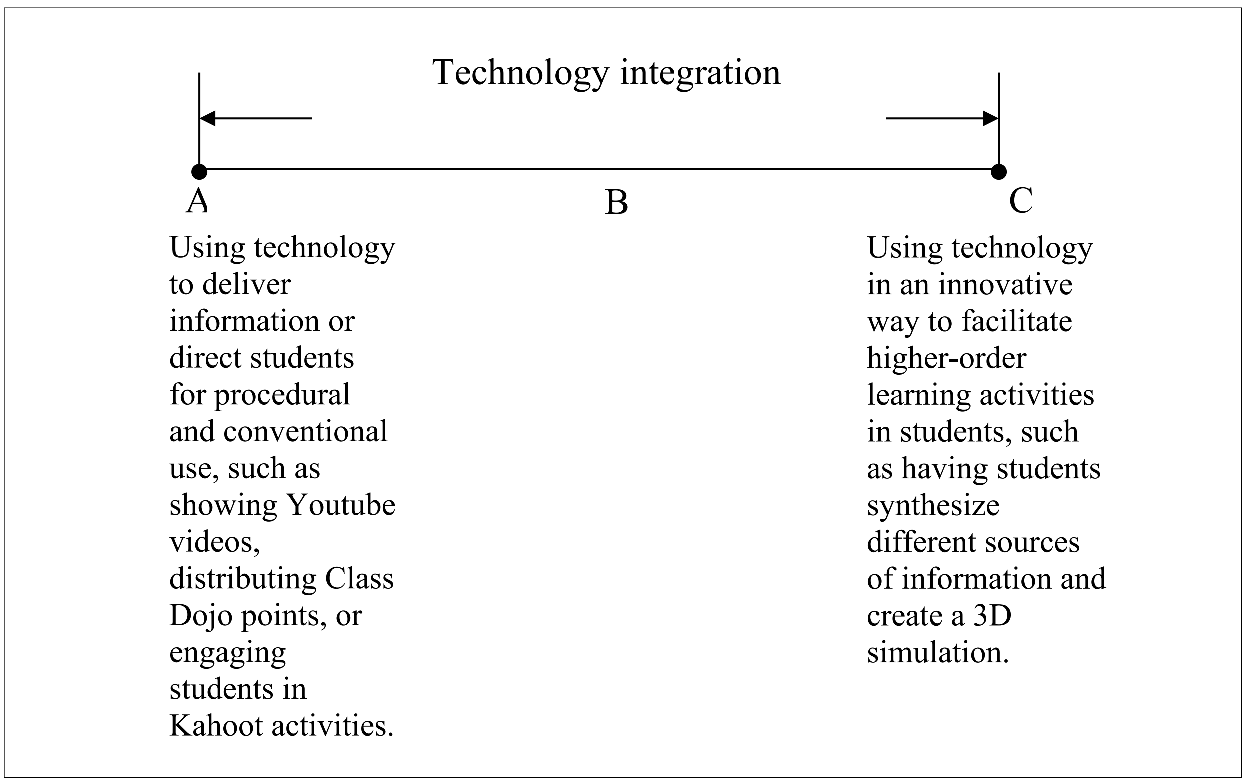
5. What grades have you taught before (including the grades you currently teach)? Please check all that apply.

K	1	2	3	4	5	6
7	8	9	10	11	12	

6. How often did you use technology in your classroom(s) (e.g., implementing teaching practices, using technology to help with classroom activities, using technology to present information, etc.)?

Never	Monthly	Weekly	Once a day	Several times a day

The spectrum below shows different levels of technology integration. Please read the descriptions below and indicate a few examples if you have integrated technology in your classrooms.



A: Please describe something you have done that as close as this: ___________________

B: Please describe something you have done that falls under in-between: ________________

C: Please describe something you have done that as close as this: ___________________

APPENDIX C

Critical Decision Method (CDM) Interview Protocol

Introduction and Permissions:

Thank you for agreeing to participate in the study. The goal of this research is to investigate how teachers apply their dynamic decision-making while designing instruction and integrating technology.

This interview is essential to help the researchers understand what factors you care about the most and what kind of decision-making processes you have experienced when you integrate technology in your instructional design. In order to maintain the integrity of the data, I would like to record the interview. Do I have your permission to record this interview? *[Pause for an answer]*

All your data will remain confidential during the research process. Neither your name and some information that indicates your identity will be kept confidential. I will point out that your quotes, anecdotes, and summarized data will probably be used in reports and publications, but they will not be linked to specific people and schools.

This interview will be one-on-one. I will only be the facilitator of the interview, so I will not judge anything that you described in the interview. No answers are wrong. Please speak freely.

1. You have indicated these technology-integrated activities you have done **in the survey (A, B, and C)**. Would you please describe more details related to these activities:

For each activity,

- Are the technology-integrated activities you described are successful experiences?
  - What subject(s) do you teach for this activity?
  - How much time did you use to plan for this activity?
  - What instructions did you provide to your students?
  - Were the students familiar with the technology?
  - Were the students familiar with the content?
  - Why did you select this technology?
  - What information did you rely on in choosing this technology? (such as learning goals, intuition, subjects, students' preferences, etc.)
  - What about that previous experience seemed relevant for this case (such as your prior experiences of using this technology)?
  - How have you approached your instructional activities using this technology?
  - Have you done anything on purpose to promote student learning?
- Have you experienced any challenges when you conducted this activity?

    - What challenges have you encountered when you conduct this activity?
    - How did you expect your students to navigate through this activity using technology?
    - What kind of adjustments have you done to make it work?
        - What did you see? What did that mean?
    - What were your specific goals and objectives at that moment?
    - What solution did you arrive at?
    - How were the results?
    - What other solutions could you have made then?
        - Would you explain why you believed [a solution] would work?
        - Why did you proceed with your final solution?
    - What did you learn from the experiences?
    - What was your overall reflection?
    - How might a novice teacher have behaved differently?
    - What training might have offered an advantage in this situation?
    - What knowledge, information, or technology tools could have helped?

About Previous Experiences:

2. Would you please tell me some other examples that you feel that are typical regarding your use of technology? *[Pause until participant has an incident in mind]*

[Remind participants to think of a time that can be a most successful or a most challenging moment]

- Are the technology-integrated activities you described are successful experiences?
    - What subject(s) do you teach for this activity?
    - How much time did you use to plan for this activity?
    - What instructions did you provide to your students?
    - Were the students familiar with the technology?
    - Were the students familiar with the content?
    - Why did you select this technology?
    - What information did you rely on in choosing this technology? (such as learning goals, intuition, subjects, students' preferences, etc.)
    - What about that previous experience seemed relevant for this case (such as your prior experiences of using this technology)?
    - How have you approached your instructional activities using this technology?
    - Have you done anything on purpose to promote student learning?
    - How did you expect your students to navigate through this activity using technology?

- What challenges have you encountered when you conduct this activity?
    - How did you expect your students to navigate through this activity using technology?
    - What kind of adjustments have you done to make it work?
        - What did you see? What did that mean?
    - What were your specific goals and objectives at that moment?
    - What solution did you arrive at?

- How were the results?
- What other solutions could you have made then?
    - Would you explain why you believed [a solution] would work?
    - Why did you proceed with your final solution?
- What did you learn from the experiences?
- What was your overall reflection?
- How might a novice teacher have behaved differently?
- What training might have offered an advantage in this situation?
- What knowledge, information, or technology tools could have helped?

3. How do you approach technology integration in general?