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A Comparison of Complex Thinking Required by the Elementary New Jersey Student Learning Standards and Past New Jersey Curriculum Standards

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Abstract

Academic learning standards define the necessary skills and knowledge that students need to master in order to become college and career ready. The best 21st century learning standards are those that provide the opportunity to develop complex thinking skills including creativity, strategic thinking, and critical thinking. The learning standards that provide an insight into complex thinking are identified as critical thinking, creativity in practice, and strategic thinking. This dissertation's intent was to examine the language of complex thinking of the newly adopted New Jersey Student Learning Standards (NJSLS) in Grades 4 & 5 mathematics as compared to the language of complex thinking of the New Jersey Core Curriculum Content Standards (NJCCCS) in Grades 4 & 5 mathematics using Webb's Depth of Knowledge module. This study aimed to reveal the extent that complex thinking skills are incorporated throughout these two specific sets of learning standards.

This study utilized mixed methods, including qualitative content analysis using Webb's Depth of Knowledge to code the learning standards in both the former New Jersey Core Curriculum Content Standards and New Jersey Student Learning Standards and descriptive statistics. Deductive category application was used to connect Webb's Depth of Knowledge framework to the existing NJSLS and NJCCCS. Each depth of knowledge level represents a specific level of cognitive complexity. The higher the DOK level of a standard, the higher level of cognitive complexity is contained within that specific standard. The higher the cognitive complexity of a standard, the more complex thinking is embedded into that standard. Each standard was rated on a 1–4 DOK level based on Webb's Depth of Knowledge methodology. To assist with reliability in coding each set of learning standards, a "double-rater read behind consensus model" was implemented as in other similar studies.

The major findings in regards to the mathematics Grades 4 & 5 NJSLS and the mathematics Grades 4 & 5 NJCCCS were compared using the DOK framework:

1. The mathematics Grades 4 & 5 NJCCCS were rated at an overall higher percentage of DOK Levels 3 and 4 than were the mathematics Grades 4 & 5 NJSLS.

2. The mathematics Grades 4 & 5 NJSLS contained a higher percentage of lower rated standards, DOK Levels 1 and 2, as compared to the mathematics Grades 4 & 5 NJCCCS.

This study suggests that more opportunities for developing complex thinking, which is essential to 21st century learning, is contained within New Jersey's older, replaced set of learning standards found in the mathematics Grades 4 & 5 NJCCCS when compared to the NJSLS adopted in 2017 mathematics Grade 4 & 5.

Dedication

What an experience this doctoral journey has been. I must admit there have been some bumps in the road, but as with anything, it is necessary to get up and continue moving. Throughout the last two years, there have been some events that I really wanted to attend, but I made the decision to research and write instead. The outcome: the completion of this work. As a result, I am confident that I will be able to lead teachers and staff to the next trajectory pedagogically.

I dedicate this dissertation to my wife, Arlenia, as well as children, Alyssa Ann and Evan Gerald. Our small family sacrificed so much to allow me the opportunity to get to the finish line. We are here…we did it, there is certainly no "I" in our team.

On October 14, 2001, I lost my mother to cancer. She was the rock in our family. As a spiritual person, I am convinced she walked next to me throughout this doctoral journey. Mom, I thank you for guiding me through this time. I love you and miss you tremendously. I am certain I have made you proud. To my dad, thank you for believing in my talent. I appreciate you more than you know. To my sisters, Kimberly and Valerie, thank you for being a constant for your little brother. Love you both immensely.

To Arlenia, you took the reins of our family for the last two years as I studied and researched. You took our children to all of their activities and provided the guidance and support they needed when I was working. I will never forget the sacrifices you made to make this possible for our family. The days that you were alone were more than we were together but I truly appreciate all you have done to keep our family intact throughout this process. I love and salute you for your unwavering tenacity. To Alyssa Ann and Evan Gerald, my two heartbeats, I love you so very much. It is important as your father for both of you to see perseverance and drive. Throughout this journey, you saw both and more. As you both grow, your mom and I will be in your corner rooting you on as the three of you did for me as I completed this doctorate.

To my dissertation committee, Dr. Tienken, the countless words of wisdom and advice given were much appreciated. There were nights when I would get up to write and I had writer's block. I would go back to an email from you and your words of encouragement made it possible for me to continue on the "dissertation road." With that being said, Dr. Tienken, I thank you for your unwavering patience and support. To Dr. Babo, as my secondary reader, your critical eye for detail provided me with another lens on this work. I eagerly awaited your feedback so the evidence of my study would be strategic for those reading it. The goal is to teach others about the critical nature of the standards and ignite learning that will impact education in local school districts. Thank you, Dr. Babo, for your support throughout the process. To Dr. Pollins, my external reader, your consistent asking how the writing was going and where I was with the research provided me with the initiative to stay the course. Not only the daily check-ins, but additionally, the advice given regarding the writing pathway was critical to the completion of this study. When we first met, I did not understand the journey called "the doctorate" until you explained to me the importance of continued learning. I am appreciative of that conversation and of all the others we had throughout this venture. To that end, Dr. Pollins, I thank you.

Table of Contents

List of Tables

List of Figures

Chapter I

Introduction

According to the Organisation for Economic Cooperation and Development (2010), changes in the labor market have increased the need for all individuals to attain higher levels of education. However, additional years of formal education might not be enough. Many advanced economies rely on people who possess skills and dispositions that transcend content knowledge and discipline-centered school subjects. Creativity, innovation, and collaboration are some skills and dispositions deemed important for the 21st century globalized economy. Skilled jobs are increasingly centered on solving unstructured problems and effectively analyzing information. In addition, artificial intelligence (AI) is increasingly substituted for manual labor and being infused into most aspects of life and work.

A recent PEW (2016) study found the number of jobs that require increased use of skills and dispositions like creative and strategic thinking rose to 90 million in 2016, up from 49 million between 1980 and 2015 (an 83% increase). Compensation has increased during the past 25 years for positions that require higher creative and strategic thinking skills. Moreover, employment in these occupations is projected to grow by more than 8% through 2024, compared to a 4.4% growth for occupations that require only low level creative and strategic thinking skills (PEW, 2016). The fastest growing jobs are projected to be those in higher paying fields (medium annual wages of $60,000+), and even they will require above-average levels of creative and strategic thinking skills, in addition to higher levels of preparation and higher analytical skills (World Economic Forum, 2015).

With so much information easily accessible via technological resources, educational aims are shifting away from the need to help students acquire cast stores of crystallized knowledge to focus instead on the ability to create, innovate, critique, evaluate, and integrate the vast amount of information now available to emerging adults (Richland & Begolli, 2016).

To be competitive in a globalized economy, students must be able to think creatively and strategically. The IBM Corporation (2012), the United States Council on Competitiveness (2012), the Institute Management Development (2012), the Organization for Economic Cooperation and Development (2013), Pink (2006), Robinson (2011), Zhao (2012), and others have identified variations of creative and/or strategic thinking they believe are important skills high school graduates need in order to access better options for college, careers, and global economic competitiveness (Tienken, 2017). Additionally, learners need to make inferences about new information or contexts, adapt their thinking in new ways, think critically, and make creative leaps of thought (Bransford, Brown, & Cocking, 1999; Genter, Holyoak, & Kokinov, 2001; Holyoak & Kokinov, 2001; National Governors Association for Best Practices, Council of Chief State School Officers, 2010; National Math Standards Panel, 2008; Next Generation Science Standards, 2013). One way government officials work to enhance economic competitiveness is through education policies that influence the types of content knowledge, skills, and dispositions public school personnel teach to students (World Economic Forum, 2015). In the United States, one policy mechanism used by federal and state governments to influence what students learn has been the imposition of state curriculum standards.

The Emergence of the New Jersey Core Curriculum Content Standards

New Jersey's first set of academic standards were adopted in 1996 and named the Core Curriculum Content Standards. According to the New Jersey Department of Education (2017), the standards described the knowledge and skills students should have acquired as a result of attending 13 years of public school.

According to the New Jersey Department of Education (2017):

> Revised every five years, the standards provide local school districts with clear and specific benchmarks for student achievement in nine content areas. Developed and reviewed by panels of teachers, administrators, parents, students, and representatives from higher education, business, and the community, the standards are influenced by national standards, research-based practice, and student needs. The standards define a "Thorough and Efficient Education" as guaranteed in 1875 by the New Jersey Constitution. Currently the standards are designed to prepare our students for college and careers by emphasizing high-level skills needed for tomorrow's world (para. 2).

Common Core State Standards. Prior to the Common Core State Standards Initiative in 2010, every state had developed and adopted its own learning standards that specified what students in Grades 3–8 and high school should be able to do as part of the mandates in the federal No Child Let Behind Act (NCLB, 2002). Every state also had its own definition of proficiency, which is the level at which a student is determined to be sufficiently educated at each grade and upon graduation as measured by mandated state standardized tests. In 2010, along with 42 other states and Washington, D.C., New Jersey voluntarily adopted the Common Core State Standards, which were developed by the National Governors Association and the Council of Chief State School Officers. The Common Core replaced the previous New Jersey Core Curriculum Content Standards for all students in Grades K–12 in English language arts and mathematics. The other seven curricular areas that comprise the NJ CCCS remained unchanged (NJDOE, 2014).

New Jersey Student Learning Standards. In 2015, under mounting national political backlash against the Common Core, former New Jersey Governor Christopher Christie instructed the New Jersey Commissioner of Education to convene a committee to revise the Common Core State Standards and rename them. Officials at the New Jersey Department of Education presented revised sets of standards to the committee for English language arts and mathematics. Committee members were asked to review the revisions. Most participants on the committee chose to review the English language arts standards, as most members were not mathematics experts. Fewer than three committee members with backgrounds in mathematics reviewed the mathematics revisions (C. Tienken, personal communication, December 4, 2017). The revisions constituted non-substantive content changes, and the NJDOE renamed the standards the New Jersey Student Learning Standards (NJSLS). In May 2016, the New Jersey School Board contended they would maintain the exact language of the CCSS in about 84% of the 1,427 math and English language arts (ELA) standards that make up New Jersey Student Learning Standards, according to the state (Clark, 2016). According to C. Tienken, about 230 standards were modified slightly, but the content remained basically the same. The most common revisions were the addition of the words "reflect" 16 times and "self-reflection" 10 times in the English language arts standards (C. Tienken, personal communication, December 4, 2017). There were 21 changes to the entire K-12 mathematics standards, and none of the changes impacted the content. Like the ELA, the changes to the mathematics standards were minor, with words or phrases like "including with the use of technology" added (C. Tienken, personal communication, December 4, 2017) and the phrase "improvised units" changed to "non-standard units" (NJDOE, 2016).

Changing the standards was widely perceived as a political tactic in advance of Christie's presidential bid. In reviewing the NJCCCS and the CCSS, some critics challenged the level of complexity and saw that the levels of cognitive complexity in the NJCCCS far surpassed those found in the CCSS (Sforza, Tienken, & Kim, 2016).

Higher-Order Thinking

In the education context, higher-order thinking has typically been defined with specific reference to the cognitive domain of Bloom's Taxonomy, a trend that is still evident in contemporary research and discourse (Barnett & Francis, 2012; Jensen, McDaniel, Woodward, & Kummer, 2014). The persistent influence of Bloom's framework most likely stems from its appealing nature and the fact that each level of cognitive sophistication, although designed to transcend specific subject matters and educational stages, can be interpreted and operationalized to suit individual contexts.

The challenge of defining "thinking skills, reasoning, critical thought, and problem solving" has been referred to as a conceptual swamp in a study by Cuban (as cited in Lewis & Smith, 1993, p. 1), and as a "century-old problem" for which "there is no well-established taxonomy or typology" (Haladyna, 1997, p. 32). Higher-order thinking skills are grounded in lower order skills such as discriminations, simple application and analysis, and cognitive strategies and are linked to prior knowledge of subject matter content (vocabulary, procedural knowledge, and reasoning patterns). According to Clark (1990), appropriate teaching strategies and learning environments facilitate the growth of higher-order thinking ability, as do student persistence, self-monitoring, and open-minded, flexible attitudes. In higher-order thinking, the path is not clear in advance, nor readily visible from any single vantage point. The process involves interpretation about uncertainty using multiple and sometimes conflicting criteria. It often yields multiple solutions, with self-regulation of thinking, to impose meaning and find structure in disorder (Clark, 1990).

As stated by Lewis and Clark (1993), higher-order thinking occurs when a person takes new information and information stored in memory and relates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. A variety of purposes can be achieved through higher-order thinking, such as deciding what to believe; deciding what to do; creating a new idea, a new object, or an artistic expression; making a prediction; and solving a non-routine problem (Lewis & Clark, 1993).

Dewey (1933) described four types of thinking, from the broadest to the most refined. The broadest type includes whatever passes through one's mind at any given moment; this sort of thinking is engaged in by everyone and is not highly valued. The second type of thinking refers to what goes beyond direct observation; this sort of thinking is a little more abstract but includes imagination and fancies that may have little to no connection with even the most implausible reality. The third type refers to a belief in what seems probable without consideration of its grounds; that is, a belief may be incoherent, may contradict facts, or may have implications that the thinker would reject if she or he stopped to consider the question more deeply. Finally, in its most refined type, thinking refers to reflective thought, and this latter sort of thinking is commonly known as higher-order thinking (Dewey, 1933). John Dewey rejected the notion that schools should focus on repetitive, rote memorization and proposed a method of "directed living" in which students would engage in real-world, practical workshops to demonstrate their knowledge through creativity and collaboration (Miettinen, 2000).

The American Society for Training and Development (2010) identified innovative thinking and action, the ability to think creatively, and the ability to generate new ideas and solutions to challenges at work "as crucial competencies and skills students will need to succeed in the global economy" (p. 13). The National Education Association (NEA) (2012), the largest public educator special interest group in the U.S., warned its members that their students will not be able to meet the varied demands of a global economy and join the 21st-century workforce unless schools prepare them with the skills to create and innovate (p. 24). The workforce is a critical component to any organization. It is the dedicated and skilled tech employees who help to ensure growth, global competitiveness, continued innovation, and economic impact for the tech sector and the country. Although there are many factors that contribute to growth and competitiveness, it is the skilled workforce that is the heart and soul of the 21st-century workforce. In addition to immediate workforce requirements, a developed pipeline of qualified and talented people must be available to all organizations and industries operating within the U.S. (CompTia, 2017).

The literature on global competitiveness and the shift to a knowledge economy reflects a conviction shared by leading corporate voices and some education officials that successful education will need to place greater emphasis on creative and strategic thinking (Tienken, 2016). Some degree of numeracy, literacy, and general knowledge is required for citizenship as well as some aspects of the least skilled jobs available in contemporary society. In addition, it is indispensable to the acquisition of the ability to gain further knowledge and the ability to turn information into knowledge. To the extent that societies fail to establish a universal standard of general education, they lay up very serious problems of social exclusion for themselves (David & Foray, 2003).

Framework for Thinking

According to Webb (1997), Depth Of Knowledge (DOK) encompasses multiple dimensions of thinking, including the:

level of cognitive complexity of information that students should be expected to know, how well they should be able to transfer knowledge to different contexts, how well they should be able to form generalizations, and how much prerequisite knowledge they must have in order to grasp ideas (p. 15).

DOK is a way to define and categorize the cognitive complexity of curriculum standards and tasks. The focus of DOK is on the cognitive complexity of required tasks or curriculum standards (Tienken, 2016).

The combination of Bloom's Taxonomy and DOK cognitive rigor forms a comprehensive structure for defining rigor, thus posing a wide range of uses at all levels of curriculum development and delivery. Understanding the branches of Bloom's Taxonomy and the more rigorous Depth of Knowledge allows for a more extensive look into the levels of complex and critical thinking embedded within the NJSLS and the NJCCSS.

Bloom's Taxonomy was created in 1948 by psychologist Benjamin Bloom and several colleagues (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). Originally developed as a method of classifying educational goals for student performance evaluation, Bloom's Taxonomy has been revised over the years and is still utilized in education today. The original intent in creating the taxonomy was to focus on three major domains of learning: cognitive, affective, and psychomotor. The cognitive domain covered "the recall or recognition of knowledge and the development of intellectual abilities and skills"; the affective domain covered "changes in interest, attitudes, and values, and the development of appreciations and adequate adjustment"; and the psychomotor domain encompassed "the manipulative or motor-skill area (Krathwohl, 2002, p. 212). Despite the creators' intent to address all three domains, Bloom's Taxonomy applies only to acquiring knowledge in the cognitive domain, which involves intellectual skill development (Krathwohl, 2002).

Hess, Jones, Carlock, and Walkup (2009) combined Bloom's taxonomy and Webb's Depth of Knowledge into a single chart called the Cognitive Rigor Matrix (CRM). The CRM defines rigor via comparisons of complex thinking. Material that requires less cognitive thinking is categorized as less rigorous, whereas material that requires more complex thinking is categorized as more rigorous. The CRM provides a comparison of varying levels or depths of knowledge applied to mathematical understanding and practices by students. Generally speaking, complex thinking increases as you go from left to right on the chart and as you go from DOK 1 to DOK 4.

Problem Statement

The New Jersey state constitution mandates that public school students receive a thorough and efficient education. The New Jersey Student Learning Standards (NJSLS) represent the content of a thorough and efficient education according to state law. The NJSLS website states, "Currently the standards are designed to prepare our students for college and careers by emphasizing high-level skills needed for tomorrow's world" (New Jersey Department of Education, 2017). Although educational policy makers continue to focus on academic rigor and a standardized education system, business leaders require students, as the future workforce, to develop creativity, strategizing complexity, adaptability, and innovation as well as analytical and problem-solving skills (Adobe, 2012; American Society for Training and Development, 2009; IBM, 2010; Kyllonen, 2012).

Public school administrators must administer the NJSLS as part of the curricular programs at their schools in order to prepare students for college and careers. However, the existing literature on the topic of complex thinking embedded within specific learning strands found in the New Jersey Student Learning Standards is limited.

As of 2018, there has been only one other study that investigated the language of complex thinking of the NJSLS and only as it related to Grades 6–8 mathematics standards as compared to previous versions of the New Jersey curriculum standards in mathematics. As a result of this lack of research, more qualitative content analysis of the cognitive complexity of the CCSS compared to the prior version of the NJCCCS is important. School administrators lack the empirical information necessary to make informed decisions about what areas, if any, in the NJSLS standards are not as complex as previously thought, and thus they might lack important information necessary to ensure quality education experiences for all students.

Purpose of this Study

The purpose for this case study with mixed methods was to describe and compare the complex thinking language embedded in the 2008 Mathematics New Jersey Core Curriculum Content Standards and the 2017 New Jersey Student Learning Standards in Grades 4 and 5.

Research Questions

The study was grounded by an overarching research question: What are the types of thinking promoted in the 2017 New Jersey Student Learning Standards in Mathematics Grades 4 & 5 compared to the 2008 New Jersey Core Curriculum Content Standards?

The following sub-questions guided the research:

1. In what way(s) does the language found in the 2017 New Jersey Student Learning Standards for Mathematics compare with the language that promotes higher-order thinking found in research literature?

2. In what way(s) does the language found in the 2008 New Jersey Core Curriculum Content Standards for Mathematics compare with the language that promotes higher-order thinking found in research literature?
3. What differences and similarities exist in the language of complex thinking between the New Jersey Core Curriculum Content Standards and the New Jersey Student Learning Standards in Mathematics for Grades 4 and 5?

Conceptual Framework for this Study

Webb's Depth of Knowledge was utilized as the conceptual framework for this qualitative analysis study (Webb, 2005). Webb's framework includes four levels of knowledge: Level 1: recall; Level 2: skills and concepts; Level 3: strategic thinking; and Level 4: extended thinking. The argument that complex thinking begins at Levels 3 and 4 is supported by the fact that the verbiage used in Levels 1 and 2 are indicative of remembering and understanding types.

The CPALMS (Collaborate, Plan, Align, Learn, Motivate, Share) study by Florida State University measured the CCSS using Webb's Depth of Knowledge. The CPALMS (2012) study provided a DOK rating to each standard as a whole, but not to sub-standards. Webb's Levels 1 and 2 were represented in the CPALMS adaptation of Webb's DOK model as low and moderate, respectively. DOK Levels 3 and 4 were collapsed into a single "high" DOK level. Despite the structural difference between the two DOK models described in Table 1, the CPALMS model was consistent with Webb's in its recognition that Levels 3 and 4 both reflected the application of strategic thinking and complex reasoning. The major difference between Levels 3 and 4 is that DOK Level 4 may represent either the application and synthesis of Level 3 knowledge and skills over an extended time period or the complex analysis of multiple concepts, issues, perspectives, or cultures, and/or any historical trends relevant to them. In either case, extended time is required for students to demonstrate Level 4 performance (CPALMS, 2012). The following table reflects an adapted version of the model.

Table 1

Levels of Depth of Knowledge

DOK Level	Title of Level
1	Recall and Reproduction
2	Skills and Concepts
3	Short-Term Strategic Thinking
4	Extended Thinking

(Webb, 2005)

As a result of this frame of thought, it was necessary that a comprehensive review of the New Jersey Student Learning Standards be conducted using Webb's Depth of Knowledge levels to ensure that they encompass complex critical thinking skills.

Significance of the Study

There have been previous studies that utilized Webb's Depth of Knowledge in order to evaluate complexity of thinking in regards to the Common Core State Standards. Webb (1997) developed a process and criteria for systematically analyzing the alignment between standards and standardized assessments. Since then, the process and criteria have demonstrated application to reviewing curricular alignment as well. This body of work offers examples of the Depth of Knowledge (DOK) model employed to analyze the cognitive expectations demanded by standards, curricular activities, and assessment tasks (Webb, 1997). The model is based upon the assumption that curricular elements may all be categorized based upon the cognitive demands required to produce an acceptable response. Each grouping of tasks reflects a different level of cognitive expectation, or depth of knowledge, required to complete the task. It should be noted that the term knowledge, as it is used here, is intended to broadly encompass all forms of knowledge (i.e. procedural, declarative, etc.).

Methodology

This study used a case study design with mixed methods and an emphasis on qualitative content analysis methods in order to compare and describe the former New Jersey Core Curriculum Content Standards in Mathematics Grades 4 and 5 and the most recent New Jersey Student Learning Standards that require students to demonstrate complexity or creativity in their thinking. Qualitative content analysis is a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns (Hsieh & Shannon, 2005). Qualitative content analysis goes beyond merely counting words or examining language intensely for the purpose of classifying a large amount of text into an efficient number of categories that represent similar meanings (Weber, 1990). The goal of content analysis is to provide knowledge and understanding of the phenomenon under study (Downe-Wamboldt, 1992, p. 314). This study aimed to equate and code the varying Depth of Knowledge levels of each mathematical standard and sub-standard of the former NJCCCS and the NJSLS for Grades 4 and 5. This was done in order to analyze and pull critical associations and conclusions. The study also used descriptive statistics to compare the percentage of standards that included language that reflected the four levels of Webb's Depth of Knowledge (DOK).

Limitations of the Study

This study was limited to two grade levels (Grades 4 and 5) due to the lack of empirical data evident in these areas. Another limitation of this study was my choice to only analyze the standards and sub-standards in mathematics for Grades 4 and 5. From this decision, additional subject area standards, standards for other grade levels, and state standards were not analyzed in this study. The results of this study were evaluated using Webb's Depth of Knowledge framework. This study examined the complexity levels found within each set of learning standards in mathematics for Grades 4 and 5, but did not assess the quality of specific learning standards encompassed within the NJCCCS or the NJSLS. Finally, this study did not examine the cognitive complexity in other state standards; it was delineated to examining the cognitive complexity as outlined within the NJCCCS and the NJSLS.

Definitions of Terms

Cognitive complexity refers to the cognitive demand associated with a particular learning standard or task based on Norman L. Webb's Depth of Knowledge (DOK) levels (Webb, 2005).

Common Core State Standards (CCSS) define what students are expected to know and be able to do. The CCSS are organized by grade level and subject area and were adopted by the state of New Jersey in 2010 (CCSS Initiative, 2017).

Higher-order thinking resists precise forms of definition (Resnick, 1987). According to Geertsen (2003), higher-order thinking is a systematic way of using the mind to confirm existing information or to search for new information using various degrees of abstraction.

Webb's Depth of Knowledge provides a vocabulary and a frame of reference when thinking about students and how they engage with the content (Webb, 2005). Depth of Knowledge offers a common language to understand "rigor," or cognitive demand, in assessments, as well as curricular units, lessons, and tasks. Webb developed four DOK levels that grow in cognitive complexity and provide educators a lens to create more cognitively engaging and challenging tasks.

The New Jersey Core Curriculum Content Standards (NJCCCS) were created by the New Jersey State Board of Education in 1996 as the framework for education in New Jersey's public schools. They clearly define what all students should know and be able to accomplish at the end of 13 years of public education. These standards were replaced by the CCCS in 2010 (NJDOE, 2017).

The New Jersey Student Learning Standards (NJSLS) were adopted in May 2016 to replace the CCCS. These standards define what students are expected to know and be able to do (NJDOE, 2017). As documented, the NJSLS are very similar to the CCSS.

Organization of Dissertation

In Chapter II, the literature review situates the study in the context of previous research and scholarly material pertaining to the critical analysis of complex thinking in the 2008 NJCCCS (New Jersey Core Curriculum Content Standards) and that of the 2017 NJSLS (New Jersey Student Learning Standards). This chapter presents a critical synthesis of empirical literature according to relevant themes or variables, justifies how the study addresses a gap or problem in the literature, and outlines the theoretical or conceptual framework of the study.

In Chapter III, the study of complex thinking evolves within a particular methodological tradition. I provide a rationale for the approach, describe the research setting and sample, and describe data collection and analysis methods. This chapter provides a detailed description of all aspects of the design and procedures of the qualitative study.

In Chapter IV, I organize and report the study's main findings, including the presentation of relevant qualitative (narrative) data.

Finally in Chapter V, I provide a summary, an overview of findings, and a conclusion, as well as recommendations for future research as it relates to policy and practice.

Chapter II

Literature Review

The purpose of this case study with mixed methods was to compare, analyze, and describe the language of complex thinking embedded within the 2008 New Jersey Core Curriculum Content Standards (NJCCCS) and the 2017 New Jersey Student Learning Standards (NJSLS) in mathematics for Grades 4 and 5. The purpose of this literature review was to critique the existing literature regarding the thinking requirements of public school curriculum standards, with a particular focus on Grades 4 and 5. The literature review also presented a review of definitions of higher-order thinking in school curriculum. Additionally, this literature review identified analyses of complex thinking in state mandated curricula standards as well as frameworks that are in alignment with the coding of learning standards.

Brookhart (2010) characterized definitions of higher-order thinking into three categories: (1) those that define higher-order thinking in terms of transfer, (2) those that define it in terms of critical thinking, and (3) those that define it in terms of problem solving (as cited in Collins, 2014). The critical thinking category includes definitions that refer to “reasonable, reflective thinking that is focused on deciding what to believe or do” (Norris & Ennis, 1989, p. 1) and “artful thinking,” which includes reasoning, questioning and investigating, observing and describing, comparing and connecting, finding complexity, and exploring viewpoints (Barahal, 2008).

Literature Search Procedures

The peer-reviewed literature selection process included the gathering of work that aligned to my theory of thought. Through consultation with several sources, I utilized the Seton Hall Library Database in order to research many online articles germane to the study. I was able to find several articles utilizing such databases as SAGE, EBSCO, and Google Scholar. In order to find articles that aligned to my theory of thought, I keyed in search terms such as higher-order thinking skills, complex thinking, New Jersey Core Curriculum Content Standards (NJCCS), New Jersey Student Learning Standards (NJSLS), and critical thinking. I focused my search on peer-reviewed literature, but I did review non-peer-reviewed literature for key words and statements that assisted with expanding definitions of complex theories of thought.

Overview of Current Literature

The overview of current literature relevant to complex and critical thinking as it relates to the former mathematics standards contained in the New Jersey Core Curriculum Content Standards and the New Jersey Student Learning Standards provided several themes. The first phase of the literature review involved the use of the keywords complex thinking, higher-order thinking, and critical thinking and resulted in an overabundance of substantial peer-reviewed articles. The literature contained explanations and claims of how the dispositions, beliefs, and skills that comprise critical thinking require epistemic cognition: how people acquire, construct, understand, and use knowledge both within and beyond the classroom (Greene, Sandoval, & Bråten, in press; Hofer & Bendixen, 2012; King & Kitchener, 1994; Kuhn, Cheney, & Weinstock, 2000). The importance of critical thinking in the realm of curriculum standards is an ongoing conversation and thus continues to be reviewed.

The second phase of the literature review was predicated on the language of complex thinking embedded within the former mathematics standards of the New Jersey Core Curriculum Content Standards in the elementary grades and those evident in the New Jersey Student Learning Standards in the area of mathematics. The literature review was narrowed to the following key indicators: 1) complex thinking, 2) higher-order thinking, and 3) critical thinking.

The articles found were then separated into two categories: non-peer-reviewed literature and peer-reviewed literature. These articles included empirical studies of critical thinking in schools and more specifically across content areas such as mathematics, English language arts, and music.

The third phase of the literature review involved investigation into Webb's Depth of Knowledge as well as a comparative look at Bloom's Taxonomy. This additional lens was used to examine levels of rigor in the NJCCCS, particularly in comparison to those of the NJSLS. Bloom's Taxonomy helps teachers formulate lessons that practice and develop thinking skills over a wide range of cognitive complexity (Bloom, 1956). Although later revised by a team of education researchers headed by Anderson and Krathwohl (2001), the overall intent of the taxonomy remains: categorize questions and activities according to their levels of abstraction. However, Bloom's Taxonomy suffers limitations when selecting test items and formulating questioning strategies because it uses verbs to differentiate taxonomy levels—many verbs appear at multiple levels and do not clearly articulate the intended complexity implied by the taxonomy.

A framework to categorize and describe thinking, Depth of Knowledge (DOK) fills this void. The resulting combination of Bloom's Taxonomy and Depth of Knowledge cognitive rigor forms a comprehensive structure for defining rigor, thus posing a wide range of uses at all levels of curriculum development and delivery. Norman Webb's Depth of Knowledge (DOK) schema has become one of the key tools educators can employ to analyze the cognitive demand (complexity) intended by the standards, curricular activities, and assessment tasks. Webb (1997) developed a process and criteria for systematically analyzing the alignment between standards and test items in standardized assessments. Since then, the process and criteria have demonstrated application to reviewing curricular alignment as well. The model categorizes assessment tasks by different levels of cognitive expectation, or depth of knowledge, required to successfully complete the task. Hess (2009) further articulated the model with content specific descriptions for use by classroom teachers and organizations conducting alignment studies.

Understanding the branches of Bloom's Taxonomy and the more rigorous Depth of Knowledge allowed for a more extensive look into the levels of complex and critical thinking embedded within the NJSLS and the NJCCSS.

Literature Inclusion Criteria

Research used in this review included:

A) Non-peer-reviewed previous dissertations on complex and higher-order thinking

B) Peer-reviewed studies published from 1999 to present that focused on complex thinking, higher-order thinking, and critical thinking

C) Classic and/or landmark studies published within the last 60 years

D) Peer-reviewed and non-peer-reviewed articles on the New Jersey Student Learning Standards and the New Jersey Common Core State Standards (both in mathematics)

E) Peer-reviewed and non-peer-reviewed sources about higher-order thinking

F) Empirical research on complex thinking

G) Non-peer-reviewed reports from think tanks and private foundations on meta cognition analysis on elementary-aged students

Methodological Issues with Existing Literature

There were several methodological issues surrounding empirical analysis, as evident within research gathered in the areas of types of thinking as well as coding versus programming within the CCSS and the NJSLS in the area of mathematics. Additionally, key terms and definitions such as creativity, complex thinking, critical thinking, and strategic thinking were unclear and ambiguous. I endeavored to provide clarity of the aforementioned terms and definitions as well as show the connections between them.

Another issue found in the empirical research was that all standards must be reviewed, not just sub-sections/standards evident within both the CCCSS and the NJSLS. Some of the research reviewed had all types of thinking embedded, yet the relevance of articles had to be determined to ensure the comparability in regards to studies involving Grades 4 and 5 mathematics in their review. Additionally, coding was evident for the major standards of the Common Core State Standards, however, not within the support or sub-standards attached to the major standards reviewed.

21st-century Skills

Within the non-peer-reviewed literature, the overall vision for 21st-century learning encompasses personalization, collaboration, communication, informal learning, productivity, and content creation as central to the competencies and skills learners are expected to develop (McLoughlin & Lee, 2008; Redecker & Punie, 2013). In addition, personal skills (initiative, resilience, responsibility, risk-taking, and creativity), social skills (teamwork, networking, empathy, and compassion), and learning skills (managing, organizing, meta-cognitive skills, and "failing forward," or altering perceptions of and response to failure) are vital to peak performance in the 21st-century workplace (Learnovation, 2009). Although many of these competencies and skills may seem modern, they "are not new, just newly important" (Silva as cited in Salas-Pilco, 2013, p.12).

According to the United National Educational, Scientific, and Cultural Organization (2015), over the last two decades no fewer than 10 international organizations and commissions, governments, private consortia, and private institutions have proposed frameworks and outlined competencies needed to address 21st-century challenges. Dede (2010) and Salas Pilco (2013) compared several frameworks to identify the evolution of themes over time and the points they have in common.

The Asia-Pacific Economic Cooperation (APEC) (2008) identified the development of 21st-century competencies among youth as a “pressing international concern” (p.12). These competencies are defined as the knowledge, skills, and attitudes necessary to be competitive in the 21st-century workforce, participate appropriately in an increasingly diverse society, use new technologies, and cope with rapidly changing workplaces. APEC (2008) defined four “overarching 21st-century competencies” that should be integrated into existing educational systems: lifelong learning, problem solving, self-management, and teamwork.

The U.S.-based Partnership for 21st-Century Skills (P21) (2007a, 2011), a coalition of business leaders and educators, proposed a framework for 21st-century learning, which identified essential competencies and skills vital for success in 21st-century work and life. These included what they call the 4Cs—communication, collaboration, critical thinking, and creativity—which are to be taught within the context of core subject areas and 21st-century themes. This framework is based on the assertion that 21st-century challenges will demand a broad skill set emphasizing core subject skills, social and cross-cultural skills, proficiency in languages other than English, and an understanding of the economic and political forces that affect societies (P21, 2007a, 2013).

The peer-reviewed literature on 21st-century skills reveal that the 21st century is quite different from the 20th in terms of the capabilities people need for work, citizenship, and self-actualization (Dede, 2009). Twenty-first-century skills are different from 20th-century skills primarily due to the emergence of very sophisticated information and communications technologies. For example, the types of work done by people—as opposed to the kinds of labor done by machines—are continually shifting as computers and telecommunications expand their capabilities to accomplish human tasks. Economists Frank Levy and Richard Murnane (2004) highlighted a crucial component of what constitutes 21st-century knowledge and skills:

> Declining portions of the labor force are engaged in jobs that consist primarily of routine cognitive work and routine manual labor—the types of tasks that are easiest to program computers to do. Growing proportions of the nation's labor force are engaged in jobs that emphasize expert thinking or complex communication—tasks that computers cannot do (p. 75).

These economists went on to explain that expert thinking involves effective pattern matching based on "detailed knowledge and metacognition, the set of skills used by the stumped expert to decide when to give up on one strategy and what to try next" (Levy & Murnane, 2004, p. 75). What a skilled physician does when all diagnostics are within normal limits but the patient is still feeling unwell is expert decision-making: inventing new problem-solving heuristics when all standard protocols have failed. "Complex communication requires the exchange of vast amounts of verbal and nonverbal information." The information flow is constantly adjusted as the communication evolves unpredictably (Levy & Munane, 2004, p. 94). A skilled teacher is an expert in complex communication, able to improvise answers and facilitate dialogue in the unpredictable, chaotic flow of classroom discussion.

Sophisticated information and communication technologies are changing the nature of perennial skills valuable throughout history, as well as creating contextual skills unique to new millennium work and citizenship (Dede, 2010). For example, collaboration is a perennial capability, always valued as a trait in workplaces across the centuries. Therefore, the fundamental worth of this suite of interpersonal skills is not unique to the 21st-century economic context. However, the degree of importance for collaborative capacity is growing in an era in which work in knowledge-based economies is increasingly accomplished by teams of people with complementary expertise and roles, as opposed to individuals doing isolated work in an industrial setting (Karoly, 2004).

According to Sizer (2007), the constructivist perspective looks at curricula experiences and development in the following way:

> The curriculum should emphasize thoroughness and depth over breadth of coverage, with an aim of developing habits of mind such as inquiring into causes, seeing from multiple perspectives, and applying learning to new situations. The curriculum should be flexible and individualized enough to allow for independent exploration. For teachers to achieve these aims, we believe that it is crucial to build professional learning communities in which they share practices and build upon one another's knowledge and skills (Fusarelli and Schoen, 2008 p. 187).

Higher-Order Thinking

There is a general understanding that as time goes by, a larger percentage of jobs require employees with higher-order thinking skills—that is, employees whose work will involve creativity, problem-solving, and critical analysis, among other skills (Ananiadou & Claro, 2009; Rimini & Spiezia, 2016). This need results from an ever-increasing interaction with technology, an endless amount of information, and the disappearance of jobs that required repetitive operations and are being taken over by robots or exported to regions where labor and production costs are lower.

Higher-level thinking is defined as “a disciplined, systematic way of using the mind to confirm existing information or to search for new information using various degrees of abstraction” (Geertsen, 2003, p. 4). According to Lewis and Smith (1993), higher-order thinking occurs when a person takes new information and information stored in their memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. According to Newman (1991), higher-order thinking is defined broadly as expanded use of the mind when a person must interpret, analyze, or manipulate information because a question needs to be answered.

Diverse skills implied by the term suggest anything from recognizing propaganda techniques to improvement of reading comprehension. The major controversies include deciding the most beneficial skills to be taught and designing productive instrumental delivery systems that promote the generalized use of these skills. Opinions differ as to what these skills are; however, most agree that problem-solving abilities or cognitive enhancement can be taught, and that higher-order thinking skills can be affected by instruction (Young, 1992 p. 47).

Both education and psychological theory recommend drawing links and making inferences about relationships among ideas, concepts, principles, and other representations. Learning through making these connections can lead to more expert-like reasoning: learners can subsequently make inferences about new information or contexts, adapt their thinking in new ways, think critically about whether insights are sensible, and make creative leaps of thought (Bransford, Brown, & Cocking, 1999; Gentner, Holyoak, & Kokinov, 2001; National Mathematics Panel, 2008; Next Generation Science Standards [NGSS], 2013). Cognitively, reasoning about relationships takes attention and support, but enables learners to transfer ideas from one context to another, make inferences, and think flexibly (Gick & Holyoak, 1983; Richland & Simms, 2015; Rittle-Johnson & Star, 2007, 2011).

There have been several hierarchies that highlight critical thinking verbiage. Although a helpful tool and the foundation for the most previous studies, Bloom's Taxonomy, developed in 1956, is viewed by educators as interactive rather than a series of discrete, hierarchical entities. The variety of skills and resulting terminologies produce an abundance of thinking skill programs that parallel Bloom's theory or some variation of the cognitive model (Young, 1992 p. 48). The revision of Bloom's Taxonomy provides a more comprehensive thinking model for students of varying levels. As a result of Bloom's Taxonomy, the emergence of such thinking that converged on this line of thought included Marzano as well as Chuska and Webb. Marzano divided his system of 21 thinking skills into the following components: focusing, information gathering, remembering, organizing, analyzing, generating, integrating, and evaluating (as cited in Grice and Jones, 1989). Furthermore, Chuska used four categories to group the 27 skills that he felt were the most important: creative or inventive skills, logical skills, experimental or creative skills, and reflective skills (as cited in Grice and Jones, 1989).

Hess, Jones, Carlock, and Walkup (2009) combined Bloom's Taxonomy and Webb's Depth of Knowledge into a single chart that is referred to as the Cognitive Rigor Matrix. The chart provides a comparison of varying levels or depths of knowledge applied to mathematical understanding and practices by students. Generally speaking, rigor increases as you move from left to right on the chart and as you move from DOK 1 to DOK 4.

From the aforementioned examples, there are many different modules that exist for critical thinking; the commonalities include reasoning, categorizing, evaluation of arguments, recognizing of assumptions, and problem solving. The basic process is knowledge through inquiry (Young, 1992, p. 48).

Today's learners encounter and must reconcile views from an increasingly complex, international, and interconnected world (OCED, 2013; The World Bank, 2011). This rapid increase in information and the ease of access to that information has led to many calls for changes to the United States' educational system, such as those outlined in the Common Core State Standards and the Next Generation Science Standards (National Governors Association Center for Best Practices, 2010; NGSS Lead States, 2013).

Critical thinking has been defined as purposeful reflecting and reasoning about what to do or believe when confronting complex issues, taking into account relevant context (Ennis, 1987). Stanovich suggested that most definitions of critical thinking include two main components (as cited in Greene & Yu, 2016). Critical thinking dispositions are relatively stable psychological factors that influence how people respond in a variety of settings. Facione suggested that inquisitiveness and intellectual honesty, among other dispositions, increase people's likelihood of thinking critically (as cited in Greene & Yu, 2016).

Some commentators on the global economy claim that today's students must not only acquire the basic knowledge and skills necessary for success in the 21st century (Anderman, Sinatra, & Gray, 2012), but they must also learn to think critically about the many complex and controversial issues of the modern world (Alexander, 2014; Bonney & Steinberg, 2011; Metzger & Flanagin, 2008; National Education Association, 2014). It is important to highlight that the complexities of thinking take time to develop. Critical thinking is not something the brain does naturally, and teaching students to think in such ways is challenging (Kahneman, 2011; Sinatra, Kienhues, & Hofer, 2014; Stanovich 2010).

Two recent meta-analyses of existing research studies shed light on how to foster critical thinking. In the first meta-analysis, Huber and Kuncel (2015) found the college experience was associated with the significant gain in general critical thinking skills and dispositions. However, they found little evidence that increasing curricular focus on general critical thinking skills would result in additional gains. Likewise, Abrami et al. (2015) found interventions targeting general critical thinking skills and dispositions were only moderately effective, but discipline-specific critical thinking interventions were more promising. The extent of uniformity between coders was also documented with regard to effect size extraction and to the coding of study features. Each effect size was coded by two raters, and two agreement rates were produced: (a) a number between 50 and 100 was assigned to each study to reflect the degree of agreement between the raters with regard to how many effect sizes should be extracted from each study, and this number was averaged across studies; and (b) a similar procedure was applied with regard to agreement as to which calculation procedures should be used to determine each effect size. The trial treatment in total lasted at least three hours. All participants were no younger than six years old (Abrami et al., 2015).

Cultivating Higher-Order Thinking

Although learning for recall requires thinking, higher-order thinking occurs when students not only acquire knowledge and skills, but also apply them to new situations. It is the kind of thinking, according to Brookhart (2010), that applies to life outside of school, where thinking is characterized by a "series of transfer opportunities rather than as a series of recall assignments to be done" (Collins, 2014).

Some researchers have investigated the art of problem-solving or analysis as a means for developing higher-order thinking skills. Metacognition, often referred to as thinking about thinking, is also a frequent topic of interest. According to the Center for Development and

Learning (CDL) (2013), a nonprofit organization dedicated to increasing success in academics, order thinking includes “concept formation, concept connection, getting the big picture, visualization, problem solving, questioning, idea generation, analytical (critical) thinking, practical thinking and creative thinking” (p. 13). One of the most important points they raise is that students need to be active learners, which is promoted by situating learning in real-world problems (Cognition and Technology Group at Vanderbilt, 1994; Collins, Brown, & Newman, 1989; Kolodner, Hmelo, & Narayanan, 1986.) According to Bruer (1993), higher-order thinking skills require a new synthesis of education and cognitive science that incorporates an extensive domain knowledge along with an appreciation of when to use that knowledge and includes metacognitive monitoring of performance needed for students to solve novel or ambiguous problems.

There are at least two key issues that go to the heart of many of the pedagogical methods that support this educational synthesis. First, all of these methods emphasize learners constructing knowledge, although educational researcher Bereiter (1994) pointed out that what students construct often represents a mastery of knowledge that is semiautonomous of their own construction. Bereiter and Scardamalia (1986) argued that individuals must learn to view knowledge as a personal artifact that can be improved by productively reflecting upon the relations between existing theory and evidence. The second method looks at the teacher as the facilitator of the learning instead of the sole proprietor of this knowledge. Learners are actively responsible for constructing their knowledge, which necessarily depends on reflective, critical thinking about that knowledge.

According to Richland and Begolli (2016), both education and psychological theory recommend drawing links and making inferences about relationships among ideas, concepts, principles, and other representations. McNeil (1992) asserted that schema theory has special relevance for teachers of reading comprehension in that it questions the traditional view that students should learn to reproduce the statements being read in the text. In contrast to this older view of reading comprehension, schema theory stresses an interactive approach that views teaching reading comprehension as a process, meaning that students are taught techniques for processing text, such as making inference, activating prior knowledge, and using critical thinking (Aloqaili, 2005a; McNeil, 1992; Orbea & Villabeitia, 2010). According to schema theory, there are no definitive or final conclusions that can be reached for the text (Norris & Phillips, 1987; Yu-hui et al., 2010). That is, schema theory deals with reading comprehension as an interactive process between readers' prior knowledge and the text being read. Sometimes readers may end up with a different understanding, based on the richness or paucity of their total previous experiences. According to Langer (1992), posing questions that ask students to share and discuss their environments can support them through a difficult piece (p. 42). Questions must be developed in order to focus on the unique role in students' intellectual development of their critical and creative thinking abilities (Langer, 1992). Therefore, a reader with a rich background will comprehend better than one who has a poorer background. In short, schema theory believes in open text or context. The interpretation is relative (Aloqaili, 2005b).

Learning through making these connections can lead to more expert-like reasoning: learners can subsequently make inferences about new information or contexts, adapt their thinking in new ways, think critically about whether insights are sensible, and make creative leaps of thought (Bransford, Brown, & Cocking, 1999; Getner, Holyoak, & Kokinov, 2001; National Mathematics Panel, 2008; Next Generation Science Standards, 2013).

Students in problem-based curricula are more likely to use their knowledge during problem-solving and to transfer higher-order thinking to new situations (DeGrave, Boshuizen, & Schmidt, 1996; Hmelo, 1995; Hmelo & Cote, 1996). Curricula should be organized so that all students are helped to examine and explore various ideas and relationships. Teachers can engage students in what they predict will be challenging problems, guide their manipulation of information to solve them, and support their efforts (Newmann, 1988). In critical thinking, being able to think means students can apply wise judgment or produce a reasoned critique. The goal of teaching is then to equip students to be wise by guiding them toward how to make sound decisions and exercise reasoned judgment. The skills students need to be taught to do this include: the ability to judge the credibility of a source; identify assumptions, generalization, and bias; identify connotation in language use; understand the purpose of a written or spoken text; identify the audience; and make critical judgments about the relative effectiveness of various strategies used to meet the purpose of the text (Collins, 2014).

The challenge of defining "thinking skills, reasoning, critical thought, and problem-solving" has been referred to as a conceptual swamp in a study by Cuban (as cited in Lewis & Smith, 1993, p. 1), and as a "century-old problem" for which "there is no well-established taxonomy or typology" (Haladyna, 1997, p. 32). Higher-order thinking skills are grounded in lower-order skills such as discrimination, simple application and analysis, and cognitive strategies and linked to prior knowledge of subject matter content (vocabulary, procedural knowledge, and reasoning patterns). Appropriate teaching strategies and learning environments facilitate the growth of higher-order thinking ability, as do student persistence, self-monitoring, and open-minded, flexible attitudes. In higher-order thinking, the path is not clear in advance, nor readily visible from any single vantage point. The process involves interpretation about uncertainty using multiple and sometimes conflicting criteria. It often yields multiple solutions, with self-regulation of thinking to impose meaning and find structure in disorder (Clarke, 1990). The higher-order thinking process and its value are best described by Lewis and Smith (1993):

> Higher-order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. A variety of purposes can be achieved through higher-order thinking…deciding what to believe; deciding what to do; creating a new idea, a new object, or an artistic expression; making a prediction; and solving a non-routine problem (p. 136).

Brookhart (2010) identified definitions of higher-order thinking as falling into three categories: (1) those that define higher-order thinking in terms of transfer, (2) those that define it in terms of critical thinking, and (3) those that define it in terms of problem solving.

Though thinking skills are not actually as separate as individual building blocks, scholars and researchers often use such metaphors. Nonetheless, mastery of content and lower-order thinking are particularly important prerequisites to higher-order thinking. According to Gagné, Briggs, and Wager (1988):

> Any lesser degree of learning of prerequisites will result in puzzlement, delay, inefficient trial and error at best, and in failure, frustration, or termination of effort toward further learning at the worst. Lesson planning which utilizes the hierarchy of intellectual skills may also provide for diagnosis of learning difficulties (p. 222).

Brookhart (2010) argued that if teachers think of higher-order thinking as problem solving, they can set lesson goals to teach students how to identify and solve problems at school and in life. This, she says, involves not just solving problems set by the teacher but solving new problems that "they define themselves, creating something new as the solution" (Collins, 2014).

Situations, skills, and outcomes are the components that challenge the individual to engage in higher-order thinking. Some interpretations might have placed metacognitive thinking as part of the connecting network. The contemporary concept of metacognition actually comes from Sternberg's Triarchic Theory of Intelligence (as cited in Crowl et al., 1997). This theory includes the components of thinking, approaches to experiences, and context of responses to problem-solving situations. The three parts of the triarchic theory are the componential aspect, the experiential aspect, and the contextual aspect.

Metacognitive strategies are complex. They include problem-finding, defined by Bruner as a task requiring the location of incompleteness, anomaly, trouble, inequity, and contradiction (as cited in Gagné, Briggs, & Wager, 1988). They link problem-finding and creativity through activities of planning, self-monitoring of progress, and self-adjustments to problem-solving strategies (Sternberg & Lubart, 1995, p. 276; Young, 1997).

Creative Thinking

Creativity can be learned (Hokanson, 2006; Karpova et al., 2011; Scott et al., 2004). Creativity is a result of cognitive development wherein individuals gain knowledge and the capability to logically think and organize information (Hirschman, 1980). Individuals are induced to learn and reason by being exposed to diverse environmental stimuli, and schools are one of the major sources of environmental stimuli (Hirschman, 1980). The educational setting can encourage the creativity of students by providing a cultural context and social norms that promote creativity. Reflecting this perspective and the emphasis on interrelationships among creativity of different levels (Hennessey & Amabile, 2010), the creative problem-solving course was developed. The working definition used to define the creativity to be developed is small ‘c’ creativity, that is, “daily problem-solving and the ability to adapt to change” (Hennessey & Amabile, 2010, p. 572).

Definitions of creativity have developed and evolved over several decades and have encompassed (a) concepts of the creative process or the mental routines that are operative in creating ideas, (b) the creative person when he or she demonstrates certain creative characteristics in personality, traits, attitudes, or behaviors, (c) the creative product or tangible object, and (d) the creative environment that fosters the creative person (Cropley, 2000; McIntyre, Hite, & Rickard, 2003; Warr & O’Neill, 2005). While a conclusive definition of creativity is elusive, its importance is undeniable. Creative thinking has been linked to well-being and successful adaptation to the demands of daily life (Cropley, 1990; Reiter-Palmon, Mumford, & Threlfall, 1998). Creative ideas are invaluable contributions one can make to an organization (Brabbs, 2001) and are the ultimate source of all intellectual property (Farnham, 1994). Moreover, creativity is stressed as a necessary requirement for U.S. prosperity and security by the National Science Foundation (National Academy of Engineering, 2006; Schunn, Paulus, Cagan, & Wood, 2006). The plethora of political, economic, and social challenges experienced on a global scale in the 21st century necessitates new creative solutions.

It has been recognized that decision making in business frequently requires unconventional thinking to solve problems with limited information and resources and that creative problem-solving skills are critical in such circumstances (Butler, 2010). There is evidence that creativity and problem solving are closely related. Highly creative people are good at problem solving, and problem-solving capability has been used to measure creativity of individuals in the past (Hirschman, 1980). Sternberg (2006) described the investment theory of creativity as the ability of creative people to buy low and sell high in the realm of ideas. Buying low means pursuing ideas that are unknown or out of favor but have growth potential. When presented, these ideas often encounter resistance. The creative individual perseveres and eventually sells high, moving on to the next new or unpopular idea. Particularly in retail, researchers have noted the importance of finding a balance between having a strong customer service orientation and the need to be innovative (Merlo, Bell, Menguc, & Whitwell, 2006).

According to Hennessey and Amabile (2010), educational observers increasingly worry about the need to educate for the 21st century. Students, they argue, need to gain not only basic reading and writing skills and knowledge across the disciplines but also core competencies in critical thinking, creativity and innovation, problem solving, communication, and collaboration. The global workforce needs to be schooled in both ways of thinking and ways of working (Saavedra & Opfer, 2012). Educational practices that seem to promote learning may inadvertently suppress creativity, for the same reasons that environmental circumstances can suppress any habit (Sternberg & Williams, 1996). The result can be a stultifying of creativity in development (Russ & Fiorelli, 2010). These practices often take away the opportunities for, encouragement of, and rewards for creativity (Beghetto, 2010; Smith & Smith, 2010).

In the creativity-fostering classroom, teachers generate and maintain a climate in which creative thinkers are respected, students tolerate new ideas, conformity is not imposed, and diversity in ideas is encouraged and appreciated (Cropley, 2006). Teachers can improve creative thinking in students by providing choices, rewarding different ideas and products, encouraging sensible risks, and emphasizing students' strengths and interests (De Souza Fleith, 2000; Kaufman & Sternberg, 2007). With increasing diversity in the classroom, teachers can utilize the positive aspects of cultural diversity that can benefit all students and make efforts to promote creative problem solving and idea generation among students (Leung, Maddux, Galinsky, & Chiu, 2008).

Fortunately there are theories specifically of creative potential which lend themselves to practical application (Helson, 1996; Runco, 2003; Smith, 1999). Consider, for example, the idea that creative thinking reflects the original interpretation of experience (Runco, 1996). Each of us has the capacity to construct original interpretations, and if it is a useful and original interpretation, it qualifies as creative. That is how creativity is typically defined, as both useful and original (Barron, 1955; Runco, 1988).

According to Runco (2008), that should apply to interpretations and ideas, just as it does to observable products. There may be no manifest product with such a focus on interpretations, but what is important is to define creativity such that it is independent of a product. The Hierarchical Framework for the Study of Creativity distinguishes between creative performance and creative potential. According to Runco (2007), the hierarchical structure is apparent because the first of these has two subcategories, namely products and persuasion. These both assume that there is an actual manifest creative performance. The second category includes person, process, and press. They do not require manifest performance, though they may lead to it; hence the idea of potential. Press was included in the original framework (Rhodes, 1961/87), but by and large was replaced by place. One of the specific suggestions of the hierarchical theory is that both are needed. Press was a concept used by Murray (1938) and others, the key idea being that there are pressures (or influences) on our behavior. That is certainly true of creative behavior, and these may include places or environments. But some are not strictly environmental. Some are more general than that (e.g., cultural and historical forces, including those tied to Zeitgeist) (Runco, 2006; Simonton, 1994).

Table 2

Hierarchical Frame for the Study of Creativity

Indicators of Creative Potential	Creative Potential	Indicators of Creative Performance	Creative Performance
Person	Personality	Products	Inventions Ideas
Process	Cognitive Social-Historical	Persuasion	Systems
Press	Distal Evolution Zeitgeist Culture Immediate (Place)	Interactions	P x E State x Trait

(Rhodes, 1961; Runco, 2007)

Table 2 separates creative potential from creative performance. The indicators within each creative trajectory separate potential from actual performance. Runco (2008) implies that if the environment supports potential, creative behavior is almost certain to manifest itself. Research on the creative process complements research on creative persons. There may be processes used by creative individuals that are not used as frequently by less creative individuals. A person may have the capacity for creative ideation but not use it.

The Common Core State Standards

The public school crisis momentum created by *A Nation at Risk* during the Reagan administration hurtled itself into the first Bush administration and resulted in a clarion call by the president for "national performance goals" (Bush, 1989). According to Tienken (2017), just as presidents before him had done, George H. W. Bush used his statement to draw a straight line that connected performance-guarantee standards to economic security and national security through an increasing use of the doctrine of specificity. The president went on to describe seven areas that national performance goals should address:

> By performance we mean goals that will, if achieved, guarantee that we are internationally competitive, such as goals related to: (a) the readiness of children to start school; (b) the performance of students on international achievement tests, especially in math and science; (c) the reduction of the dropout rate and the improvement of academic performance, especially among at-risk students; (d) the functional literacy of adult Americans; (e) the level of training necessary to guarantee a competitive workforce; (f) the supply of qualified teachers and up-to-date technology; and (g) the establishment of safe, disciplined, and drug-free schools (p.12).

The seven areas identified by Bush at the Education Summit eventually become a centerpiece of the president's State of the Union address on January 31, 1990. By then, the areas had morphed into six specific goals to be achieved by 2000:

> By the year 2000, every child must start school ready to learn. The United States must increase the high school graduation rate to no less than 90 percent. And we are going to make sure our schools' diplomas mean something. In critical subjects at the 4th, 8th, and 12th grades we must assess our students' performance. By the year 2000, U.S. students must be first in the world in math and science achievement (Bush, 1990, para.1).

In the 1990s, the Standards & Accountability Movement began in the U.S., as states began (a) outlining what students were expected to know and be able to do at each grade level, and (b) implementing assessments designed to measure whether students were meeting the standards. As part of this education reform movement, the nation's governors and corporate leaders founded Achieve, Inc. in 1996 as a bipartisan organization to raise academic standards and graduation requirements, improve assessments, and strengthen accountability in all 50 states

(Achieve, 2011). The initial motivation for the development of the Common Core State Standards was part of the American Diploma Project (ADP) (Hess, 2013).

A 2004 report, titled *Ready or Not: Creating a High School Diploma That Counts*, found that both employers and colleges are demanding more of high school graduates than in the past (Achieve, 2004). According to Achieve (2004), "current high-school exit expectations fall well short of employer and college demands" (p. 3). The report explained that the major problem facing the American school system was that high school graduates were not provided with the skills and knowledge they needed to succeed in college and careers. "While students and their parents may still believe that the diploma reflects adequate preparation for the intellectual demands of adult life, in reality it falls far short of this common-sense goal" (Achieve, 2004, p. 9). The report said that the diploma itself lost its value because graduates could not compete successfully beyond high school, and that the solution to this problem is a common set of rigorous standards (Achieve, 2017).

In 2009, the NGA convened a group of people to work on developing the standards. Announced on June 1, 2009, the initiative's stated purpose was to "provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them" (Common Core State Standards Initiative, 2013, para. 1). Additionally, "The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers," which should place American students in a position in which they can compete in a global economy (Common Core State Standards Initiative, 2013, p. 1).

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According to Supovitz and McGuinn (2017), there were opponents as well as proponents of the implementation of the Common Core. Additionally, both sides provided different perspectives regarding the implementation. Several of the interest groups reported spending a lot of time correcting or counteracting what they saw as misinformation or myths about the standards. The CCSSO, Achieve, the National PTA, and the Foundation for Excellence in Education all said that they tracked and corrected myths about the standards for their members. Interviewees, however, lamented that information could not fight ideology very effectively, and CCSS opponents often relied on passionate rhetorical arguments rather than debate the standards on their merits.

Standards are chosen by reformers as a lever to catalyze change because they are connected to so many different areas of education and have implications for so many aspects of the education system, including funding, curriculum, assessment, and the organization of instructional time. Ironically, these very reasons also created the opportunity for opponents of reform to attack the implications of the reform rather than the reform itself. The diverse set of opponents of the CCSS took advantage of these many connections to successfully redefine the issue of educational standards and connect it to a variety of hot-button issues that brought together a disparate coalition of opposition (McGuinn & Supovitz, 2016; Supovitz, Daly, & Del

Fresno, 2015).

Common arguments against the Common Core standards are that: (a) they amount to a defacto national curriculum, (b) they may actually be lower than existing state standards, and (c) little evidence exists that the Common Core will improve student learning (Ujifusa, 2013, p. 1). Furthermore, poverty affects a child's ability to make full use of the new teaching approaches and resources offered by Common Core (C. Tienken, personal communication, December 4, 2017). According to Tienken:

> Merely dumping resources on a school serving impoverished students won't solve the achievement gap because it's not an achievement gap. A lot of it has to do with life experiences they have prior to school. When you have a group of kids out and about and exposed to different things, they generally have large sight vocabularies and learn to read at an earlier age due to larger site vocabularies and general life experiences (personal communication, December 4, 2017).

Many have argued that the CCSS cleverly tried to skirt this deep-rooted dilemma by positioning itself as a state-led effort (McDermott, 2012; McDonnell & Weatherford, 2013). However, this was compromised by federal incentives for standards adoption under RTTT and the funding of the CCSS-aligned test consortia.

Another temporal factor that had an influence on the dynamics surrounding the CCSS movement was the shadow extending from the previous high-stakes testing era of the NCLB legislation of 2001. Even though the CCSS were a renewed effort at creating standards, albeit with associated and aligned assessments, a lot of backlash against the CCSS came from those who felt that high-stakes testing was too dominant in the education system and who viewed the CCSS era as a further extension of testing and accountability (Supovitz & McGuinn, 2017).

It is important to note that the Common Core State Standards are not state standards. They're national standards, created by Gates-funded consultants for the National Governors Association (NGA). They were designed, in part, to circumvent federal restrictions on the adoption of a national curriculum, hence the insertion of the word "state" in the brand name. States were coerced into adopting the Common Core by requirements attached to the federal Race to the Top grants and, later, the No Child Left Behind waivers (Rethinking Schools, 2013). Over 170 organizations, education-related and corporations alike, have pledged their support to the initiative. Yet the evidence presented by its developers, the National Governors Association (NGA) and Council of Chief State School Officers (CCSSO), seems lacking compared to the independent reviews and the available research on the topic that suggest the CCSS and those who support them are misguided.

The standards have not been validated empirically, and no metric has been set to monitor the intended and unintended consequences they will have on the education system and children (Mathis, 2010). Yet most of the nation's governors, state education leaders, and many education organizations remain committed to the initiative. In addition, the standards themselves and the exams that accompany them have not proven to be a catalyst for these vital skills (Tienken & Zhao, 2010). In May 2015, then Governor Christopher Christie of New Jersey was one of the latest governors to criticize the Common Core State Standards. As of school year 2017-2018, districts across the state have moved to the New Jersey Student Learning Standards that are based on the Common Core State Standards.

The Emergence of the New Jersey Students Learning Standards

According to the New Jersey Department of Education (2017), for more than a decade, research studies of mathematics education in high-performing countries have concluded that mathematics education in the United States must become substantially more focused and coherent in order to improve mathematics achievement in this country. To deliver on this promise, the mathematics standards are designed to address the problem of a curriculum that is a mile wide and an inch deep.

Officials at the NJDOE (2017) claim that the standards draw on research and the most important international models for mathematical practice. They endeavor to follow the design envisioned by William Schmidt and Richard Houang (2002) by not only stressing conceptual understanding of key ideas, but also by continually returning to organizing principles (coherence) such as place value and the laws of arithmetic to structure those ideas.

In addition, the "sequence of topics and performances" that is outlined in a body of math standards must respect what is already known about how students learn (NJDOE, 2017). As Confrey (2007) pointed out, developing "sequenced obstacles and challenges for students…absent the insights about meaning that derive from careful study of learning, would be unfortunate and unwise" (NJSLS, 2017, para 3). Therefore, the development of the standards began with research-based learning progressions detailing what is known today about how students' mathematical knowledge, skill, and understanding develop over time.

The New Jersey Student Learning Standards replaced the Common Core State Standards in classrooms across the state as of school year 2017-2018. According to the NJDOE (2017), the New Jersey Student Learning Standards include Preschool Teaching and Learning Standards, as well as nine K-12 standards for the following content areas:

- 21st-century Life and Careers
- Comprehensive Health and Physical Education
- English Language Arts

- Mathematics
- Science
- Social Studies

In May 2016, the State Board of Education approved renaming the curriculum standards for preschool through Grade 12 from the Core Curriculum Content Standards to the New Jersey Student Learning Standards. This term change affected 32 policies in the Critical Policy Reference Manual (CPRM) (NJDOE, 2017).

According to Neff, (2016), some of the changes, though, are more substantial. For instance, English standards have been altered to de-emphasize the close reading of unfamiliar texts (a favorite approach in Common Core). Instead, the proposal calls for more emphasis on background knowledge and context when reading texts. Several English standards have also been shifted to new grade levels. Almost all significant changes are to English standards, while math is almost entirely unchanged, save for some adjustments to wording (Neff, 2016).

New Jersey maintained about 84% of the 1,427 math and English language arts (ELA) standards that made up Common Core, according to the state. About 230 standards were modified slightly, but the content remained basically the same. The most common revisions were the addition of the words "reflect" 16 times and "self-reflection" 10 times in the English language arts standards (C. Tienken, personal communication, December 4, 2017). There were 21 changes to the entire K-12 mathematics standards, and none of the changes impacted the content. Like the ELA, the changes were minor with words or phrases like "including with the use of technology" added.

Table 3

K-12 English Language Arts Revisions

Grade Level	Standard	Revised Standard
3	RL.3.10. By the end of the year, read and comprehend literature, including stories, dramas, and poetry, at the high end of the Grades 2–3 text complexity band independently and proficiently.	RL.3.10. By the end of the year, read and comprehend literature, including stories, dramas, and **poems at grade level text complexity or above, with scaffolding as needed.**
4	RL.4.9. Compare and contrast the treatment of similar themes and topics (e.g., opposition of good and evil) and patterns of events (e.g., the quest) in stories, myths, and traditional literature from different cultures.	RL.4.9. (previously RL.5.9.) Compare, contrast **and reflect on (e.g., practical knowledge, historical/cultural context, and background knowledge) stories in the same genre (e.g., mysteries and adventure stories) on their approaches to similar themes and topics.**
6	RL.6.10. By the end of the year, read and comprehend literature, including stories, dramas, and poems, in the Grades 6–8 text complexity band proficiently, with scaffolding as needed at the high end of the range.	RL.6.10. By the end of the year, read and comprehend literature, including stories, dramas, and poems **at grade level text complexity or above, scaffolding as needed.**
9-10	RL.9-10.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	RL.9-10.1. Cite strong and thorough textual evidence **and make relevant connections** to support analysis of what the text says explicitly as well as inferentially, **including determining where the text leaves matters uncertain.**
11-12	RL.11-12.7. Analyze multiple interpretations of a story, drama, or poem (e.g., recorded or live production of a play or recorded novel or poetry), evaluating how each version interprets the source text. (Include at least one play by Shakespeare and one play by an American dramatist.)	RL.11-12.7. Analyze multiple interpretations of a story, drama, or poem (e.g., recorded or live production of a play or recorded novel or poetry), evaluating how each version interprets the source text. **(e.g., Shakespeare and other authors.)**

*Revisions are in **BOLD** (NJDOE, 2017)

Table 4

K-12 Mathematics Revisions

Grade Level	Standard	Revised Standard
K	K.OA.A.1. Represent addition and subtraction with objects, fingers, mental images, sounds (e.g., claps), acting out situations, verbal explanations, expressions, or equations.	K.OA.A.1. Represent addition and subtraction **up to 10** with objects, fingers, mental images, **drawings**, sounds (e.g., claps), acting out situations, verbal explanations, expressions, or equations.
4	4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...*	4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm, **mm**; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...*
7	7.NS.A.1a Describe situations in which opposite quantities combine to make 0. *For example, a hydrogen atom has 0 charges because its two constituents are oppositely charged.*	7.NS.A.1a Describe situations in which opposite quantities combine to make 0. *For example,* ***In the first round of a game, Maria scored 20 points. In the second round of the same game, she lost 20 points. What is her score at the end of the second round?***
8	8.G.A.1 Verify experimentally the properties of rotations, reflections, and translations. a. Lines are taken to lines and line segments to line segments of the same length b. Angles are taken to angles of the same measure c. Parallel lines are taken to parallel lines	8.G.A.1 Verify experimentally the properties of rotations, reflections, and translations. a. Lines are **transformed** to lines and line segments to line segments of the same length b. Angles are **transformed** to angles of the same measure c. Parallel lines are **transformed** to parallel lines

Table 4 (continued)

Grade Level	Standard	Revision
HS	F.BF.B.5 (+) Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.	F.BF.B.5 (+) **Use** the inverse relationship between exponents and logarithms to solve problems involving **exponents and logarithms.**
HS	A.SSE.B.4 Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. *For example, calculate mortgage payments*	A.SSE.B.4 Derive **and/or explain the derivation of the** formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. *For example, calculate mortgage payments*

*Revisions are in **BOLD** (NJDOE, 2017)

Notably, the standards leave enough of Common Core in place that the committee recommended the state keep using standardized tests produced by the Partnership for Assessment of Readiness for College and Careers (PARCC)—a multi-state consortium creating Common Core-aligned tests that has endured much backlash (Neff, 2016). It is suggested that the content of the NJSLS is the same as the CCSS because students are still responsible for taking the PARCC Assessment.

Although the former governor of New Jersey, Chris Christie, stated the need to revise the standards to align them closely with the needs of students in this state, advocates that support the Common Core have stated common education standards are essential for producing the educated work force America needs to remain globally competitive (Common Core State Standards Initiative, 2017). This voluntary state-led effort will help ensure that all students can receive the college and career-ready, world-class education they deserve, no matter where they live (Common Core State Standards Initiative, 2017). Another supporter, Janet B. Bray, Executive

Director, Association for Career and Technical Education of the Common Core, pointed out that the K-12 standards work recognizes that students in the United States are now competing in an international environment and will need to meet international benchmarks to remain relevant in today's workplace (Common Core State Standards Initiative, 2017).

According to the U.S. Department of Education, (2013), the Common Core State Standards emerged from what was known as No Child Left Behind. In 2002, NCLB was passed with overwhelming bipartisan support and presented as a way to close long-standing gaps in academic performance. NCLB marked a change in federal education policy—away from its historic role as a promoter of access and equity through support for things like school integration, extra funding for high-poverty schools, and services for students with special needs, to a much less equitable set of mandates around standards and testing, closing or reconstituting schools, and replacing school staff.

NCLB required State Boards of Education to adopt statewide curriculum standards and to test students annually to gauge progress toward reaching the standards. Under threat of losing federal funds, all 50 states adopted or revised their standards and began testing every student, every year, in every grade from 3–8 and again in high school (U.S. Department of Education, 2013). The professed goal was to make sure every student was on grade level in math and language arts by requiring schools to reach 100% passing rates on state tests for every student in 10 subgroups (U.S. Department of Education, 2013).

According to Karp (2017), by the time the first decade of NCLB was over, more than half the schools in the nation were on the lists of failing schools, and the rest were poised to follow. As 2014 approached, however, the results of NCLB for stimulating improvement in student achievement to meet the espoused goal were mixed (Dee & Jacob, 2011; Goertz, 2005; Hess & Petrilli, 2009; Mintrop & Sunderman, 2009; Nichols & Berliner, 2007; Pruitt & Bowers, 2014). According to Karp (2014), in Massachusetts, which is generally considered to have the toughest state standards in the nation, arguably more demanding than the Common Core, 80% of the schools were facing NCLB sanctions. This is when the NCLB waivers appeared. The bipartisan coalition that passed NCLB had collapsed, and gridlock in Congress made revising it impossible. U.S. Education Secretary Arne Duncan, with dubious legal justification, made up a process to grant NCLB waivers to states that agreed to certain conditions.

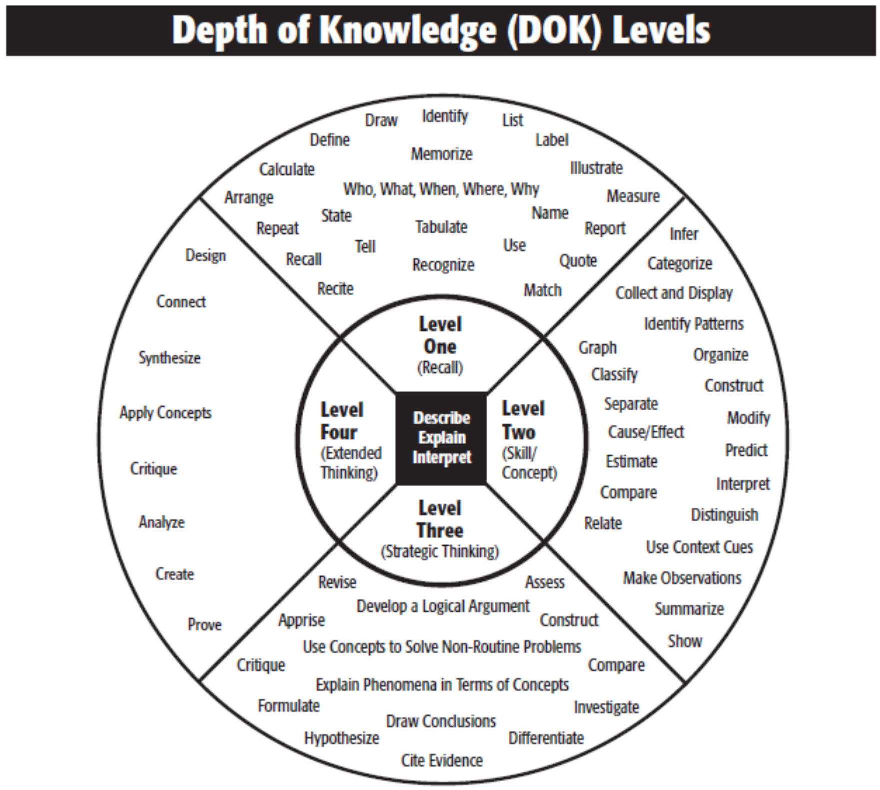
According to Karp (2017), 40 states were granted conditional waivers from NCLB; if they agreed to tighten the screws on the most struggling schools serving the highest needs students, they could ease up on the rest, provided they also agreed to use test scores to evaluate all their teachers, expand the reach of charter schools, and adopt college and career-ready curriculum standards. These same requirements were part of the Race to the Top program, which turned federal education funds into competitive grants and promoted the same policies, even though they have no track record of success as school improvement strategies (Karp, 2017).

Depth of Knowledge

Depth of Knowledge (DOK) forms another important perspective of cognitive complexity. The best known work in this area, that of Norman Webb (1997, 1999), compelled states to rethink the meaning of test alignment to include both the content assessed in a test item and the depth to which we expect students to demonstrate understanding of that content. In other words, the complexity of both the content (e.g., interpreting literal versus figurative language) and the required task (e.g., solving routine versus non-routine problems) both define each DOK level shown in Table 1.

Although related through their natural ties to the complexity of thought, Bloom's Taxonomy and Webb's DOK model differ in scope and application. Bloom's Taxonomy categorizes the cognitive skills required of the brain when faced with a new task, therefore describing the type of thinking processes necessary to answer a question. The DOK model, on the other hand, relates more closely to the depth of content understanding and scope of a learning activity, which manifests in the skills required to complete the task from inception to finale (e.g., planning, researching, drawing conclusions).

Today, interpreting and assigning intended DOK levels to both the standards and the related assessment items form critical components of any alignment analysis. Educators have applied Webb's DOK levels across all content areas (Hess, 2004, 2005a, 2005b, 2006a, 2006b; Petit & Hess, 2006). Many states and districts employ DOK to designate the depth and complexity of state standards to align the state's large-scale assessments or to revise existing standards to achieve higher cognitive levels for instruction. Consequently, teachers need to develop the ability to design instruction and create units of curriculum and classroom assessments for a greater range of cognitive demand.



Level One Activities	Level Two Activities	Level Three Activities	Level Four Activities
Recall elements and details of story structure, such as sequence of events, character, plot and setting. Conduct basic mathematical calculations. Label locations on a map. Represent in words or diagrams a scientific concept or relationship. Perform routine procedures like measuring length or using punctuation marks correctly. Describe the features of a place or people.	Identify and summarize the major events in a narrative. Use context cues to identify the meaning of unfamiliar words. Solve routine multiple-step problems. Describe the cause/effect of a particular event. Identify patterns in events or behavior. Formulate a routine problem given data and conditions. Organize, represent and interpret data.	Support ideas with details and examples. Use voice appropriate to the purpose and audience. Identify research questions and design investigations for a scientific problem. Develop a scientific model for a complex situation. Determine the author's purpose and describe how it affects the interpretation of a reading selection. Apply a concept in other contexts.	Conduct a project that requires specifying a problem, designing and conducting an experiment, analyzing its data, and reporting results/ solutions. Apply mathematical model to illuminate a problem or situation. Analyze and synthesize information from multiple sources. Describe and illustrate how common themes are found across texts from different cultures. Design a mathematical model to inform and solve a practical or abstract situation.

Figure 1. Webb's Depth of Knowledge (Webb, 2005)

Related Studies

Content standards are concise, written descriptions of what students are expected to know and be able to do at a specific stage of their education. Content standards describe educational objectives (i.e., what students should have learned by the end of a course, grade level, or grade span), but they do not describe any particular teaching practice**,** curriculum, or assessment method (although this is a source of ongoing confusion and debate).

According to the Great School Partnership (2014), in each subject area, standards are typically organized by grade level or grade span. Consequently, they may be called grade-level expectations or grade-level standards, and the sequencing of standards across grades or stages of academic progress is called a learning progression (although terminology may vary from place to place). Learning progressions map out a specific sequence of knowledge and skills that students are expected to learn as they progress through their education. There are two main characteristics of learning progressions: (1) the standards described at each level are intended to address the specific learning needs and abilities of students at a particular stage of their intellectual, emotional, social, and physical development, and (2) the standards reflect clearly articulated sequences—that is, each grade-level learning expectation builds upon previous expectations while preparing students for more challenging concepts and more sophisticated coursework at the next level. The basic idea is to make sure that students are learning age-appropriate material (knowledge and skills that are neither too advanced nor too rudimentary), and that teachers are sequencing learning effectively or avoiding the inadvertent repetition of material that was taught in earlier grades (Great Schools Partnership, 2014).

With the content standards already established not only in New Jersey but nationwide, there has been a charge to evaluate and analyze varying learning standards utilizing Webb's Depth of Knowledge levels in order to determine the complex thinking within specific standards.

CPALMS (Collaborate, Plan, Align, Learn, and Share). Based at Florida State University, the CPALMS (2014) study utilized Webb's Depth of Knowledge in order to measure cognitive complexity within the standards. As a structure for identifying the alignment of the cognitive demands that standards and corresponding assessment place on learners, Florida's original three-level model of low, moderate, and high DOK has served the state well since its implementation in 2004. Although the state's three-level model continues to be a useful framework for assessing DOK, particularly for the purposes of assessment, now to make it advisable to draw finer distinctions among the levels of complexity that are called for in the text of an individual standard or instructional unit.

Cognitive complexity relates specifically to the cognitive demands that can be inferred from the language of a content standard. Context complexity differs from cognitive complexity in that it includes factors such as prior knowledge, processing of concepts and skills, sophistication, number of parts, and application of content structure required to meet an expectation or attain an outcome (CPALMS, 2014).

CPALMS (2014) coordinated the development of common definitions of using Dr. Norman Webb's model for Depth of Knowledge. Common definitions were developed for English language arts, mathematics, science, social studies, and health education. Additionally, CPALMS hosted a workshop in July of 2012 to determine the content complexity ratings for the mathematics and ELA standards. A team of curriculum developers, researchers, subject area experts, and teachers from around the state were involved in this event. Professional development was provided to all participants by a team of leading cognitive experts including Dr. Norman Webb. Webb's Levels 1 and 2 were represented in Florida's adaptation of Webb's DOK model as low and moderate, respectively. DOK Levels 3 and 4 were collapsed into a single, "high" DOK level. Florida is now adopting Webb's four-level DOK model of content complexity as a means of classifying the cognitive demand presented by standards and curriculum (CPALMS, 2014).

Webb's DOK levels form an important perspective of cognitive complexity (Webb, 1997, 2002). Webb (2005) describes his DOK framework as nominative rather than as a taxonomy.

DOK levels name four different ways students interact with content and moves from lower- to higher-order thinking in this manner: DOK 1=Recall, DOK 2=Skills and Concepts, DOK 3=Strategic Thinking, and DOK 4=Extended Thinking (Niebling, 2012). Each level indicates how deeply students understand and engage with the content in order to respond, not simply the type of thinking used. The Webb levels do not necessarily indicate degree of difficulty, in that Level 1 can ask students to recall or restate either simple information or complex, more difficult information. Conversely, deeper understanding of a concept is required to be able to explain how and why a concept works (DOK 2), apply it to real-world phenomena with justification and supporting evidence (DOK 3), or to integrate one concept with other concepts or other perspectives (DOK 4) to produce novel ideas or solutions.

Smarter Balance Assessment Consortium. New state standards are challenging students to understand subject matter more deeply, think more critically, and apply their learning to the real world (Smarter Balanced, 2017). In the Smarter Balance Assessment Consortium, to measure these new state standards, educators from Smarter Balanced states worked to develop new, high-quality assessments in English language arts and mathematics for Grades 3–8 and high school (Smarter Balanced, 2017).

Sato et al.'s (2011) study was a descriptive alignment study of the Common Core State Standards (CCCS,) intended to determine which content was eligible for the Smarter Balance Assessment Consortium's end-of-year summative assessment for English language arts (ELA) and mathematics in Grades 3–8 and high school. The high school standards analyzed were those for Grades 9–10 and 11–12 for ELA and all conceptual categories in mathematics.

According to Sato et al. (2011), the organization of the standards in the CCSS differs between ELA and mathematics, both in the way the content was categorized (e.g., by strand, domain, or conceptual category) and across grade levels/spans (ELA has cross-grade College and Career Readiness Anchor Standards, whereas mathematics standards are organized on domains that vary across grade levels/spans according to grade-appropriate content). The results of the study were organized and presented in a manner consistent with the organization of each content area in the CCSS (Sato et al., 2011).

Sato et al. (2011) asserted the pattern for DOK levels is similar for all standards across eligible standards. Across all grade levels, with the majority of standards coded to DOK Level 2 decreasing slightly and the standards coded to DOK 3 increasingly slightly from the elementary grades to the secondary grades. Standards coded to DOK Level 4 increased from Grades 3 to 6, and became constant between Grades 7 and 9–10, rising slightly at Grades 11–12. Standards coded to DOK Level 1 followed the reverse pattern, decreasing from Grades 3 through 5, and remaining about the same at Grades 6 through 12 (Sato et al., 2011).

According to Sato et al. (2011), in the area of mathematics across all grade levels and conceptual categories, the majority of standards were coded at DOK Level 1 and/or Level 2. In Grade 7, Grade 8, and especially the high school conceptual category of geometry, a notable number of standards were also coded to Level 3. One standard in geometry was coded to Level 4 (Sato et al., 2011).

Iowa Core Literacy and Mathematics Standards. The Iowa Core Standards for Literacy and Mathematics play a central role in defining what teachers teach in Iowa. The standards define the topical, procedural, and conceptual knowledge students must learn, as well as the type of thinking in which they must engage. This is known as cognitive demand or cognitive complexity. In other words, the standards require teachers to provide students with instructional experiences that not only address the topical, procedural, and conceptual knowledge in the standards, but the type of thinking called for by the standards as well (Iowa Department of Education, 2012). Compelling evidence suggests that when teachers align their instruction to an assessment, students perform better on that assessment. However, the impact of alignment is only detectable when both topical/conceptual knowledge and cognitive complexity are taken into consideration (Gamoran, Porter, Smithson, & White, 1997).

The Iowa Core Standards for Literacy and Mathematics have been coded for cognitive complexity using Webb's Depth of Knowledge (DOK) approach (Webb, 2005). The DOK called for in each standard reflects the complexity of the standard, not its difficulty. The topical/conceptual knowledge detailed in a standard will be more or less difficult for each student, but requires a consistent level of complexity across students. The DOK of a standard describes the type of work students are most commonly required to perform to demonstrate their attainment of the standard.

Niebling's (2012) study attempted to obtain cognitive complexity/demand codes for the Iowa Core Standards in Literacy and Mathematics that could be imported into the Iowa Curriculum Alignment Toolkit (ICAT). Webb's Depth of Knowledge framework was used to assign cognitive complexity/demand dimension codes to the Iowa standards. The number and percentage of English language arts standards at DOK Level 1 decreased as grade level increased, while the number and percentage of standards at DOK Levels 2 and 3 increased as grade level increased. For mathematics Grades K-2, the decrease in DOK Level 1 standards and increase in DOK Level 2 across Grades K-2 was less dramatic than in the literacy standards. There appears to be an increase in both the number and percentage of standards at DOK Level 3 for Grade 1, but a decrease for both kindergarten and Grade 2. Though the results for mathematics are harder to interpret than those for English language arts, there does seem to be a general trend in both content areas of increasing cognitive rigor as students get older (Niebling, 2012).

According to Niebling (2012), there were 48 Iowa-specific standards added to English language arts across all grade levels/spans, and 10 for mathematics. Most of the Iowa-specific additions to the English language arts standards were at DOK Levels 2 and 3, with fewer at DOK Level 1 and none at DOK Level 4. Most of the Iowa-specific additions to the mathematics standards were at DOK Levels 2 and 3, with fewer at DOK Level 1 and none at DOK Level 4 (Niebling, 2012).

In general, there appears to be an increase in cognitive complexity/demand across Grades K-12 for both literacy and mathematics, though the pattern is much harder to detect in mathematics after Grade 2. Furthermore, there does appear to be a leveling off in terms of increase of cognitive complexity/demand in literacy after Grade 6. Finally, whereas there is a general increase in the number and percentage of DOK Level 4 standards starting in Grade 3 in literacy, there is only one DOK Level 4 standard in the entire set of mathematics standards, in high school geometry (Niebling, 2012).

Other Cognitive Frameworks

Bloom's Taxonomy. In 1956, a group of educational psychologists headed by Benjamin Bloom developed a classification of levels of intellectual behavior important in learning. Bloom created this taxonomy for categorizing the levels of abstraction of questions that commonly occur in educational settings (Hess, Carlock, Jones & Walkup, 2009). Bloom saw the original taxonomy as more than a measurement tool. He believed it could serve as a common language about learning goals to facilitate communication across persons, subject matter, and grade levels; a basis for determining for a particular course or curriculum the specific meaning of broad educational goals, such as those found in the currently prevalent national, state, and local standards; a means for determining the congruence of educational objectives, activities, and assessments in a unit, course, or curriculum; and a panorama of the range of educational possibilities against which the limited breadth and depth of any particular educational course or curriculum could be contrasted (Bloom, 1956).

The original taxonomy provided carefully developed definitions for each of the six major categories in the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. Bloom (1956) defined these categories in the following way:

> Knowledge: Remembering or retrieving previously learned material.
>
> Comprehension: The ability to grasp or construct meaning from material.
>
> Application: The ability to use learned material, or to implement material in new concrete situations.
>
> Analysis: The ability to break down or distinguish the parts of material into components so that its organizational structure may be better understood.
>
> Synthesis: The ability to put parts together to form a coherent or unique new whole.
>
> Evaluation: The ability to judge, check, and even critique the value of material for a given purpose (p. 2).

Using these levels for analysis, Bloom found that over 95% of test questions students encounter at the college level required them to think only at the lowest possible level: the recall of information (Hess et al., 2009). Bloom's committee identified three domains of educational activities: cognitive (knowledge), affective (attitude), and psychomotor (skills). Within the cognitive domain, which is tied directly to mental skills, Bloom identified a hierarchy of six levels that increased in complexity and abstraction from the simple recall of facts—knowledge—

to the highest order of thinking—evaluation (Bloom, 1956). In practice, educators assigned Bloom's Taxonomy levels according to the main action verb associated with a level in the taxonomy. For example, examining the meaning of a metaphor and categorizing geometric shapes would both align to the analysis level of Bloom's Taxonomy. While educators have found such verb cues of Bloom's Taxonomy levels to be useful in guiding teacher questioning, verbs often appear at more than one level in the taxonomy (e.g., appraise, compare, explain, select, write), and often the verb alone is inadequate for determining the actual cognitive demand required to understand the content addressed in a test question or learning activity (see Figure 1) (Hess et al., 2009).

Bloom's Taxonomy Revision 2001. Building upon Bloom's early work, many educational and cognitive psychologists have since developed various schemas to describe the cognitive demand for different learning and assessment contexts. In 2001, Anderson and Krathwohl presented a structure for rethinking Bloom's Taxonomy. Whereas the original taxonomy possessed one dimension, the revised taxonomy table applied two dimensions: cognitive processes and knowledge. The cognitive processes resemble those found in the original taxonomy, but placement on the taxonomy continuum has changed slightly (e.g., evaluation no longer resides at the highest level) and descriptions have been expanded and better differentiated for analyzing educational objectives (Anderson & Krathwohl, 2001). According to Wilson (2016), Bloom's revised taxonomy breaks down the cognitive domain as follows:

> Remembering: Recognizing or recalling knowledge from memory.
>
> Understanding: Constructing meaning from different types of functions, be they written or graphic messages or activities like interpreting, exemplifying, classifying, summarizing, inferring, comparing, or explaining.

Applying: Carrying out or using a procedure through executing or implementing. Applying relates to or refers to situations where learned material is used through products like models, presentations, interviews, or simulations.

Analyzing: Breaking materials or concepts into parts, determining how the parts relate to one another or how they interrelate, or how the parts relate to an overall structure or purpose.

Evaluating: Making judgments based on criteria and standards through checking and critiquing. Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation. In the newer taxonomy, evaluating comes before creating as it is often a necessary part of the precursory behavior before one creates something.

Creating: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. Creating requires users to put parts together in a new way, or synthesize parts into something new and different, creating a new form or product (para. 6.).

The revised descriptors consider both the processes (the verbs) and the knowledge (the nouns) used to articulate educational objectives This restructuring of the original taxonomy recognizes the importance of the interaction between the content taught characterized by factual, conceptual, procedural, and metacognitive knowledge and the thought processes used to demonstrate learning (Anderson & Krathwohl, 2001).

Table 5

A Comparison of Descriptors: Bloom's Original Taxonomy and the Revised Bloom's Taxonomy Cognitive Process Dimensions

Bloom's Taxonomy (1956)	**The Revised Bloom Process Dimensions** (2001)
Knowledge Define, duplicate, label, list, memorize, name, order, recognize, relate, recall, reproduce, state	**Remember** Retrieve knowledge from long-term memory, recognize, recall, locate, identify
Comprehension Classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate	**Understand** Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion (such as from examples given), predict, compare/contrast, match like ideas, explain, construct models (e.g., cause-effect)
Application Apply, choose, demonstrate, dramatize, employ, illustrate, interpret, practice, schedule, sketch, solve, use, write	**Apply** Carry out or use a procedure in a given situation; carry out (apply to a familiar task), or use (apply) to an unfamiliar task
Analysis Analyze, appraise, calculate, categorize, compare, criticize, discriminate, distinguish, examine, experiment, explain	**Analyze** Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, find coherence, deconstruct (e.g., for bias or point of view)
Synthesis Rearrange, assemble, collect, compose, create, design, develop, formulate, manage, organize, plan, propose, set up, write	**Evaluate** Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique
Evaluation Appraise, argue, assess, choose, compare, defend, estimate, explain, judge, predict, rate, core, select, support, value, evaluate	**Create** Put elements together to form a coherent whole, reorganize elements into new patterns/structures, generate, hypothesize, design, plan, construct, produce for a specific purpose

(Anderson & Krathwohl, 2001; Bloom, 1956)

Bloom's Taxonomy encompasses both higher order as well as lower order levels of thinking. Bloom's Revised Taxonomy not only improved the usability of it by using action words, but also added a cognitive and knowledge matrix. While Bloom's original cognitive taxonomy did mention three levels of knowledge or products that could be processed, they were not discussed very much and remained one-dimensional. The three levels of knowledge are:

- Factual-The basic elements students must know to be acquainted with a discipline or solve problems.
- Conceptual-The interrelationships among the basic elements within a larger structure that enable them to function together.
- Procedural-How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods (Bloom).

In Krathwohl and Anderson's (2001) revised version, the authors combined the cognitive processes with the above aforementioned levels of knowledge to form a matrix. In addition, they added another level of knowledge, metacognition, which is knowledge of cognition in general, as well as awareness and knowledge of one's own cognition (Anderson & Krathwohl, 2001).

Though they do not provide the level of complexity that will shape my study on higher-order thinking acquisition, the original Bloom's Taxonomy and revised version from Anderson and Krathwohl provide an insight on cognitive processing and thinking. Additionally, though Webb's Depth of Knowledge provides the framework for this study, Marzano's Thinking Skills Framework and Hess' Cognitive Rigor Matrix have areas of complex thinking that can be useful to consider.

Marzano's Thinking Skills Framework. Robert Marzano (2000), respected educational researcher, has proposed what he calls *The New Taxonomy of Educational Objectives*. Developed to respond to the shortcomings of the widely used Bloom's Taxonomy and the current environment of standards-based instruction, Marzano's (2000) model of thinking skills incorporates a wider range of factors that affect how learners think and provides a more research-based theory to help teachers improve their learners' thinking.

Marzano's Taxonomy was made up of three systems—the self-system, the metacognitive system, and the cognitive system—as well as the knowledge domain, all of which are important for thinking and learning. When faced with the option of starting a new task, the self-system decides whether to continue the current behavior or engage in the new activity; the metacognitive system sets goals and keeps track of how well they are being achieved; the cognitive system processes all the necessary information, and the knowledge domain provides the content.

Marzano's Knowledge Domain. According to Marzano (2000), traditionally, the focus of most teaching and learning has been on the component of knowledge. Learners were assumed to need a significant amount of knowledge before they could think seriously about a subject. Unfortunately, in conventional classrooms, teaching rarely moved beyond the accumulation of knowledge, leaving learners with a mental file cabinet full of facts, most of which are quickly forgotten after the final test (Marzano, 2000).

Knowledge is a critical factor in thinking. Without sufficient information about the subject being learned, the other systems have very little to work with and are unable to engineer the learning process successfully. A high-powered automobile with all the latest technological features still needs some kind of fuel to fill its purpose. Knowledge is the fuel that powers the thinking process.

Marzano (2000) identified three categories of knowledge: information, mental procedures, and physical procedures. Simply put, information is the "what" of knowledge and procedures are the "how-to." Information consists of organizing ideas, such as principles, generalizations, and details, such as vocabulary terms and facts. Principles and generalizations are important because they allow us to store more information with less effort by placing concepts into categories. For example, a person may never have heard of an akbash, but once someone knows that the animal is a dog, he knows quite a bit about it (Marzano, 2000).

According to Marzano (2000), mental procedures can range from complex processes, such as writing a research essay, to simpler tasks such as tactics, algorithms, and single rules. Tactics, like reading a map, consist of a set of activities that do not need to be performed in any particular order. Algorithms, like computing long division, follow a strict order that does not vary by situation. Single rules, such as those covering capitalization, are applied individually to specific instances (Marzano, 2000).

According to Marzano (2000), the degree to which physical procedures figure into learning varies greatly by subject/learning area. The physical requirements necessary for reading may consist of no more than left-to-right eye movement and the minimal coordination needed to turn a page. On the other hand, physical and vocational education may require extensive and sophisticated physical processes, such as playing tennis or building a piece of furniture. Contributing factors to effective physical processing include strength, balance, manual dexterity, and overall speed of movement. Many of the activities that learners enjoy in their leisure time, such as sports or electronic game playing, require refined physical procedures (Marzano, 2000).

Cognitive system. According to Marzano (2000), the mental processes in the cognitive system take action from the knowledge domain. These processes give people access to the information and procedures in their memory and help them manipulate and use this knowledge. Marzano (2000) breaks the cognitive system down into four components: knowledge retrieval, comprehension, analysis, and knowledge utilization. Each process is composed of all the previous processes. Comprehension, for example, requires knowledge retrieval; analysis requires comprehension, and so on (Marzano, 2000).

Knowledge retrieval. Marzano (2000) compares knowledge retrieval to the knowledge component of Bloom's Taxonomy, in that it involves recalling information from permanent memory. At this level of understanding, learners are merely calling up facts, sequences, or processes exactly as they have been stored (Marzano, 2000).

Comprehension. According to Marzano (2000), at a higher level, comprehension requires identifying what is important to remember and placing that information into appropriate categories. Therefore, the first skill of comprehension, synthesis, requires the identification of the most important components of the concept and the deletion of any that are insignificant or extraneous. Through representation, information is organized in categories that make it more efficient to find and use. Graphic organizers, such as maps and charts, encourage this cognitive process. Interactive thinking tools such as the Visual Ranking Tool, which allows learners to compare their evaluations with others, the Seeing Reason Tool, which helps learners develop maps of systems, and the Showing Evidence Tool, which supports the creation of good arguments, also serve the purpose of representing knowledge (Marzano, 2000).

Analysis. Marzano (2000) identified analysis as more complex than simple comprehension. Analysis includes five cognitive processes: matching, classifying, error analysis, generalizing, and specifying. By engaging in these processes, learners can use what they are learning to create new insights and invent ways of using what they have learned in new situations (Marzano, 2000).

Knowledge utilization. The final level of the cognitive process addresses the use of knowledge. Marzano (2000) asserted the processes of using knowledge are especially important components of thinking for project-based learning since they include processes used by people when they want to accomplish a specific task. Decision making is a cognitive process that involves the weighing of options to determine the most appropriate course of action. Problem solving occurs when an obstacle is encountered on the way to achieving a goal. Sub-skills for this process include identification and analysis of the problem (Marzano, 2000).

Metacognitive system. According to Marzano (2000), the metacognitive system is the "mission control" of the thinking process and regulates all the other systems. This system sets goals and makes decisions about which information is necessary and which cognitive processes best suit the goal. It then monitors the processes and makes changes as necessary. For example, a senior phase learner who is contributing to a virtual museum about different rocks first establishes the goals of what his/her webpage will communicate and what it will look like. Then he/she chooses what strategies he/she will use to find out what he/she needs to know in order to create the page. As he/she implements the strategies, he/she monitors how well they are working, changing, or modifying how he/she is working in order to complete the task successfully (Marzano, 2000). Research on metacognition, particularly in literacy and mathematics, makes a convincing case that instruction and support in the control and regulation of thinking processes can have a strong impact on achievement (Paris, Wasik, & Turner, 1991; Schoenfeld, 1992).

Hess' Cognitive Rigor Matrix. Karin Hess' quest for a better and more sophisticated interpretation of cognitive rigor began in 2005 when she first combined two existing models for describing rigor and deeper learning that were widely accepted in the fields of education and assessment in the United States. Although related through their natural ties to the complexity of thought, Bloom's thinking levels and Webb's Depth of Knowledge levels differ in scope, application, and intent (Hess, Jones, Carlock, & Walkup, 2009). The result of this early thinking was the Hess Cognitive Rigor Matrix (CRM), a model that superimposed Bloom's Taxonomy with Norman Webb's Depth of Knowledge levels. The Hess CRM assists teachers in applying what cognitive rigor might look like in the classroom and guides test developers in designing test items and performance tasks. Content-specific descriptors in each of the Hess CRMs are used to categorize and plan for various levels of abstraction, meaning an analysis of the mental processing required of assessment questions and learning tasks (Hess et al., 2009).

Hess' Cognitive Rigor Matrix provides a comparison of varying levels or depths of knowledge applied to mathematical understanding and practices by students. Generally speaking, rigor increases as you go from left to right on the chart and as you go from DOK 1 to DOK 4. The Cognitive Rigor Matrix from Hess et al. (2009) shows student and teacher roles for each DOK level along with question stems that generally fit with that level.

Hess' Cognitive Rigor Matrix & Curricular Examples: Applying Webb's Depth-of-Knowledge Levels to Bloom's Cognitive Process Dimensions - *ELA*

Revised Bloom's Taxonomy	**Webb's DOK Level 1** **Recall & Reproduction**	**Webb's DOK Level 2** **Skills & Concepts**	**Webb's DOK Level 3** **Strategic Thinking/ Reasoning**	**Webb's DOK Level 4** **Extended Thinking**
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	○ Recall, recognize, or locate basic facts, details, events, or ideas explicit in texts ○ Read words orally in connected text with fluency & accuracy			
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion), predict, compare/contrast, match like ideas, explain, construct models	○ Identify or describe literary elements (characters, setting, sequence, etc.) ○ Select appropriate words when intended meaning/definition is clearly evident ○ Describe/explain who, what, where, when, or how ○ Define/describe facts, details, terms, principles ○ Write simple sentences	○ Specify, explain, show relationships; explain why, cause-effect ○ Give non-examples/examples ○ Summarize results, concepts, ideas ○ Make basic inferences or logical predictions from data or texts ○ Identify main ideas or accurate generalizations of texts ○ Locate information to support explicit-implicit central ideas	○ Explain, generalize, or connect ideas using supporting evidence (quote, example, text reference) ○ Identify/ make inferences about explicit or implicit themes ○ Describe how word choice, point of view, or bias may affect the readers' interpretation of a text ○ Write multi-paragraph composition for specific purpose, focus, voice, tone, & audience	○ Explain how concepts or ideas specifically relate to *other* content domains or concepts ○ Develop generalizations of the results obtained or strategies used and apply them to new problem situations
Apply Carry out or use a procedure in a given situation; carry out (apply to a familiar task), or use (apply) to an unfamiliar task	○ Use language structure (pre/suffix) or word relationships (synonym/antonym) to determine meaning of words ○ Apply rules or resources to edit spelling, grammar, punctuation, conventions, word use ○ Apply basic formats for documenting sources	○ Use context to identify the meaning of words/phrases ○ Obtain and interpret information using text features ○ Develop a text that may be limited to one paragraph ○ Apply simple organizational structures (paragraph, sentence types) in writing	○ Apply a concept in a new context ○ Revise final draft for meaning or progression of ideas ○ Apply internal consistency of text organization and structure to composing a full composition ○ Apply word choice, point of view, style to impact readers' /viewers' interpretation of a text	○ Illustrate how multiple themes (historical, geographic, social) may be interrelated ○ Select or devise an approach among many alternatives to research a novel problem
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, find coherence, deconstruct (e.g., for bias or point of view)	○ Identify whether specific information is contained in graphic representations (e.g., map, chart, table, graph, T-chart, diagram) or text features (e.g., headings, subheadings, captions) ○ Decide which text structure is appropriate to audience and purpose	○ Categorize/compare literary elements, terms, facts/details, events ○ Identify use of literary devices ○ Analyze format, organization, & internal text structure (signal words, transitions, semantic cues) of different texts ○ Distinguish: relevant-irrelevant information; fact/opinion ○ Identify characteristic text features; distinguish between texts, genres	○ Analyze information within data sets or texts ○ Analyze interrelationships among concepts, issues, problems ○ Analyze or interpret author's craft (literary devices, viewpoint, or potential bias) to create or critique a text ○ Use reasoning, planning, and evidence to support inferences	○ Analyze multiple sources of evidence, or multiple works by the same author, or across genres, time periods, themes ○ Analyze complex/abstract themes, perspectives, concepts ○ Gather, analyze, and organize multiple information sources ○ Analyze discourse styles
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique			○ Cite evidence and develop a logical argument for conjectures ○ Describe, compare, and contrast solution methods ○ Verify reasonableness of results ○ Justify or critique conclusions drawn	○ Evaluate relevancy, accuracy, & completeness of information from multiple sources ○ Apply understanding in a novel way, provide argument or justification for the application
Create Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, produce	Brainstorm ideas, concepts, problems, or perspectives related to a topic or concept	○ Generate conjectures or hypotheses based on observations or prior knowledge and experience	○ Synthesize information within one source or text ○ Develop a complex model for a given situation ○ Develop an alternative solution	○ Synthesize information across multiple sources or texts ○ Articulate a new voice, alternate theme, new knowledge or perspective

Figure 2. Hess' Cognitive Rigor Matrix (Hess et al., 2009)

According to Hess et al. (2009), the intended DOK level can be assigned to anything from an instructional question to broader course objectives and assessment items/tasks using the following guidelines:

- The DOK level assigned should reflect the level of work students are most commonly required to perform in order for the response to be deemed proficient, such as in rubric descriptions describing proficient performance.
- The DOK level should reflect the complexity of cognitive processes demanded by the learning or assessment objective and task rather than its difficulty. Ultimately, the DOK level describes the depth of understanding required by a task, not whether or not the task is considered "difficult."
- If there is a question regarding which of two levels a standard addresses, such as Level l–Level 2, or Level 2–Level 3, it is appropriate to assign the highest level as the "DOK ceiling" for the task, but also provide opportunities at the lower DOK levels as an instructional progression (e.g., summarizing a text/DOK 2 before analyzing a text/DOK 3; making observations/DOK 2 before conducting investigation/DOK 3) (Hess, 2009).
- The DOK level should be assigned based upon the cognitive demand (mental processing) required by the central performance described in the objective or task.
- The task's or objective's central verb(s) alone is/are not sufficient to assign a DOK level. Developers must consider "what comes after verb"—the complexity of the task and content/concepts—in addition to the mental processing required by the requirements set forth in the objective (Hess, 2009 p. 3).

Blank, Porter, and Smithson's Surveys of Enacted Curriculum. A partnership among researchers at the Council of Chief State School Officers (CCSSO) and the Wisconsin Center for

Education Research, Blank, Porter, and Smithson (2001), developed a practical research tool for collecting consistent, reliable data on math and science instruction based on teacher reports. The data from the Surveys of Enacted Curriculum (SEC) gave states, districts, and schools an objective method of analyzing teaching practices and teachers' professional development in relation to content standards and system goals for improvement (Blank, 2002). This approach does not rely on direct comparison of assessments or assessment items with objectives or standards. Instead, it employs a two-dimensional framework defining content at the intersections of topics and cognitive demands (Porter, 2002).

According to Blank et al. (2001), the expectations for students in mathematics have the following cognitive operational definitions:

- Memorization of Facts: At this level students are able to recite mathematics facts, recall mathematical terms and computational procedures.
- Communicate Understanding of Mathematical Concepts: At this level students use representations to model mathematical ideas, explain findings and results from data analysis, and develop or explain relationships between concepts.
- Performing of Procedures: At this level students will use numbers to count, order, and denote. Additionally, students will follow procedures or directions.
- Conjecturing, Generalizing and Prove: At this level students will determine the truth of a mathematical pattern or proposition. Additionally, they will write formal and informal proofs. They will recognize, generate, and create patterns.
- Solving of Non-Routine Problems or Making Connections: At this level students will apply and adapt a variety of strategies, apply mathematics in contexts outside of mathematics, and synthesize content and ideas from several sources (p. 104).

The CCSSO (2001) used the Survey of Enacted Curriculum (SEC) in order to conduct an alignment study in which the Common Core State Standards were compared to those of varying state standards. Thirty-five specialists in the field were identified, including those who were able to code and analyze standards. It was proven in this study that the SEC was a powerful tool when it came to alignment of standards, though not all states were a part of the study. Additionally, summative ratings for all states under each area of the framework were identified (memorize, perform procedures, demonstrate understanding, conjecture, solve non-routine problems). In New Jersey, only Grades 3 and 8 were studied, aligning the CCSS and the NJCCCS. It is important to note that English language arts was not a part of the study (CCSSO, 2001).

Another study by Porter et al. (2011) compared the rigor of the Common Core State Standards in the area of mathematics (CCSSM) to various state-level standard documents using the Surveys of Enacted Curriculum, attending to topics covered at each grade level, and to categories of cognitive demand (memorize, perform procedures, demonstrate understanding, conjecture, solve non-routine problems). This study found that the CCSSM represented a modest shift toward higher levels of cognitive demand as compared to the state-level standards, but that the state-level standards, when looked at individually, included major inconsistencies from state to state, with some being highly correlated and some showing low correlations. It is important to note that complex thinking within a specific set of standards was not analyzed utilizing the SEC (Porter et al., 2011).

According to Porter et al. (2011), the primary purpose of the SEC data set is to support conversations among teachers about instructional practice and content. The SEC provides an objective method for educators to analyze the degree of alignment (or consistency) between current instruction and state content standards and assessments. By examining the congruence and incongruence of content and cognitive demand between standards and assessments, standards and curriculum, and assessments and curriculum, practitioners can begin to have more meaningful discussions about the connections that exist.

This study is within the scope of examining complex thinking, though it falls short when looking at complex thinking. Looking at the research thus far, Webb's Depth of Knowledge has been used more frequently than the SEC. Additionally, the SEC examines the difficulty of the curriculum standards, not the complexity of a specific set of curriculum standards, which is what my study intends to analyze.

Yuan and Le's Deeper Learning Initiative: RAND Corporation. Rand Education, a unit of the Rand Corporation, conducted the Deeper Learning Initiative for the William and Flora Hewlett Foundation (Yuan & Le, 2012). The William and Flora Hewlett Foundation's Education Program was initiated in 2010. The primary focus of this initiative was on student mastery of core academic content and their development of deeper learning skills. Examples of these deeper learning skills include critical thinking, problem solving, collaboration, communication, and learn-how-to-learn skills (Yuan & Le, 2012, p. iii). The goal of this study was to look strategically at United States students and their assessment patterns. Additionally, Yuan and Le (2012) sought to determine how the assessments as well as curriculum emphasize deeper learning skills, thus making these skills a vital component of the school culture.

Yuan and Le (2012) chose 17 states that had state assessments in Grades 3–8 as well as Grade 11. The core subjects of interest were English language arts and mathematics. Unfortunately the state of New Jersey was not included in the study. Yuan and Le (2012) reviewed several frameworks but felt that Webb's Depth of Knowledge best suited their study, as it fit their need to assess the cognitive rigor of a test item, as opposed to the other frameworks that are used to describe cognitive rigor at hand (Yuan & Le, 2012, p. xii).

According to Yuan and Le (2012), in total, the research team examined more than 5,100 state test items from 201 tests. These items constituted the entire pool of released items available from the 17 states included in the analysis. For each state test, they applied Webb's DOK framework to analyze the cognitive rigor of individual test items and summarized the percentage of items that met the criteria for each DOK level. Two researchers and two subject experts rated the cognitive rigor of more than 5,100 released state test items using Webb's DOK framework, with two raters per subject. The inter-rater reliability was high (above 0.90) for both subjects (Yuan & Le, 2012, p. xiii).

Yuan and Le (2012) found open-ended (OE) items had a greater likelihood of reaching DOK level 3 or 4 than did multiple-choice (MC) items (p. xvi). They found 0 percent of students in the U.S. were assessed on deeper learning in mathematics through state tests, 1–6 percent of students were assessed on deeper learning in reading through state tests, and 2–3 percent of students were assessed on deeper learning in writing through state tests. Overall, 3–10 percent of U.S. elementary and secondary students were assessed on deeper learning on at least one state assessment (Yuan & Le, 2012, p. xiv).

As a result of the low cognitive demands of state assessments revealed in Yuan and Le's (2012) study, the goal of the Deeper Learning Initiative was to increase the percentage of students assessed on deeper learning skills to at least 15% by 2017. In addition, because of the interdependence between critical thinking and problem solving skills and fluency with the core concepts, practices, and organizing principles that constitute a subject domain, it was necessary to develop an analytic framework that would allow an analysis of the mastery of core conceptual content as integrated with critical thinking and problem solving (Yuan & Le, 2012, p. xvi).

Through the review of this study, it became apparent that my study falls in line with the thinking of Yuan and Le regarding complex thinking at elementary grade levels 4 and 5. Webb's Depth of Knowledge served as the best framework for my analysis. In addition, Webb's Depth of Knowledge (DOK) has proven successful in studies such as Andrew Porter's (2002) five-level cognitive rigor framework; Karin Hess et al.'s (2009) matrix that combines Webb's DOK framework and Bloom's Taxonomy of Educational Objectives; and Newmann, Lopez, and Bryk's (1998) conclusion that Webb's DOK is the framework needed to critically analyze complex thinking.

Theoretical Framework

My purpose for this mixed methods study was to compare, analyze, and describe the language of complex thinking embedded within the 2008 New Jersey Core Curriculum Content Standards (NJCCCS) and the 2017 New Jersey Student Learning Standards (NJSLS) in Mathematics for Grades 4 & 5. In creating the NJSLS, New Jersey maintained about 84% of the 1,427 math and English language arts (ELA) standards that made up Common Core, according to the state. About 230 standards were modified slightly, but the content remained exactly the same.

In regards to this study, the revisions to the mathematics standards were minor. As evidenced below in the Grades 4 and 5 crosswalk, a unit of measure was added to the Grade 4 standard. Within Grade 5 standard 5.MD.C.4, the word ***non-standard*** was added to replace the word ***improvised***. In Grade 5 standard 5.MD.C5.b, in the formula V=b x h, the ***B*** was capitalized in the new standard whereas it was lowercase in the CCSS. As evidenced, the content did not change. These aforementioned revisions were the only changes evident; all other standards remained the same. The revisions from the Common Core to the NJSLS are displayed in Table 6 below.

Table 6

Original CCSS in Mathematics and Minor Revisions in the NJSLS

Grade Level	Standard	Revised Standard
4	4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...*	4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm, mm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...*
5	5.MD.C.4 Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.	5.MD.C.4 Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and non-standard units.
5	5.MD.C.5b. Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole- number edge lengths in the context of solving real world and mathematical problems	5.MD.C.5b. Apply the formulas $V = l \times w \times h$ and $V = B \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole- number edge lengths in the context of solving real world and mathematical problems

(NJDOE, 2017)

This analysis study and subsequent grade level equivalency were selected based on the lack of research in the elementary grades. Though there were areas of validity and success, as indicated in this literature review, Webb's Depth of Knowledge provides the appropriate framework to analyze, compare, and describe levels of complex thinking.

The Webb (1997, 2002) alignment process is one of a handful of processes that have been used to determine the match between curriculum standards and assessments (Blank, 2002). In general, this process identifies four criteria that are used to compare the relation between standards and assessments. The process is conducted in two stages. In the first stage, reviewers code the Depth of Knowledge (DOK) levels of standards. In the second stage, reviewers code the DOK levels of assessment items and the corresponding curriculum standards or objectives. Reviewers coded assessment items directly to the curriculum standards. Findings are reported for each of the four criteria, along with the attainment of specified acceptable levels. The reviewers' entry of coding and the analysis of data have been automated using a web-based tool (Webb, 2005).

Standards and assessments can be aligned not only on the category of content covered by each but also on the basis of the complexity of knowledge required by each. DOK consistency between standards and assessment indicates alignment if what is elicited from students on the assessment is as demanding cognitively as what students are expected to know and do as stated in the standards (Webb, 2007).

Webb's Depth of Knowledge has been the most widely researched tool for assessing the alignment of intended, enacted, and assessed curriculum (Wyse & Viger, 2011). Webb (1997, 2007) used four standards to address alignment issues:

1. Categorical congruence measures the extent to which the same or consistent categories of content appear in both the content standards and the assessment.
2. Depth of knowledge (DOK) consistency measures the extent to which the cognitive demands in the content standards are the same as what people are required to know and do on the assessment.
3. Range of knowledge correspondence measures the extent to which the content standards

and the assessment cover a similar span of knowledge.

4. Balance of representation measures the extent to which the knowledge is distributed similarly in the content standards and the assessment (p. 15).

The theoretical framework of this study used Webb's second criteria, which focuses on cognitive complexity. This type of thinking occurs at Levels 3 and 4 of Webb's Depth of Knowledge. Level 3 is strategic thinking, and Level 4 is extended thinking. Level 3 requires cognitive demands that are complex and abstract. At this level, the tasks require more demanding reasoning, though the complexity does not result from the fact that there are multiple answers. Level 3 activities include drawing conclusions from observations, critiquing, developing a logical argument, and using concepts to solve non-routine problems (Webb, 1999).

Additionally, as explained by Webb (1999), Level 4 thinking requires investigation, complex reasoning, planning, developing, and thinking, probably over an extended period of time. At Level 4, the cognitive demands of the task should be high and the work should be very complex. Students at this level are required to make several connections, such as relating ideas within the content area or among content areas and selecting one approach among many possibilities in order to solve a problem. Level 4 activities include designing and conducting experiments, making connections between a finding and related concept and phenomena, combining and synthesizing ideas into new concepts, and critiquing experimental designs. There is an implicit expectation to compare and contrast complex thinking as explained in several studies reviewed in my study. Furthermore, the expectation of more analysis and reasoning attributes (Levels 3 and 4) should be explored.

According to Webb (1997), DOK possesses several dimensions, such as the cognitive complexity of information students should be expected to know, how well they transfer this knowledge, how well they make generalizations, and how much prerequisite knowledge they must possess in order to grasp ideas (p. 15). Interpreting and assigning DOK levels to both objectives within standards and to assessment items is an essential requirement of alignment analysis. These descriptions help to clarify what the different levels represent in, for example, mathematics (Webb, 2007).

The following are Webb's (2007) four Depth of Knowledge levels that were used as the theoretical framework for this study:

Level 1 (Recall). Level 1 includes recalling information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula.

Level 2 (Skills/Concept). Level 2 includes the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make decisions as to how to approach the problem or activity, whereas Level 1 requires students to demonstrate rote response, perform a well-known algorithm, follow a set procedure (like a recipe), or perform a clearly defined series of steps. Key words that generally distinguish a Level 2 item include classify, organize, estimate, make observations, collect and display data, and compare data.

Level 3 (Strategic Thinking). Level 3 requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. In most instances, requiring students to explain their thinking is at Level 3. Activities that require students to make conjectures are also at this level. The cognitive demands at Level III are complex and abstract.

Level 4 (Extended Thinking). Level 4 requires complex reasoning, planning, developing, and thinking most likely over an extended period of time. The extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking (p.23).

In today's global economy, students need to be lifelong learners who have the knowledge and skills to adapt to an evolving workplace and world (NJDOE, 2017). The term 21st-century skills is generally used to refer to certain core competencies such as collaboration, digital literacy, critical thinking, and problem solving, and advocates believe schools need to teach these skills to help students thrive in today's world (Rich, 2010). Critical-thinking skills begin to take form in Level 3 as well as Level 4 of Webb's Depth of Knowledge. Level 3, also known as Strategic Thinking, requires cognitive demands that are abstract and complex (Webb, 2007). The complexity does not result from the fact that there are multiple answers, a possibility for both Levels 1 and 2, but because the task requires more demanding reasoning. An activity, however, that has more than one possible answer and requires students to justify the response they give would most likely be at Level 3. Other Level 3 activities include (a) drawing conclusions from observations, (b) citing evidence and developing a logical argument for concepts, (c) explaining phenomena in terms of concepts, and (d) using concepts to solve problems (Webb, 2007).

At Level 4, the cognitive demands of the task should be high and the work should be very complex. Students should be required to make several connections—relate ideas within the content area or among content areas—and should have to select one approach among many possible ways to solve a problem. Level 4 activities include (a) developing and proving conjectures, (b) designing and conducting experiments, (c) making connections between a finding and related concepts and phenomena, (d) combining and synthesizing ideas into new concepts, and (e) critiquing experimental designs (Webb, 2007).

Norman Webb's Depth of Knowledge (DOK) schema has become one of the key tools educators can employ to analyze the cognitive demand (complexity) intended by standards, curricular activities, and assessment tasks. Webb (1997) developed a process and criteria for systematically analyzing the alignment between standards and test items in standardized assessments. Since then, the process and criteria have demonstrated application to reviewing curricular alignment as well. It is clear through the analysis of the varying studies presented in this literature review that knowledge of DOK Levels 3 and 4 is necessary in the understanding of critical thinking.

Organization of Dissertation

An explanation of the methodology of this study is presented in Chapter Three. Chapter Three includes research questions, policy implications, and an introduction to the current study as well as the design of the study. Additionally, Chapter Three includes a comprehensive look into the coding protocols employed in this study as well as how the standards were dissected based on Webb's Depth of Knowledge.

Chapter III

Methodology

The purpose for this mixed method study was to compare, analyze, and describe the language of complex thinking embedded within the 2008 New Jersey Core Curriculum Content Standards (NJCCCS) and the 2017 New Jersey Student Learning Standards (NJSLS) in Mathematics Grades 4 & 5. Schools across the country have been increasingly challenged to prepare students with 21st-century competencies to compete in a global economy (Kyllonen, 2012, p.3). 21st-century skills can be organized into the areas of cognitive skills (e.g., critical thinking, problem solving, creativity), interpersonal skills (communication skills, social skills, teamwork, cultural sensitivity, dealing with adversity), and intrapersonal skills (self-management, self-regulation, time management, self-development, lifelong learning, adaptability, executive functioning). Furthermore, 21st-century skills can serve as student learning outcomes, curriculum can be built around developing them, teacher professional development can emphasize such instruction, and various learning environments could be developed to promote them (Kyllonen, P. C., Lipnevich, A. A. Burrus, J. & Roberts, R. D. 2008). Although educational policy makers continue to focus on academic rigor and a standardized education system, business leaders increasingly request that employees be able to demonstrate creativity, strategizing complexity, adaptability, and innovation as well as analytical and problem-solving skills (American Society for Training and Development, 2009; IBM Study, 2010; Kyllonen, 2012; Adobe, 2012).

The New Jersey Student Learning Standards (NJSLS) and the New Jersey Core Curriculum Content Standards (NJCCCS) were selected as the focal point of this analysis study.

Consequently, subsequent the grade level equivalency was selected predicated on the lack of research in the elementary grades particularly in the area of mathematics.

Research Questions

The study was grounded by an overarching research question: What are the types of thinking promoted in the 2017 New Jersey Student Learning Standards in Mathematics Grades 4 & 5 compared to the 2008 New Jersey Core Curriculum Content Standards?

The following sub-questions guided the research:

1. In what way(s) does the language found in the 2017 New Jersey Student Learning Standards for Mathematics compare with the language that promotes higher-order thinking found in research literature?
2. In what way(s) does the language found in the 2008 New Jersey Core Curriculum Content Standards for Mathematics compare with the language that promotes higher-order thinking found in research literature?
3. What differences and similarities exist in the language of complex thinking between the New Jersey Core Curriculum Content Standards and the New Jersey Student Learning Standards in Mathematics for Grades 4 & 5?

Policy Context

In 1996, the New Jersey State Board of Education adopted the state's first set of academic standards called the Core Curriculum Content Standards (NJDOE, 2017). The standards described what students should know and be able to do upon completion of a thirteen-year public school education. Revised every five years, the standards provided local school districts with clear and specific benchmarks for student achievement in nine content areas. Developed and reviewed by panels of teachers, administrators, parents, students, and representatives from higher education, business, and the community, the standards are influenced by national standards, research-based practice, and student needs. The standards define a "Thorough and Efficient Education" as guaranteed in 1875 by the New Jersey Constitution (NJDOE, 2017).

In 2015, under mounting national backlash against the Common Core, former New Jersey Governor Christopher Christie instructed the New Jersey Commissioner of Education to convene a committee to revise the Common Core State Standards and rename them. According to Mark Biedron, president of the NJ State Board of Education, "It won't be substantially different. We looked at everything to make sure that it was crystal clear, age appropriate. Yes, there were some changes, but there were no major changes." The New Jersey School Board in May 2016 contended that they would maintain about 84 percent of the 1,427 math and English language arts (ELA) standards that make up Common Core, according to the state. About 230 standards were modified slightly, but the content remained basically the same. The most common revisions were the addition of the words "reflect," 16 times and "self-reflection" 10 times in the English language arts standards (C. Tienken, personal communication December 4, 2017). There were 21 changes to the entire K-12 mathematics standards and none of the changes impacted the content. Like the ELA, the changes were minor with words or phrases like, "including with the use of technology" added. The New Jersey Student Learning Standards across contents were used in classrooms statewide beginning in the 2017-2018 school year. In essence, the New Jersey Student Learning Standards are based on the Common Core State Standards. In reviewing the NJCCCS and the CCSS, some critics challenged the level of complexity and saw that the levels of cognitive complexity in the NJCCCS far surpassed those found in the CCSS (Sforza, Tienken, & Kim, 2016).

According to the Common Core Initiative (2017), the standards defined the knowledge and skills students should gain throughout their K-12 education in order to graduate high school prepared to succeed in entry-level careers, introductory academic college courses, and workforce training programs. Advocates for the Common Core State Standards claim that these new standards provide a framework for higher-level skill development unlike previous standards and require students to produce evidence of learning through products that emphasize the use of higher-level thinking skills (VanTassel-Baska, 2015, p. 60). The Common Core authors and supporters claim that the standards focus on skills, not about specific texts or methods used to teach those skills. Decisions about resources and methods are to be left to local school districts to decide (VanTassel-Baska, 2015, p. 61).

Research Design

I used a case study with mixed methods. A case study is an in-depth description and analysis of a bounded system (Merriam, 2009 p. 40). To continue, Yin (2008) stated that a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (p.18). Wolcott (1992) saw it as "an end-product of field-oriented research" (p.36) rather than a strategy or method.

A case study may also be selected because it is intrinsically interesting; a researcher could study it to achieve as full an understanding of the phenomenon as possible (Merriam, 2009 p. 42). Although Merriam's (2009) definition of a qualitative case study is that of an in-depth description and analysis of a bounded system, it is congruent with other definitions (Bogdan & Biklen, 2007; Cresswell, 2007; Patton, 2002; Stake, 2005). Bogdan & Biklen (2014), defined a case study as a detailed examination of a single or one setting, or single subject, a single depository of documents, or a particular event (p. 271).

The case study design was best suited for this study because it provided the tools from which to study complex phenomena within their contexts. Additionally, this is a particularly appealing design for educational studies (Merriam, 2009). With discussion on complexity thinking in regards to students across grade levels and its impact on the pedagogical awareness, it is necessary that all stakeholders evaluate current curricula to ensure that it is designed to promote those necessary skills.

Case studies offer both strengths and weaknesses. One strength of the case study is that it simplifies and manages data without destroying complexity and context. Additionally, qualitative case studies are highly appropriate for questions where preemptive reduction of the data will prevent discovery (Atieno, 2009 p. 16). Case studies are generally anchored in real-life situations and offer insights to others. The case design has proven particularly useful for studying educational innovations, evaluating programs, and informing policy (Merriam, 2009, p. 51). As a possible weakness, findings cannot be extended to wider populations with the same degree of certainty that larger analyses can.

Methods

I utilized a qualitative content analysis method for the first part of the study to code each of the NJSLS and NJCCCS standards and sub-standards in mathematics Grades 4 & 5. Bogdan and Biklen (1982) defined qualitative data analysis as "working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others" (p. 145).

Qualitative analysis requires some creativity, for the challenge is to place the raw data into logical, meaningful categories; to examine them in a holistic fashion; and to find a way to communicate this interpretation to others. Hsieh and Shannon (2005) stressed that the "success of a content analysis depends greatly on the coding process" (p. 1285). The coding activities for each set of standards in each subject area and grade level followed the same procedure as described by Mayring (2000). We analyzed and coded the Grades 4 & 5 NJCCCS in English language arts and mathematics as well as the Grades 4 & 5 NJSLS in English language arts and mathematics based on their corresponding Depth of Knowledge levels. Each standard was assigned a 1-4 DOK level based on Webb's Depth of Knowledge methodology. Furthermore, utilizing Mayring's (2000) step model as a guide, a coding agenda was created using rules as described in the Webb Alignment Tool; the DOK definitions, examples, and coding.

Qualitative content analysis is one of the several qualitative methods currently available for analyzing data and interpreting its meaning (Schreier, 2012). As a research method, it represents a systematic and objective means of describing and quantifying phenomena (Downe-Wamboldt, 1992; Schreier, 2012). As a result of the review of several studies, CPALMS (2012) and Niebling (2012), qualitative content analysis has proven to be a successful and dependable method of coding curriculum standards using Webb's Depth of Knowledge. Therefore, I felt it was appropriate to utilize qualitative content analysis for my coding purposes.

In deductive content analysis, the organization phase involves categorization matrix development, whereby all the data are reviewed for content and coded for correspondence to or exemplification of the identified categories (Polit & Beck, 2012). The categorization matrix can be regarded as valid if the categories adequately represent the concepts, and from the viewpoint of validity, the categorization matrix accurately captures what was intended (Schreier, 2012). The deductive category matrix was utilized in this study to show the connection with Webb's Depth of Knowledge (2005) and the existing Webb's Depth of Knowledge as it pertains to the

New Jersey Student Learning Standards and the former New Jersey Core Curriculum Content Standards.

Webb's Alignment Tool (WAT) training manual (2005) served as the best option for the coding requirements in this case study because the categories most closely align with existing descriptions of complex thinking. Webb's (2005) Depth of Knowledge (DOK) levels that were used as the framework for this study are as follows:

Level 1 (Recall)—Items at this level require a student to recall a simple definition, term, fact, procedure, or algorithm.

Level 2 (Skill/Concept)—Items at this level require a student to develop some mental connections and make decisions on how to set up or approach a problem or activity to produce a response.

Level 3 (Strategic Thinking)—Items at this level require a student to engage in planning, reasoning, constructing arguments, making conjectures, and/or providing evidence when producing a response. Items at this level require some complex reasoning and connections to be made.

Level 4 (Extended Thinking)—Items at this level require a student to engage in complex planning, reasoning, conjecturing, and development of lines of argumentation. Items at this level require a student to make multiple connections between several different key and complex concepts.

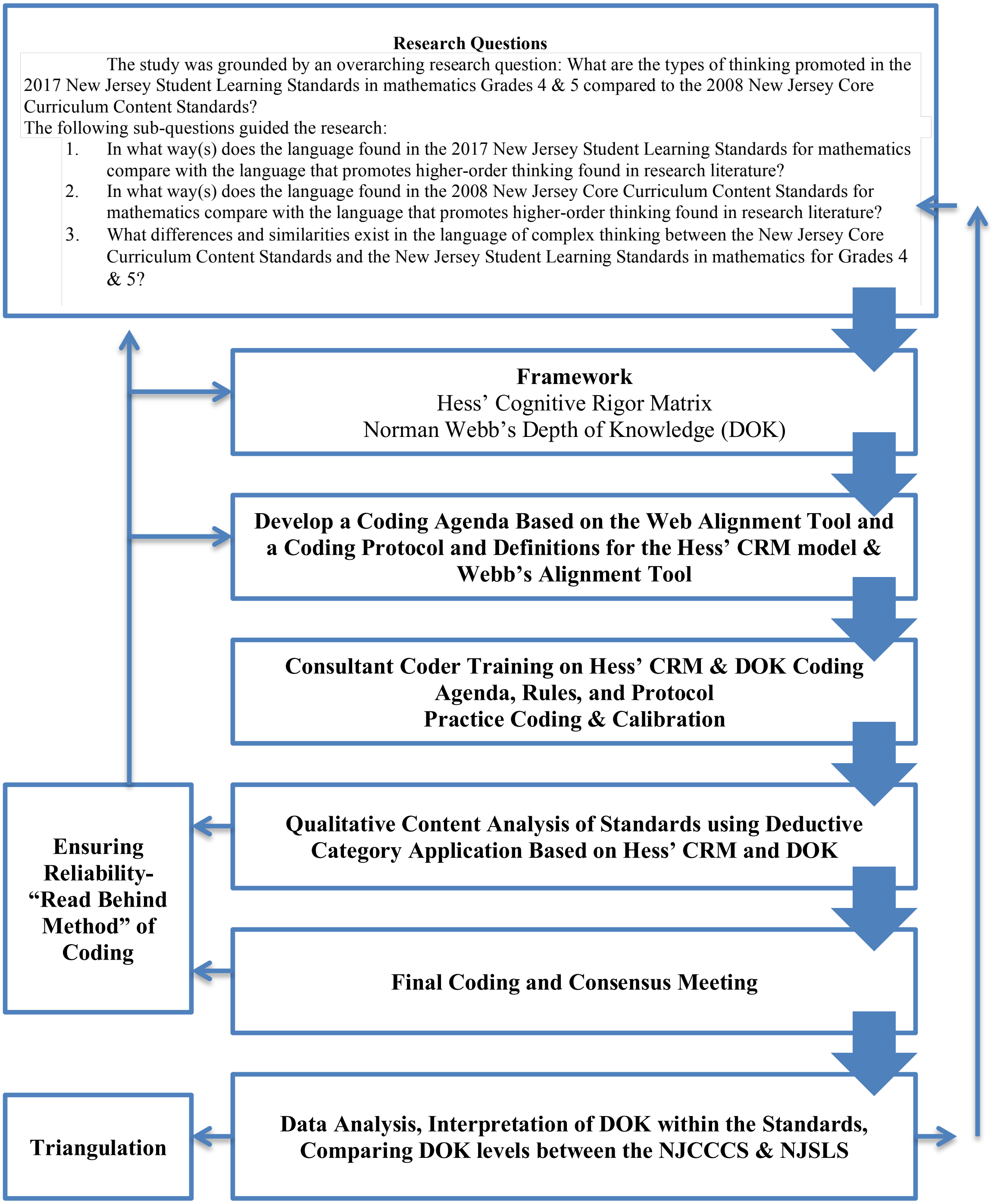


Figure 3. Adapted from page 36 of Web Alignment Tool (WAT) Training Manual http://www.wcer.wisc.edu/WAT/Training%20Manual%202.1%20Draft%20091205.doc Norman L. Webb and others (Add Martyr Webb).

According to Merriam, (2009 p.152), determining the authenticity and accuracy of documents is part of the research process. It is the investigator's responsibility to determine as much as possible about the document, its origins and reasons for being written, its author, and the context in which it was written. Once documents have been located, their authenticity must be assessed. “The author, the place and the date of writing all need to be established and verified” (McCulloch, 2004, p. 42). According to Merriam, 2009, in qualitative studies, a form of content analysis is used to analyze documents.

Once documents have been located, their authenticity must be assessed (McCulloch, 2004, p. 42). It is the investigator’s responsibility to determine as much as possible about the document, its origins and reasons for being written, its author, and the context in which it was written (Merriam, 2009). Qualitative research generates rich, detailed and valid process data that contribute to the in-depth understanding of a context for the research (Yardley, 2000). The degree of inter-coder agreement (reliability) is influenced by many components of the research process, such as the quality of coding instructions, configuration of the codebook, coder training, and coder diligence in carrying out their coding tasks (Sanders & Cuneo, 2011). In this study, the New Jersey Student Learning Standards in mathematics Grades 4 & 5 and the former New Jersey Core Curriculum Content Standards in mathematics Grades 4 & 5 were coded and analyzed based on the corresponding Webb’s Depth of Knowledge level. Each standard was rated 1-4 predicated on Webb’s et al. (2005) Depth of Knowledge procedure. Additionally, Mayring’s Template (2000), known as a coding agenda, was utilized based on recommendations provided in the Webb’s Alignment Tool (Webb, 2005) training manual and used throughout this qualitative analysis study.

I used quantitative methods, specially, frequencies, and descriptive statistics for the second part of the study in which I described the differences and similarities that exist in the language of complex thinking between the New Jersey Core Curriculum Content Standards and the New Jersey Student Learning Standards in mathematics for Grades 4 & 5. I calculated the percentage of standards that were categorized in each level of Webb's DOK based on the qualitative analysis of the language of the standards.

Description of Documents

A number of terms were used to refer to sources of data in a study other than interviews or observations. The term *document* as the umbrella term refers to a wide range of written, visual, digital, and physical material relevant to the study at hand. Documents, as the term is used in (Merriam 2009), also include what LeCompte and Preissle (1993) define as artifacts—"symbolic materials such as writing and signs and non-symbolic materials such as tools and furnishings" (p. 216). The curriculum documents analyzed in this study were the 2008 Mathematics New Jersey Core Curriculum Content Standards (NJDOE, 2008) and the 2017 Mathematics New Jersey Student Learning Standards (NJDOE, 2017). Both sets of curriculum documents were downloaded from the NJDOE website on April 28, 2018. The New Jersey Student Learning Standards is a 99-page document that provides the learning standards from kindergarten through twelfth grade. The focus of this study is Grades 4 and 5 mathematics. As a result, I focused on pages 28-38 that contained the fourth and fifth grade standards. The following were the topics presented in the NJSLS (NJDOE, 2017):

Grade Four Mathematics NJSLS

Operations and Algebraic Thinking

• Use the four operations with whole numbers to solve problems.

• Gain familiarity with factors and multiples.

• Generate and analyze patterns.

Number and Operations in Base Ten

- Generalize place value understanding for multi-digit whole numbers.
  - Use place value understanding and properties of operations to perform multi-digit arithmetic.

Number and Operations—Fractions

- Extend understanding of fraction equivalence and ordering.
- Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.
- Understand decimal notation for fractions, and compare decimal fractions.

Measurement and Data

- Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.
- Represent and interpret data.
- Geometric measurement: understand concepts of angle and measure angles.

Geometry

- Draw and identify lines and angles, and classify shapes by properties of their lines and angles.

Grade Five Mathematics NJSLS

Operations and Algebraic Thinking

- Write and interpret numerical expressions.
- Analyze patterns and relationships.

Number and Operations in Base Ten

- Understand the place value system.
- Perform operations with multi-digit whole numbers and with decimals to hundredths.

Number and Operations—Fractions

• Use equivalent fractions as a strategy to add and subtract fractions.

• Apply and extend previous understandings of multiplication and division to multiply and divide fractions.

Measurement and Data

• Convert like measurement units within a given measurement system.

• Represent and interpret data.

• Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.

Geometry

• Graph points on the coordinate plane to solve real-world and mathematical problems.

• Classify two-dimensional figures into categories based on their properties.

(New Jersey Student Learning Standards, 2017, p. 34)

The 2008 Mathematics NJCCCS standards were specifically outlined for mathematics when searching for the document. The standards and the revisions encapsulated 47 pages. Additionally, the 2008 NJCCCS in mathematics was arranged by strand across all grade levels including preschool learning expectations in mathematics. According to NJDOE, 2008, the new standards are more specific and clearer than the previous standards. The new standards are organized into a smaller number of standards that correspond to the content clusters of the statewide assessments. The new standards are intended to serve as clear guides to the assessment development committees so that there should be no gaps between the standards and the test specifications. The new standards include expectations at Grades 2, 3, 5, 6, and 7, as well as at Grades 4, 8, and 12. The following were the topics presented in the NJCCCS (NJDOE, 2008):

4.1.4 A. Number Sense

1. Use real-life experiences, physical materials, and technology to construct meanings for numbers (**unless otherwise noted, all indicators for Grade 4 pertain to these sets of numbers as well**).
    - Whole numbers through millions
    - Commonly used fractions (denominators of 2, 3, 4, 5, 6, 8, 10, 12, and 16) as part of a whole, as a subset of a set, and as a location on a number line
    - Decimals through hundredths
2. Demonstrate an understanding of place value concepts.
3. Demonstrate a sense of the relative magnitudes of numbers.
4. Understand the various uses of numbers.

    • Counting, measuring, labeling (e.g., numbers on baseball uniforms), locating (e.g., Room 235 is on the second floor)
5. Use concrete and pictorial models to relate whole numbers, commonly used fractions and decimals to each other, and to represent equivalent forms of the same number.
6. Compare and order numbers.
7. Explore settings that give rise to negative numbers.

4.1.4 B. Numerical Operations

1. Develop the meanings of the four basic arithmetic operations by modeling and discussing a large variety of problems.

- Addition and subtraction: joining, separating, comparing
- Multiplication: repeated addition, area/array

- Division: repeated subtraction, sharing

2. Develop proficiency with basic multiplication and division number facts using a variety of fact strategies (such as “skip counting” and “repeated subtraction”) and then commits them to memory.

3. Construct, use, and explain procedures for performing whole number calculations with:

    - Pencil-and-paper
    - Mental math
    - Calculator

4. Use efficient and accurate pencil-and-paper procedures for computation with whole numbers.

    - Addition of 3-digit numbers
    - Subtraction of 3-digit numbers
    - Multiplication of 2-digit numbers
    - Division of 3-digit numbers by 1-digit numbers

5. Construct and use procedures for performing decimal addition and subtraction.

6. Count and perform simple computations with money.

    - Standard dollars and cents notation

7. Select pencil-and-paper, mental math, or a calculator as the appropriate computational method in a given situation depending on the context and numbers.

8. Check the reasonableness of results of computations.

9. Use concrete models to explore addition and subtraction with fractions.

10. Understand and use the inverse relationships between addition and subtraction and between multiplication and division.

4.1.4 C. Estimation

1. Judge without counting whether a set of objects has less than, more than, or the same number of objects as a reference set.
2. Construct and use a variety of estimation strategies (e.g., rounding and mental math) for estimating both quantities and the results of computations.
3. Recognize when an estimate is appropriate, and understand the usefulness of an estimate as distinct from an exact answer.
4. Use estimation to determine whether the result of a computation (either by calculator or by hand) is reasonable.

Building upon knowledge and skills gained in preceding grades, by the end of **Grade 5,** students will:

4.1.5 A. Number Sense

1. Use real-life experiences, physical materials, and technology to construct meanings for numbers **(unless otherwise noted, all indicators for Grade 5 pertain to these sets of numbers as well)**.
    - All fractions as part of a whole, as subset of a set, as a location on a number line, and as divisions of whole numbers
    - All decimals
2. Recognize the decimal nature of United States currency and compute with money.
3. Demonstrate a sense of the relative magnitudes of numbers.

4. Use whole numbers, fractions, and decimals to represent equivalent forms of the same number.
5. Develop and apply number theory concepts in problem solving situations.
    - Primes, factors, multiples of 6. Compare and order numbers.

4.1.5 B. Numerical Operations

1. Recognize the appropriate use of each arithmetic operation in problem situations.
2. Construct, use, and explain procedures for performing addition and subtraction with fractions and decimals with:
    - Pencil-and-paper
    - Mental math
    - Calculator
3. Use an efficient and accurate pencil-and-paper procedure for division of a 3-digit number by a 2-digit number.
4. Select pencil-and-paper, mental math, or a calculator as the appropriate computational method in a given situation depending on the context and numbers.
5. Check the reasonableness of results of computations.
6. Understand and use the various relationships among operations and properties of operations.

4.1.5 C. Estimation

1. Use a variety of estimation strategies for both number and computation.
2. Recognize when an estimate is appropriate, and understand the usefulness of an estimate as distinct from an exact answer.
3. Determine the reasonableness of an answer by estimating the result of operations.

4. Determine whether a given estimate is an overestimate or an underestimate.

Coders

As a part of this study, the selection of a coding committee had to be established. Based on this philosophy the committee had the necessary qualifications that aided in the validity of the research. The vast experience of the coding committee increases the validity and perspective of this research study.

Data Collection

The following are the sample rules adapted from the Webb's Alignment Training Manual that two coders followed when assigning Depth of Knowledge levels to each standard.

1. The DOK level of an objective should be the level of work students are most commonly required to perform at that grade level to successfully demonstrate their attainment of the objective.
2. The DOK level of an objective should reflect the *complexity* of the objective, rather than its *difficulty*. The DOK level describes the kind of thinking involved in a task, not the likelihood that the task will be completed correctly.
3. In assigning a DOK level to an objective, coders should consider the complete domain of items that would be appropriate for measuring the objective and identify the Depth of Knowledge level of the most common of these items.
4. If there is a question regarding which of two levels an objective matches, such as Level 1 or Level 2, or Level 2 or Level 3, it is usually appropriate to select the higher of two levels.
5. The team of reviewers should reach consensus on the DOK level for each objective before coding any items for that grade level (Webb.,2005, p. 36).

Additionally, WAT included Tips for Facilitating the Consensus Process. The following facilitator tips were used during the coding process:

1. Read each objective aloud before discussing it.
2. As you go through the objectives, actively solicit comments from all reviewers.
3. Use your printout to call on people who coded DOK differently from the coding of other members of the group, and ask them to explain why they coded the objective to the particular DOK level.
4. Once two reviewers have described how they have coded an objective differently, ask a third reviewer to highlight the differences between the two interpretations.
5. Restate and summarize to reviewers your interpretation of what the reviewers have agreed on and what they have disagreed on.
6. If there is a difference in interpretation of the objective's *terminology or expectations* appeal to a reviewer with experience in teaching that grade level with these standards to discern how the state's teachers might be interpreting the objective.
7. Ask if anyone, through other reviewers' explanations, now want to change his or her mind about their original coding.
8. If the viewpoints on the DOK level of an objective is divided, point to the most likely skills or content knowledge required in the objective, not the more extreme possibilities the objective might allow for.
9. As the facilitator, try not to dominate the consensus process. Even if you have strong feelings about the DOK level of an objective, wait to see if other reviewers highlight your point.

   (Webb at el, 2005, p.33).

Two coders using Webb's coding protocol have already proven to be effective in two large-scale studies that used the WAT to analyze and code standards based on DOK complexity (Yuan & Le, 2012; Sato et al., 2011). Each deductive category within Mayring's (2000) step model (See Figure 3) has explicit descriptions, examples, and DOK coding rules adapted from the WAT (Webb, et al., 2005) training manual. A coding agenda was developed in order to assess mathematics standards specifically in Grades 4 and 5 as evidenced in Table 7. In order ensure the consistency and reliability within the process of coding, the Depth of Knowledge Wheel was referenced throughout the process.

Table 7

Sample Coding Agenda

Category	Definition	Examples	Coding Rules
Level 1 (Recall)	Level 1 (Recall) includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. That is, in mathematics, a one-step, well defined, and straight algorithmic procedure should be included at this lowest level.	Read, write, and compare decimals in scientific notation.	Items at this level require a student to recall a simple definition, term, fact, procedure, or algorithm.
Level 2 (Skill/Concept)	Level 2 (Skill/Concept) includes the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make some decision as to how to approach the problem or activity.	Construct two-dimensional pattern for three-dimensional models, such as cylinders and cones.	Items at this level require a student to develop some mental connections and make decisions on how to set up or approach a problem or activity to produce a response

Category	Definition	Examples	Coding Rules
Level 3 (Strategic Thinking)	Level 3 (Strategic Thinking) requires reasoning, planning, using evidence, and a higher level of thinking that the previous two levels two levels. In most instances, requiring students to explain their thinking is at Level 3. Activities that require students to make conjectures are also at this level. The cognitive demands at Level 3 are complex and abstract. The complexity does not result from the fact that there are multiple answers, a possibility for both Levels 1 and 2, but because the task requires more demanding reasoning.	Solve two-step linear equations and inequalities in one variable over the rational numbers, interpret the solution or solutions in the context from which they arose, and verify the reasonableness of results.	Items at this level require a student to engage in planning, reasoning, constructing arguments, making conjectures, and/or providing evidence when producing a response.
Level 4 (ExtendedThinking)	Level 4 (Extended Thinking) requires complex reasoning, planning, developing, and thinking, most likely over an extended period of time. The extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking. At Level 4, the cognitive demands of the task should be high and the work should be very complex. Students should be required to make several connections—relate ideas within the content area or among content areas—and have to select one approach among many alternatives on how the situation should be solved, in order to be at this highest level.	Design a statistical experiment to study a problem and communicate the outcomes. For example, if a student has to take the water temperature from a river each day for a month and then construct a graph, this would be classified as a Level 2.	Items at this level require a student to engage in complex planning, reasoning, and development of lines of argumentation. Items at this level require a student to make multiple connections between several different key and complex concepts.

(Webb, 2005)

Table 7 is a sample template of how Webb suggests that coding and recording of each of the standards should take place. Additionally, it is important to note that the coding template used in this study was adapted from the following previous studies: Web Alignment Tool Training Manual (2005), Niebling (2012), as well as Sforza (2014). The usage of Niebling (2012) and Sforza (2014) coding templates allowed for the validity in this study as they were both utilized coding learning standards using Webb's Depth of Knowledge. Table 8 outlines the template used in this study that was slightly modified to include the standards applicable to this study. Adapting Niebling (2012), Sforza (2014), and Burns (2017) added the validity necessary to this study. To add, Webb's Depth of Knowledge and Hess Cognitive Rigor Matrix were utilized in this study to code the learning standards. Inter-rater reliability was enacted throughout the coding process in that if there was difficulty consensus on a standard then the higher Depth of Knowledge level was selected as agreed upon at the initial committee meetings.

Table 8

Sample Paper Version of the Standards

Wisconsin Grade 4 Mathematics Standards Reviewer__________

Number	**Standard**	**DOK Level**
5.	Data Analysis and Probability	
5.a	Represent categorical data using tables and graphs, including bar graphs, line graphs, and line plots.	
5.b	Determine if outcomes of simple events are likely, unlikely, certain, equally likely, or impossible.	
5.c	Represent numerical data using tables and graphs, including bar graphs and line graphs.	

(Webb et al., 2005)

Table 9

New Jersey Student Learning Standards Grades 4 & 5 Sample Coding Sample

5th Grade Standards			
Operations and Algebraic Thinking 5.OA			
	A. Write and Interpret Numerical Expressions	DOK	Notes
1.	Use parentheses, brackets, or braces in numerical expressions, and evaluate expressions with these symbols.		
2.	Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them. For example, express the calculation “add 8 and 7, then multiply by 2” as 2 × (8 + 7). Recognize that 3 × (18932 + 921) is three times as large as 18932 + 921, without having to calculate the indicated sum or product.		
B.	Analyze Patterns and Relationships		
1.	Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane. For example, given the rule “Add 3” and the starting number 0, and given the rule “Add 6” and the starting number 0, generate terms in the resulting sequences, and observe that the terms in one sequence are twice the corresponding terms in the other sequence. Explain informally why this is so.		

(Adapted from Webb, 2005, p. 97–98)

Reliability and Validity

According to Merriam (2009) reliability in research design is based on the assumption that there is a single reality and that studying it repeatedly will yield the same results. Reliability refers to the extent to which research findings can be replicated. In other words, if the study is repeated, will it be replicated? Reliability is problematic in the social sciences simply because human behavior is never static.

According to Merriam (2009), the connection between reliability and internal validity from a traditional perspective rests for some on the assumption that a study is more valid if repeated observations in the same study or replications of the entire study produce the same results. This logic relies on repetition for the establishment of truth, but as everyone knows, measurements, observation, and people can be repeatedly wrong (Merriam, 2009).

Qualitative researchers can never capture an objective "truth" or "reality"; there are a number of strategies that you as a qualitative researcher can use to increase the "credibility" of your findings, or as Wolcott (2005, p.160) writes, increase "the correspondence between research and the real world." Probably the most well-known strategy to shore up the internal validity of a study is what is known as *triangulation* (Merriam, 2009, p. 215). Merriam described four different types of triangulation used in increasing validity:

1. Use of multiple methods-example observations
2. Multiple sources of data-example documents
3. Multiple investigators-example interviews
4. Multiple theories-on a given subject matter (Merriam, 2009, p. 215).

In order to ensure the validity of this study, a review of coding methods from other studies was included into this research. Additionally, in order to ensure reliability and credibility, the findings of my study were compared to those former studies that had already been successful in coding the CCSS while using Webb's Alignment Tool for alignment purposes.

Writers of joint research projects advocate that coding in these cases can and should be a collaborative effort (Erickson & Stull, 1998; Guest & MacQueen, 2008). Multiple minds bring multiple ways of analyzing and interpreting the data: "a research team builds codes and coding builds a team through the creation of shared interpretation and understanding of the phenomenon being studied" (Weston et al., 2001, p. 382). As a result, I used two coders in the analysis of the standards, using the inter-rater reliability method.

Moreover, this study involved two analysts in coding each of the standards and then comparing their data and findings, thus increasing inter-rater reliability (Merriam, 2009, p. 216). To increase the coders' reliability was a "double-rater read behind consensus model," which proved effective in coding standards for other studies (Miles, Huberman, & Saldaña, 2014, p. 84; Sato, Lagunoff, & Worth, 2011, p. 11). Both analysts were trained utilizing the Webb training manual (2005) on how to properly code each standard. All standards were coded based on Webb's Depth of Knowledge (2005) coding protocol using my revised coding agenda. In addition, member checks were used as an additional inter-rater reliability strategy and allowed me to validate my coding analysis with that of the second coder, identifying any biases (p. 111). As a result, in this study the analysts used the same coding agenda rules of coding and data. The analysts were properly trained in the usage of Webb's Depth of Knowledge in order to code the standards taken from the WAT training manual 2.0.

Training Procedures

Credibility refers to the "adequate representation of the constructions of the social world under study" (Bradley, 1993, p.436). The importance of the validity and reliability of the results must be reported in a systematic fashion. David Evans and Paul Gruba (2002, p.112) remind us that our minds continue to work on problems when we aren't thinking about them consciously.

In order to provide systematic and commonality amongst the coders, the coders were all trained using Webb's Depth of Knowledge protocol (Webb et al., 2005). The coding committee met on several occasions to review Webb's Alignment Tool in order to maintain fidelity of the coding process. The review of Webb's Alignment Tool, definitions, scenarios, and examples analyzed assisted with the completion of the coding agenda for this study and what each Depth of Knowledge level should signify in the area of mathematics.

After the review of the Webb's Alignment Tool and subsequent meetings regarding the role of each of the coders as well as the establishment of the coding agenda, the coding committee took on the task of coding the Mathematics Standards Grades 4 & 5 of the former New Jersey Core Curriculum Content Standards (NJDOE, 2009).

As a result of following protocol in the coding process, the coding committee took part in training meetings to obtain a keen understanding of expectations. Upon completion of the training meetings, the coding committee began to code the standards evident in the area of mathematics in Grades 4 & 5 of the New Jersey Core Curriculum Content Standards (NJDOE, 2008) utilizing the read coding rules as well as the read behind consensus model.

The coding committee began by coding and comparing the first 10 learning standards for inter-rater agreement. After a substantial rate of agreement of 80% or better, the next 20 learning standards were coded and again compared for inter-rater agreement. Again, the same goal was evident, agreement had to stand at 80% or better. As a result of the consistency amongst the coding committee, the remaining standards were coded in groups of 20. Inter-rater reliability was checked throughout the process.

Throughout the coding process, members of the committee reviewed my DOK findings and noted if they agreed or not with each coded standard. Any disagreements between the two analysts were noted and discussed. These discussions continued until a consensus was reached. This process of utilizing the read behind consensus model continued with the coding of the Grades 4 & 5 Mathematics New Jersey Student Learning Standards (NJDOE, 2017). After all the anchor standards and sub-standards of the former NJCCCS and the NJSLS were coded, the results of this analysis were compared using related studies that coded standards for example (Niebling, 2012; Sato et al., 2011; Sforza, 2014, and Burns, 2017).

Data Analysis

The qualitative data used for this content analysis study compromised of two sets of pre-existing mathematics standards. The first set of standards analyzed was from the 2008 New Jersey Core Curriculum Content Standards. The second set of standards analyzed was from the 2017 New Jersey Student Learning Standards. As aforementioned, there are currently no empirical exists regarding Depth of Knowledge levels of the New Jersey Student Learning Standards in Grades 4 & 5 compared to the Depth of Knowledge levels of the former New Jersey Student Learning Standards. According to the Organisation for Economic Cooperation and Development (2010), many advanced economies rely on people who possess skills and dispositions that transcend content knowledge and discipline-centered school subjects, such as creativity, innovation, and collaboration. Skilled jobs are increasingly centered on solving unstructured problems and effectively analyzing information. Additionally, the NJCCCS were replaced by the NJSLS in that there were claims of greater thinking skills for students within the State of New Jersey. Moreover, these claims had to be either affirmed or denied to ensure that these greater thinking skills prepared students for competitiveness for their peers in other countries holistically.

As a result of former studies from Sforza (2014), CPALMS, (2014), and Burns (2017), the proportion of learning standards at each Depth of Knowledge (Webb, 2005) level was calculated appropriately as well as graphed. Additionally, all sub-standards were analyzed as well. The coding of sub-standards and anchor standards related to the NJSLS and the former NJCCCS is an improvement over similar studies that only included anchor standards and/or assigned Depth of Knowledge ratings to learning standards in their research (Niebling, 2012; Sato et al., 2011). Sub-standards are specific skills related to anchor standards whereby anchor standards are overarching, generalized standards that must be obtained. The Sforza (2014) study compared the NJCCCS for mathematics and language arts in Grades 9–12 and the Burns (2017) study compared NJCCCS for mathematics and language arts in Grades 6–8, and the anchor standards as well as the sub-standards aligned to the anchor standards were also coded.

As a result of the qualitative coding analysis, the results from the New Jersey Core Curriculum Content Standards and the New Jersey Student Learning Standards in Mathematics Grades 4 & 5 were calculated separately, analyzed, summarized, and reported in Chapter Four with a detailed analysis of the two sets learning standards. The graphs illustrated in Chapter Four show distinct trends and findings evident through the analysis of the three research questions. The following quantitative method was used to calculated to show the percentage of standards at each Depth of Knowledge level:

$$\text{\% of standards} = \frac{\text{\# of standards coded at the DOK level}}{\text{total \# of possible standards}}$$

For example, if there were 54 mathematics standards in the NJSLS, 22 of which were coded at a DOK level of 1, using the formula above, we would get the following result:

$$\frac{22}{54} = 41\% \text{ at DOK Level 1}$$

The above referenced simple formula was utilized to calculate all percentages of DOK distribution in both the NJSLS and NJCCCS mathematics curriculum standards Grades 4 and 5.

Role of the Researcher

This research is important and relevant to content pedagogy and practice. As a current administrator in an A Factor Group School District, the lowest of the eight groupings, the discussion of curriculum standards is ever present. As a teacher, vice principal, and principal within an A District Factor School District, the lowest of the eight groupings and then as a principal, assistant superintendent, and now deputy superintendent in both a DFG and A factor group school districts, I have worked closely with the former New Jersey Core Curriculum Content Standards and now the New Jersey Student Learning Standards. The interaction I have had with the NJCCCS had been in terms of lesson planning and implementation, direct and targeted instruction, and evaluative purpose particularly when I became a school leader in the capacity of vice principal and principal. The NJSLS that became a fixture in terms of curriculum standards in 2017 is evident in my work in the evaluative and instruction sense in my role as the head of Curriculum and Instruction.

In review of discussions in prior graduate programs as well as through reading about both the Common Core and the New Jersey Core Curriculum Content Standards, I found myself thinking that the NJCCCS were more lower level and basic than the Common Core. When the Common Core came into play, the media outlets often showed a one-sided view of the standards, thus creating the bias within my mindset. As I researched the standards analyzed and coded them appropriately, I had to remind myself to take the personal bias out of the process. Throughout the process, the consensus model allowed the coders to take out personal biases.

Coders incorporated into this research study came from diverse educational backgrounds including differing types of school districts i.e., suburban and urban as well as grade levels, i.e., elementary, middle, and high school.

As the group leader of the coding process, I adapted the role for the WAT training manual (Webb et al., 2005). The following are the duties of the group leader:

1. To register each group member with the WAT;
2. To enter into the WAT the number and types of assessment items for each grade's assessment(s);
3. To enter the state's standards and objectives into the WAT;
4. To train the reviewers in using the WAT and to familiarize them with the Depth of Knowledge (DOK) levels for their content area;
5. To lead the group's consensus process for determining the DOK levels of the standards and objectives for each grade level, and to enter this information into the WAT (Webb et al., 2005, p. 5).

Analyzing the consensus model as well as coding rules mentioned prior (Steps 1–5 per WAT; Webb et al., 2005), each coder reviewed the anchor standards as well as the sub-standards of the former New Jersey Core Curriculum Content Standards as well as the New Jersey Student Learning Standards. Throughout the coding process, each standard was coded as per the WAT (Webb et al., 2005). When a consensus process needed to be conducted, the following steps to reach a consensus about the DOK levels of the objectives were taken:

1. Reviewers individually entered DOK values for each of the objectives in the appropriate grade level.
2. The group leader printed out the reviewers' individual DOK values.

3. The group came to a consensus about the DOK level of each objective.

I found that the Tips for Facilitating the Consensus Process helped guided this work. The WAT (Webb et al., 2005, p. 33) illustrated the facilitation process I utilized:

1. Read each objective before discussing it.
2. As you go through the objectives, actively solicit comments from all reviewers. Pay special attention to making sure that the reviewers from within the state feel involved. (Not every reviewer needs to address every objective, but make sure that everyone is included in the process.)
3. Use your printout to call on people who coded DOK levels differently from the coding of other members of the group, and ask them to explain why they coded the objective to the particular DOK level. Be sure they use the DOK definitions to justify their answers.
4. Once two reviewers have described how they have coded an objective differently, ask a third reviewer to highlight the differences between these two interpretations.
5. Restate and summarize to reviewers your interpretation of what the reviewers have agreed on and what they have disagreed on.
6. If there is a difference in interpretation of the objective's *terminology* or *expectations*, appeal to a reviewer with experience in teaching that grade level with these standards to discern how the state's teachers might be interpreting the objective.
7. Ask if anyone, through other reviewers' explanations, now wants to change his or her mind about their original coding.
8. If the viewpoints on the DOK level of an objective are divided, point to the most likely skills or content knowledge required in the objective, not the more extreme

possibilities the objective might allow for.

9. As the facilitator, try not to dominate the consensus process. Even if you have strong feelings about the DOK level of an objective, wait to see if other reviewers highlight your point.

In this study, coders were made aware that the WAT (Webb et al., 2005) would be used as a means to ensure that bias was absent and a focus was established during the coding process.

Chapter Summary and Subsequent Chapter

In this chapter, I was able to describe the coding protocol used to code the former New Jersey Common Core State Standards (NJCCSS) and the New Jersey Student Learning Standards (NJSLS). The step model of qualitative research was examined. In addition, this chapter took an in-depth look into reliability and validity. Webb's Alignment Tool Training Manual was utilized to train all coders throughout the coding process of coding each standard predicated on Webb's (2005) Depth of Knowledge Wheel. As indicated in this chapter, examples, definitions, and coding rules were evident and thus placed into a specific, organized coding agenda. To ensure that nothing in terms of reliability were missed, a separate coding agenda for all NJCCSS and NJSLS in English language arts and mathematics standards was created. A more efficient sample-coding template was created indicating the standard objective, number, and Depth of Knowledge level. The next chapter presents the findings of my study with an analytical focus on answering all three research questions as presented in the aforementioned chapters.

Chapter IV

Results

Introduction

This chapter presents findings predicated on the research questions aforementioned in the previous chapters. I used a case study with mixed methods. A case study is an in-depth description and analysis of a bounded system (Merriam, 2009 p. 40). To continue, Yin (2008) stated that a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (p.18). Wolcott (1992) saw it as “an end-product of field-oriented research” (p.36) rather than a strategy or method.

A case study may also be selected because it is intrinsically interesting; a researcher could study it to achieve as full an understanding of the phenomenon as possible (Merriam, 2009 p. 42). Although Merriam’s (2009) definition of a qualitative case study is that of an in-depth description and analysis of a bounded system, it is congruent with other definitions (Bogdan & Biklen, 2007; Cresswell, 2007; Patton, 2002; Stake, 2005). Bogdan & Biklen (2014) defined a case study as a detailed examination of a single or one setting, or single subject, a single depository of documents, or a particular event (p. 271).

The case study design was best suited for this study because it provided the tools from which to study complex phenomena within their contexts. Additionally, this is a particularly appealing design for educational studies (Merriam, 2009). With discussion on complexity thinking in regards to students across grade levels and its impact on the pedagogical awareness it is necessary that all stakeholders evaluate current curricula to ensure that it is designed to promote those necessary skills.

Findings for Research Question 1

Research Question 1. In what way(s) does the language found in the 2017 New Jersey Student Learning Standards for mathematics compare with the language that promotes higher-order thinking found in research literature?

The 2017 Grade Four NJSLS included 31% of the standards that included language that reflected DOK Level One and 68% of the standards coded at a DOK Level Two. Moreover, 1% of the standards included language that reflected DOK Level Three. Finally, 0% of the standards were coded at a DOK Level Four.

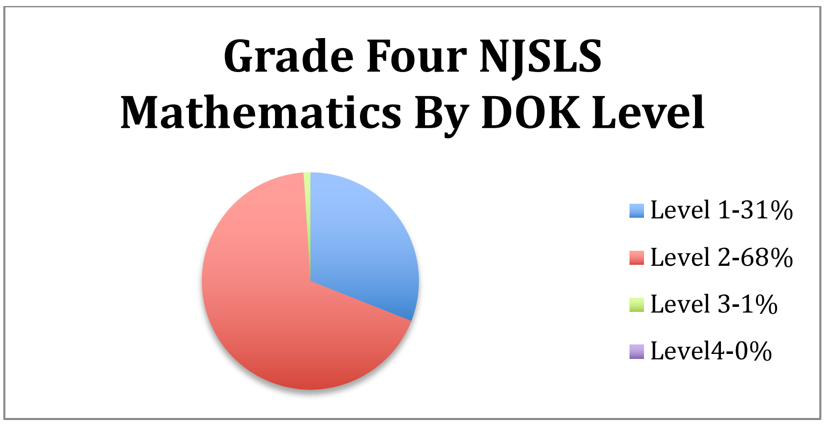


Figure 4. Grade Four Distribution of NJSLS Mathematics by DOK Level.

The Grade Five NJSLS had 22% of the standards that included language that reflected DOK Level One and 50% of the standards included language that reflected DOK Level Two. Moreover, 28% of the standards included language reflected DOK Level Three. Finally, 0% of the standards included language reflected DOK Level Four.

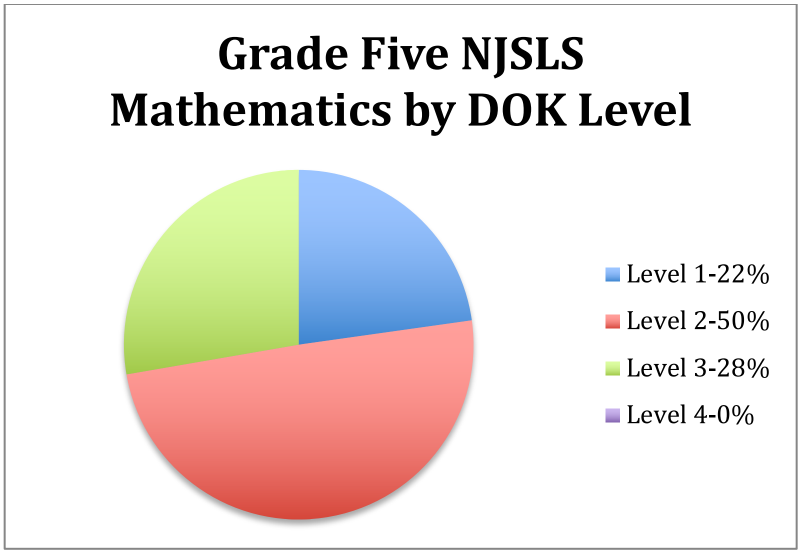


Figure 5. Grade Five Distribution of NJSLS Mathematics by DOK Level.

Language of the NJSLS. The New Jersey Student Learning Standards (NJSLS, 2017) for mathematics in Grades 4 & 5 were coded using Webb's Depth of Knowledge. Webb (2005) assigns four DOK ratings, which increases in complexity from 1 (Recall) to 4 (Extended Thinking). Mathematical standard rated at a DOK Level 1 requires basic recall of facts and definitions in addition to performing basic one-step problems. Recall, recognize, and use are some of the keywords that can be identified within a mathematical standard rated at a DOK Level 1. The following are examples of 2017 NJSLS Grades 4 & 5 in mathematics coded at a DOK Level 1.

Grade Four NJSLS Sample: **Use the four operations with the whole numbers to solve problems 4.OA:** 1. Interpret a multiplication equation as comparison, e.g., 35= 5x7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations (NJSLS Mathematics Standards, 2017, p. 29).

Grade Five NJSLS Sample: **Operations and Algebraic Thinking 5.OA:** Writing and Interpret Numerical Expressions: Use parentheses, brackets, or braces in numerical expressions, and evaluate expression with these symbols (NJSLS Mathematics Standards, 2017, p. 35).

The distribution of the language in NJSLS that reflected DOK Level 2 was 68% for Grade 4 and 50% for Grade 5. DOK Level 2 standards require the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make decisions as to how to approach the problem or activity, whereas Level 1 requires students to demonstrate rote response, perform a well-known algorithm, follow a set procedure (like a recipe), or perform a clearly defined series of steps. Keywords that generally distinguish a Level 2 item include classify, organize, estimate, make observations, collect and display data, and compare data (Webb, 2005).

The following are examples of 2017 NJSLS Grades 4 & 5 in mathematics coded at DOK Level 2:

> Grade Four Example**: Use the four operations with the whole numbers to solve problems 4.OA:** Multiply or divide to solve word problems involving multiplicative comparisons, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem, distinguishing multiplicative comparison from additive comparisons. (NJSLS Mathematics Standards, 2017, p. 29).
>
> Grade Five Example**: Numbers and Operations in Base Ten: Understanding the Place Value System 5 OA:** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10 (NJSLS Mathematics Standards, 2017, p. 35).

The distribution of language in NJSLS that reflected DOK Level 3 was 1% in Grade 4 and 28% in Grade 5. DOK Level 3 standards require reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. In most instances, requiring students to explain their thinking is at Level 3. Activities that require students to make conjectures are also at this level. The cognitive demands at Level 3 are complex and abstract (Webb, 2005).

The following are examples of 2017 NJSLS Grades 4 & 5 in Mathematics coded at a DOK Level 3:

> Grade Four Example**: Extend understanding of fraction equivalence and ordering 4.NF:** Explain why a fraction a/b is equivalent to a fraction (n× a) / (n×b) by using visual fraction models, with attention to how number and size of the parts differ even though the two fractions themselves are the same. Use the principle to recognize and generate equivalent fractions (NJSLS Mathematics Standards, 2017, p. 30).
>
> **Numbers and Operations-Fractions: Use equivalent fractions as a strategy to add and subtract fractions 5.NF:** Interpret the product (a/b) × q as a parts of a partition of q into b equal parts; equivalently, as the result of a sequence of operations a × q ÷ b. For example, use a visual fraction model to show (2/3) × 4 = 8/3, and create a story context for this equation. Do the same with (2/3) × (4/5) = 8/15. (In general, (a/b) × (c/d) = ac/bd.) (NJSLS Mathematics Standards, 2017, p. 36).

The distribution of language in NJSLS that reflected DOK Level 4 in Grades 4 & 5 was 0%. There were no indicators of level cognitive complexity as evidenced by DOK within the NJSLS. DOK Level 4 standard requires complex reasoning, planning, developing, and thinking most likely over an extended period of time. The extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking (Webb, 2005).

Findings for Research Question 2

Research Question 2: In what way(s) does the language found in the 2008 New Jersey Core Curriculum Content Standards for mathematics compare with the language that promotes higher-order thinking found in research literature?

The 2008 Grade Four NJCCCS included had 41% of the standards that included language that reflected DOK Level One and 52% of the standards that included language that reflected DOK Level Two. Moreover, 6% of the standards that included language that reflected DOK Level Three. Finally, 1% of the standards that included language that reflected DOK Level Four.

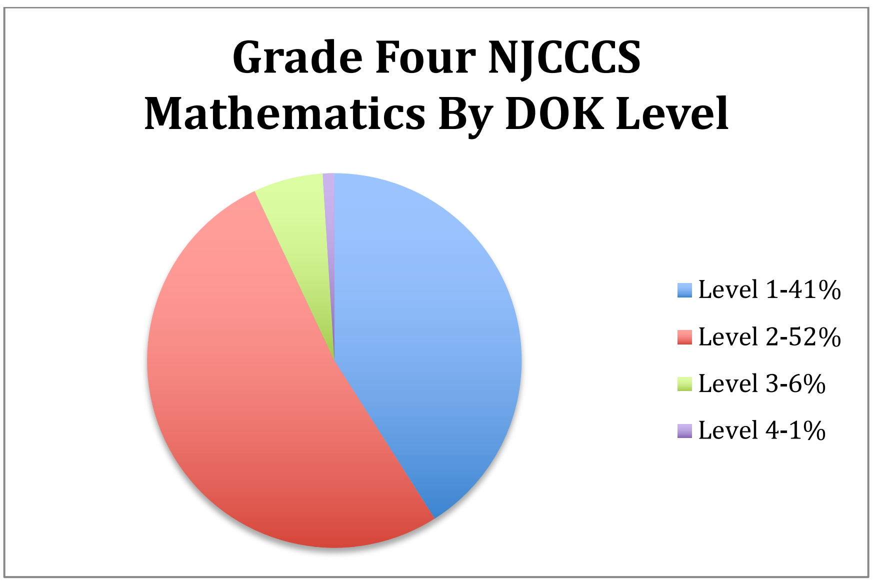


Figure 6. Grade Four NJCCCS Distribution Mathematics By Grade Level

The 2008 NJCCCS Grade Five had 15% of the standards that included language that reflected DOK Level One and 56% of the standards included language that reflected DOK Level Two. Moreover, 25% of the standards included language that reflected DOK Level Three. Finally, 1% of the standards included language that reflected DOK Level Four.

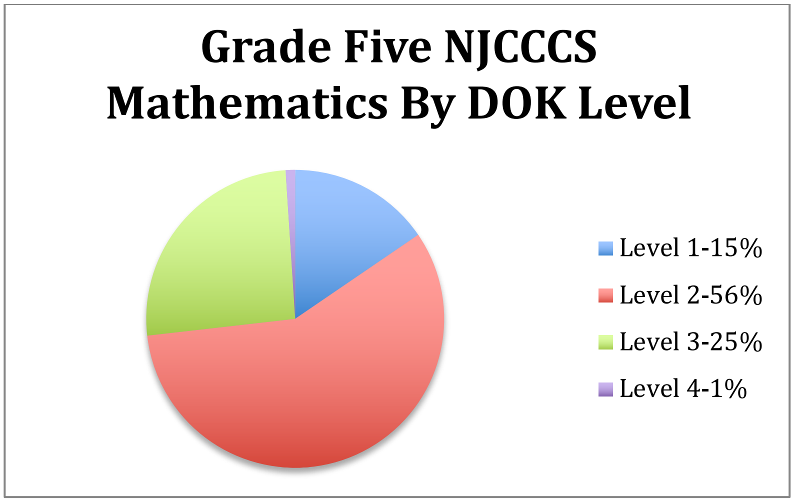


Figure 7. Grade Five NJCCCS Distribution Mathematics By Grade Level

Language of the NJCCCS. The 2008 Learning Standards in mathematics in Grades 4 & 5 were coded as a result of analyzing the extent of complex thinking language embedded standards. New Jersey replaced the 2008 Learning Standards in 2010 as a result of the implementation of the Common Core. In 2017, New Jersey moved from the Common Core to the New Jersey Student Learning Standards.

The distribution of DOK Level 1 in mathematics Grades 4 & 5 of the NJCCCS was 41% in Grade 4 and 15% in Grade 5. Mathematical standards rated at a DOK Level 1 require basic recall of facts and definitions in addition to performing basic one-step problems. Recall, recognize, and use are some of the keywords that can be identified within a mathematical standard rated at a DOK Level 1 (Webb, 2005).

The following are examples of 2008 NJCCCS Grades 4 & 5 in mathematics coded Level 1.

Grade Four Example: **Numerical Operations 4.1.4B: Develop the meanings of four basic arithmetic operations by modeling and discussing a large variety of problems Multiplication:** repeated addition, area/array (NJSLS Standards 2017, p. 14).

Grade Five Example: **Geometric Properties 4.2.5 A:** Identify similar figures (NJSLS Standards 2017, p. 16).

The distribution of DOK Level 2 coded in mathematics in Grade 4=52% and 56% in Grade 5. DOK Level 2 standards require the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make decisions as to how to approach the problem or activity, whereas Level 1 requires students to demonstrate rote response, perform a well-known algorithm, follow a set procedure (like a recipe), or perform a clearly defined series of steps. Keywords that generally distinguish a Level 2 item include classify, organize, estimate, make observations, collect and display data, and compare data (Webb, 2005).

The following are examples of 2008 NJCCCS Grades 4 & 5 in mathematics coded at Level 2.

Grade Four Example: **Estimation 4.1.4 C:** Judge without counting whether a set of objects has less than, more than, or the same number of objects as a reference set (NJSLS Standards 2017, p. 15).

Grade Five Example: **Measuring Geometric Objects 4.2.4 E:** Use a protractor to measure angles (NJSLS Standards 2017, p. 16).

The distribution of DOK Level 3 standards coded in mathematics in Grade 4 was 6% and 25% in Grade 5. DOK Level 3 standards require reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. In most instances, requiring students to explain their thinking is at Level 3. Activities that require students to make conjectures are also at this level. The cognitive demands at Level 3 are *complex and abstract* (Webb, 2005).

The following are examples of 2008 NJCCCS Grades 4 & 5 in mathematics coded at Level 3.

Grade Four Example: **Probability 4.4.4 B:** Predict probabilities in a variety of situations (e.g., given the number of items of each color in a bag, what is the probability that an item picked will have a particular color)

- What students think will happen
- Collect data and use that data to predict the probability (experimental)
- Analyze all possible outcomes to find the probability (theoretical) (NJSLS Standards 2017, p. 34).

Grade Five Example: **Measuring Geometric Objects 4.2.4 E:** Develop informal ways of approximating the measures of familiar objects (e.g., use a grid to approximate the area of the bottom of one's foot) (NJSLS Standards 2017, p. 22).

The distribution of NJCCCS DOK Level 4 coded in mathematics in Grade 4 was 1% and 1% in Grade 5. DOK Level 4 standard requires complex reasoning, planning, developing, and thinking most likely over an extended period of time. The extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking (Webb, 2005).

The following are examples of 2008 NJCCS Grades 4 & 5 in mathematics coded at Level 4.

Grade Four Example: **Discrete Mathematics-Vertex Edge Graphs and Algorithms 4.4.4.D:** Explore vertex-edge graphs and tree diagrams

- Vertex, edge, neighboring/adjacent number of neighbors
- Path, circuit (i.e., path that ends at its starting point) (NJSLS Standards 2017, p. 38).

Grade Five Example: **Discrete Mathematics Vertex-Edge Graphs and Algorithms 4.4.5 D:** Devise strategies for winning simple games (e.g., start with two piles of objects, each of two players in turn removes any number of objects from a single pile, and the person to take the last group of objects wins) and express those strategies as sets of directions (NJSLS Standards 2017, p. 38).

Findings for Research Question 3

Research Question 3: What differences and similarities exist in the language of complex thinking between the New Jersey Core Curriculum Content Standards and the New Jersey Student Learning Standards in Mathematics for Grades 4 & 5?

The trajectory of the final research question was to compare and contrast the distribution in language of complex thinking as it relates to two sets of standards: the former New Jersey Core Curriculum Content Standards (NJDOE, 2008) and the current New Jersey Student Learning Standards (2017).

DOK Distribution. Grades 4 & 5 Mathematics NJCCCS Standards contained the same percentage (56%) of standards coded at DOK Level 1, as compared to the Grades 4 & 5 Mathematics NJSLS (56%). Grades 4 & 5 Mathematics NJSLS, 68 % of the standards in Grade 4 were coded a DOK Level 2 and 50% of the standards were coded at a DOK Level 2 in Grade 5. The NJSLS was compared to the NJCCCS where 56% of the standards in Grade 4 were coded at DOK Level 2 and 56% were coded at DOK Level 2. The Grades 4 &5 Mathematics NJCCCS were coded at DOK Level 3 percentage of 31%, which was 4% more than the Grades 4 & 5 Mathematics Grades 4 & 5 NJSLS percentage of 29%. The Grades 4 & 5 Mathematics NJCCCS also had a higher coded DOK Level 4 percentage of 2%, as compared to 0% contained in the Grades 4 & 5 Mathematics NJSLS. This represents a 2% difference in standards coded at a DOK Level 4 between the NJCCCS and NJSLS. Figures 8 and 9 show the NJCCCS/NJSLS DOK distribution comparison charts.

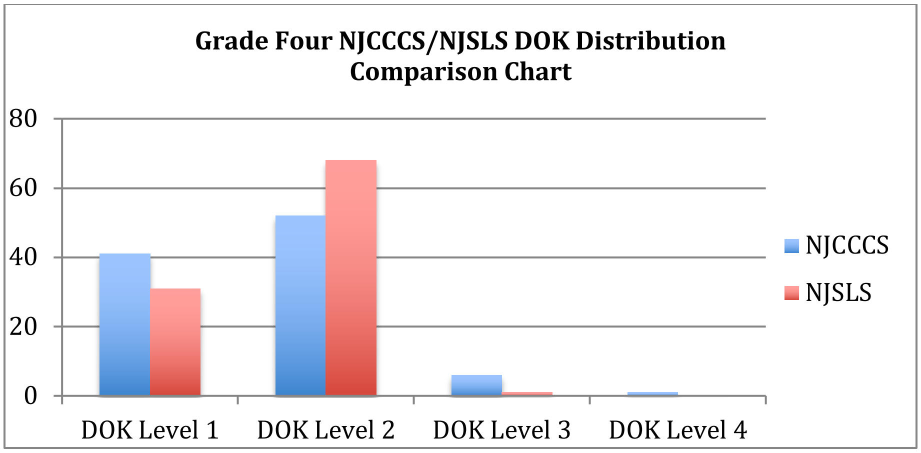


Figure 8. NJCCCS/NJSLS Mathematics DOK Distribution Comparison of Cognitive Complexity

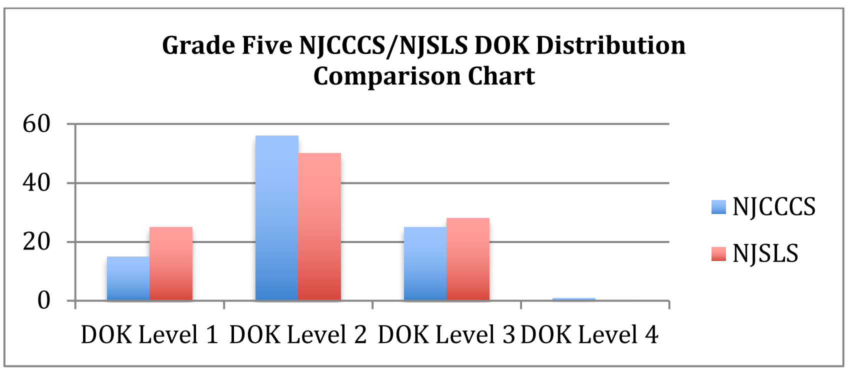


Figure 9. NJCCCS/NJSLS Mathematics DOK Distribution Comparison of Cognitive Complexity

In terms of reaching higher levels of complex thinking, cognitive complexity contained at DOK Levels 3 (Strategic Thinking) and DOK Level 4 (Extended Thinking) must be obtained. Figures 8 and 9 showed the distribution of complex thinking contained in each set of learning standards in Grades 4 and 5 as evidenced in the 2008 New Jersey Core Curriculum Content Standards and the 2017 New Jersey Student Learning Standards.

Summary

The major findings from the data were as follows:

1. The mathematics standards from the 2008 NJCCCS exhibited a higher

percentage of Depth of Knowledge Levels 3 & 4 than those evident in the 2017 NJSLS.

2. The NJSLS Grades 4 & 5 in the area of mathematics exhibited a higher percentage of Depth of Knowledge Levels 1 & 2 than those evident in the 2008 NJCCCS.

Chapter Five of the dissertation presents conclusions, interpretation of findings, context of findings, implications for policy, and practice, and future directions of research and recommendations.

Chapter V

Conclusions and Policy Recommendations

Summary, Overview, Discussion of Data, and Restatement of the Problem

In Chapter Five, I provide the summary of the study, which includes the restatement of the problem, brief comments on the findings as they relate to the three research questions, as well as a conclusion, implications for policy and practices, and recommendations for future research. The purpose for this case study with mixed methods was to describe and compare the complex thinking language embedded within the 2008 Mathematics New Jersey Core Curriculum Content Standards and the 2017 New Jersey Student Learning Standards in Grades 4 & 5. The study was limited to two grade levels (Grades 4 and 5). Another limitation of this study was my choice to only analyze the standards and sub-standards in mathematics for Grades 4 and 5. From this decision, additional subject area standards, standards for other grade levels, and state standards were not analyzed in this study.

Webb's Depth of Knowledge (DOK) was utilized as the conceptual framework for this study. Webb's DOK consists of four levels of knowledge: Level 1, recall, and Level 2, skills and concepts, are levels that require basic knowledge recitation and comprehension. No creative thinking is taking place in DOK Levels 1 and 2. Webb's Depth of Knowledge Level 3, strategic thinking and complex reasoning, and Level 4, extended levels of thinking, are the levels where students are able to reach deeper, analytical, and more strategic/extended levels of thinking and complex reasoning (Webb, 2005). Levels 3 and 4 require students to think deeper as well as more analytically.

Conclusion

Higher-order thinking has typically been defined in the education context with specific reference to the cognitive domain of Bloom's Taxonomy, a trend that is still evident in contemporary research and discourse (Barnett & Francis, 2012; Jensen, McDaniel, Woodward, & Kummer, 2014). The persistent influence of Bloom's framework most likely stems from its appealing nature and the fact that each level of cognitive sophistication, although designed to transcend specific subject matters and educational stages, can be interpreted and operationalized to suit individual contexts.

As stated by Lewis and Clark (1993), higher-order thinking occurs when a person takes new information and information stored in memory and relates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. A variety of purposes can be achieved through higher-order thinking, such as deciding what to believe; deciding what to do; creating a new idea, a new object, or an artistic expression; making a prediction; and solving a non-routine problem (Lewis & Clark, 1993).

Dewey (1933) described four types of thinking, from the broadest to the most refined. The broadest type includes whatever passes through one's mind at any given moment; this sort of thinking is engaged in by everyone and is not highly valued. The second type of thinking refers to what goes beyond direct observation; this sort of thinking is a little more abstract but includes imagination and fancies that may have little to no connection with even the most implausible reality. The third type refers to belief in what seems probable without consideration of its grounds; that is, a belief may be incoherent, may contradict facts, or may have implications that the thinker would reject if she or he stopped to consider the question more deeply. Finally, in its most refined type, thinking refers to reflective thought, and this latter sort of thinking is commonly known as higher-order thinking (Dewey, 1933). John Dewey rejected the notion that schools should focus on repetitive, rote memorization and proposed a method of "directed living" in which students would engage in real-world, practical workshops to demonstrate their knowledge through creativity and collaboration (Miettinen, 2000).

Valid assessment of higher-order thinking skills requires that students be unfamiliar with the questions or tasks they are asked to answer or perform and that they have sufficient prior knowledge to enable them to use their higher-order thinking skills in answering questions or performing tasks. Psychological research suggests that skills taught in one domain can generalize to others. Over long periods of time, individuals develop higher-order skills (intellectual abilities) that apply to the solutions of a broad spectrum of complex problems.

Three item/task formats are useful in measuring higher-order skills: (a) selection, which includes multiple-choice, matching, and rank-order items; (b) generation, which includes short-answer, essay, and performance items or tasks; and (c) explanation, which involves giving reasons for the selection or generation responses.

Classroom teachers recognize the importance of having students develop higher-order skills yet often do not assess their students' progress. The conversation then lends itself to lower order skills. According to the National Research Council (1987), expert thinking does indeed require a high degree of domain knowledge. Hopefully no one is arguing that kids can be high-level thinkers 'without knowing anything.' But the notion that students have to be immersed in 'lower-level' factual and procedural knowledge before they can do 'higher-level' thinking work doesn't comport with what we know from cognitive research.

The results from this study suggest that the NJSLS require less higher-order thinking than the NJCCCS. The majority of thinking found in the mathematics and English language arts standards require DOK Level 1 and 2 thinking, declarative knowledge, and procedural thinking. This raises the spectre of functional fixedness. Functional fixedness or a rigidity in thinking that limits an individual from identifying alternatives to a solution, in that students will be able to answer specific tasks based on how the question or task is worded or the category in which the question is located (Dunker as cited in Anderson & Johnson, 1966). Higher-level questions allow students to think critically about topics. The lack of higher-order questions can lead students to develop a closed mindset to the categories and literacy skills that they interact with across content areas. In the same thought, if adequate practice in the development of higher-order thinking skills is not provided in other aspects of the curriculum, such as classroom lessons to which students are exposed, functional fixedness will be further developed. This will cause further problems when higher-order thinking tasks are introduced in the classroom. What we have seen are kill and drill activities that lend themselves to lower level questions and thus do not allow for students to think outside of the box. Additionally, if students are only asked to identify one correct answer instead of thinking through several processes analytically, they will not expand their repertoire of critical thinking skills. Exposure to higher-order thinking questions or techniques within classroom instruction via curricula resources and authentic learning experiences must be present in order for students to think critically, problem solve as well as think beyond the entry levels of understanding.

Dewey (1916) recognized that a purely scholastic approach, based on knowledge acquisition presented limits on student learning and thinking:

> When education, under the influence of a scholastic conception of knowledge which ignores everything but scientifically formulated facts and truths, fails to recognize that primary or initial subject matter always exists as a matter of active doing, involving the

> use of the body and the handling of material, the subject matter of instruction is isolated from the needs and purposes of the learner, and so becomes just a something to be memorized and reproduced upon demand. Recognition of the natural course of development, on the contrary, always sets out with situations which involve learning by doing (p. 133).

Cognitive biases such as functional fixedness keep those that are not considering changing their fixed mindset to a growth mindset from seeing the full range of solutions to a problem and affect the ideas that are generated and considered. The inability to recognize alternative approaches and uses of elements constrains creativity, and thus limits ideation and problem solving. Simple tasks will not lend itself to higher-order thinking and thus will not allow learners to move to strategic and extended thinking as evidenced by DOK Levels 3 and 4. The study showed that the former NJCCCS allowed for more extended thinking than that of the current NJSLS. There remain forms of functional fixedness within the current NJSLS that do not allow students through questioning and discussion to expand their critical thinking.

As aforementioned, school districts, through policy implications, must ensure that the groundwork is established to allow stakeholders to make revisions to curricula. To that end, school leaders will be charged with the task of ensuring that instructional opportunities to expand students' critical thinking and creativity through multiple measures is established with fidelity. According to Fowler, "Policy is constructed by local agencies (district level) that guide the procedures and operations of a school district. It is important to note that school administration/leadership are deemed the policymakers, as they have to carry out the procedures as delineated by boards of education," (Fowler, 2012). Development of policy will drive the work that must be done at the local level to ensure that students are afforded sound instructional opportunities across content areas.

Implications/Recommendations for Policy

Local control should be returned to school districts in order to provide students with a democratic education free from one-size-fits-all learning standards and learn from the Cardinal Principles of Secondary Education (Commission on the Reorganization of Secondary Education, 1918); remove one-size-fits-all standards mandates and replace with more holistic goals.

According to Tienken, (2017), a policy-making body, like a state education agency, develops, copies, and/or purchases a set of curriculum standards that specify expected outputs and then adopts a one-size-fits-all testing program to monitor implementation and determine the attainment of the standards based on predetermined expectations and student output. Finally, through legislation and administrative code the policy-making body mandates that public school personnel teach the specified standards and administer the tests to monitor student achievement of the standards and judge teacher effectiveness. The approach is known as performance-guarantee policy making. The policies and practices focus on guaranteed outputs. The outputs are stipulated in the form of curriculum expectations or standards (p. 3).

Standards mandate content and output expectations, thereby causing funneling of information based on the complexity of the output expectations. Standards are composed in expectation language—outcome related. With that being said, local school districts will outline the outputs while the states determine the majority of the content. In the same vein as writing curriculum, those that are contributing to the major output should be able to provide recommendations as they have the expertise in that given area. This example will satisfy the requirements of the Every Student Succeed Act (ESSA). This will allow districts to customize at the local entity and allow states to report their approved content to the federal entity.

ESSA will help to ensure that all students have resources and support throughout all New Jersey schools as a result of local assistance through the following:

- Providing more opportunity for all students including, for the first time, indicators of school success or student support to help identify and begin closing opportunity gaps
- Including less focus on, and a decoupling of, the high stakes associated with standardized tests, so students have more time to learn and teachers have more time to teach
- Empowering educators with a greater voice in educational and instructional decisions; and incentivizing collaboration of educators, families, and communities to support local schools

ESSA has allowed for local districts to have a voice in educational policy and implementation. Moreover, stakeholders must participate in meetings with policymakers (state education agency, state legislators, the governor, school boards, district office, etc.). The engagement process must be open and transparent. Local entities must make sure stakeholders are part of building plans and making decisions throughout the implementation process.

Historical Background

According to Kahlenberg and Janey (2016), throughout U.S. history, Americans have pivoted between whether the central priority of public education should be to create skilled workers for the economy or to educate young people for responsible citizenship. Both goals are important, of course, but with the recent rise of a global economy, the emphasis has shifted away from preparing citizens and toward serving the needs of the marketplace (p. 1).

There is a general understanding that as time goes by, a larger percentage of jobs require employees with higher-order thinking skills; that is, employees whose work will involve creativity, problem solving, and critical analysis, among other skills (Ananiadou & Claro, 2009; Rimini & Spiezia, 2016). This need results from an ever-increasing interaction with technology, an endless amount of information, and the disappearance of jobs that require repetitive operations and are being taken over by robots or exported to regions where labor and production costs are lower.

Policymakers must make it a priority to recognize the importance of empowering local school districts to make curriculum decisions based on their own high expectations for student learning, not top-down learning standards that ignore the individual needs and differences of students found throughout this diverse nation. In essence, stakeholders must be present so the top-down approach is not evident; rather a local collaboration is the guiding force.

The Eight-Year Study (also known as the Thirty-School Study) was an experimental project conducted from 1930 to 1942 by the Progressive Education Association (PEA), in which thirty high schools redesigned their curriculum while initiating innovative practices in student testing, program assessment, student guidance, curriculum design, and staff development. Aikin's (1942) Eight-Year Study already demonstrated that curriculum could be an entirely locally developed project and still produce better results than traditional standardized curricular programs (Tienken, 2011, p. 14, 2016).

Curriculum organization and articulation is what some have called a proximal variable (Wang, Haertel, and Walberg, 1993). That means it becomes most influential when it is closer to the student. Curriculum must be designed and developed locally, by the teachers, administrators, and students who use and experience it, to have the greatest influence (Tanner & Tanner, 2007;

Wang, Haertel, and Walberg, 1993). Alexander's (2002) study of course-taking pattern before and after the introduction of New York's regent standards revealed that local contexts, such as school size and demographics, accounted for most of the disparity in course taking, and universal curriculum requirements did little to overcome that after their initial implementation. Local context, involvement, and input matter greatly.

According to Tienken (2011), a comprehensive curriculum is supposed to fulfill a unifying and specializing function. A curriculum that is developed at the local level must include the traditional subject content, but just as important, it will allow local curriculum developers to cater instruction to meet the diverse needs of the 21st-century learner (Dewey, 1938; Howe & Meens, 2012).

Recent studies strengthen and support the efficacy of diverse, decentralized, creative, problem-based curricula to provide students the skills they need for the future (Hmelo-Silver 2004; Wirkala and Kuhn 2011). Results from other landmark studies also demonstrate that there is not "one best path" for students in high school, and standardized curricula sequences are not necessary to achieve superior results in elementary and high schools (e.g., Thorndike 1924; Jersild et al., 1941). Schools are training grounds to subject societal limitations on low socio-economic individuals, often penalizing those with less financial resources and their teachers for conditions over which these youngsters and adults do not have control (Tienken & Orlich, 2013 p.72). The assertion that one curriculum can prepare all students for any college or career lacks face validity and defies logic (Zhao 2012).

A one-size-fits-all system of education "which professes to be based on the ideas of freedom may become as dogmatic as ever was the traditional education which it reacted against" (Dewey, 1938, p. 181). Wang, Haertel, and Walberg (1993) found that education that directly influences a student will have a direct and positive effect on student learning as compared to indirect influences such as national standards. A holistic educational curriculum is echoed in Aiken's (1942) Eight-Year Study where college prescriptions were removed to give students the opportunity to focus more on their personal growth within their community. In review of the empirical data from this study, standards such as the Common Core State Standards were no more engaging than older standards. If we place the New Jersey Student Learning Standards into this frame, the fact remains the same. As aforementioned, New Jersey maintained about 84% of the 1,427 math and English language arts (ELA) standards that made up Common Core, according to the state. About 230 standards were modified slightly, but the content remained basically the same. The most common revisions were the addition of the words "reflect" 16 times and "self-reflection" 10 times in the English language arts standards (C. Tienken, personal communication, December 4, 2017). There were 21 changes to the entire K-12 mathematics standards, and none of the changes impacted the content. Like the ELA, the changes were minor with words or phrases like, "including with the use of technology" added.

The Cardinal Principles of Secondary Education (1918) have holistic learning embedded into their principles and provide students with the tools necessary to "practice nonconventional models of thinking that enhance motivation" (Burke-Adams, 2007, p. 59). Within the Cardinal Principles of Secondary Education (Commission on the Reorganization of Secondary Education, 1918), "Individual differences in pupils and the varied needs of society alike demand that education be so varied as to touch the leading aspects of civic, occupational, and leisure life," (p.13). According to Tienken & Orlich, (2013), most parents want what's best for their children. Subjecting all students to a one-size-fits-all standardized education where their individual learning needs are discarded at testing time is malpractice. In a time when we're standardizing everything in our schools, we should be personalizing. To correct a general misconception, the results from the Aiken Eight Year Study (1942) proved that many different forms of secondary curricular design can ensure college success and that high school need not be chained to a college preparatory curriculum.

The results of this study suggest that the New Jersey Student Learning Standards are not going to develop students pedagogically in the form of complex thinking more than the former standards before them. To add, this data from this study shows that the New Jersey Student Learning Standards may in fact decrease opportunities for students to reach higher-order thinking skills as evidenced by the lower cognitive complexity found within the NJSLS Grades 4 & 5 mathematics. As a result of these findings, I recommend that revisions be made to the New Jersey Student Learning Standards in the area of mathematics, particularly in terms of adding complex thinking into each of the learning standards; this also includes the sub-standards. In addition, policymakers must empower school districts to review their curricula and make sound changes in the effort of promoting high quality standards and assessments that do not fit into the one-size-fits-all model. Instead, these high-quality standards and assessments will allow for differentiated learning models while tapping into the varying learner types in the classroom setting. There is no evidence providing both a successful nationalized curriculum and a holistic and creative education (Kohn, 2010). The "administrative progressives" need to stop the illusion of Tyack's "one best system" of education and embrace a holistic education that supports the complex democratic and creative 21st-century system of education (Howe & Meens, 2012).

1. State Board of Education must take advantage of flexibilities offered in the Elementary and Secondary Education Act (ESSA) that support local control curriculum decisions.

The Elementary and Secondary Education Act (ESEA) was signed into law in 1965 by President Lyndon Baines Johnson, who believed that "full educational opportunity" should be "our first national goal." From its inception, ESEA was a civil rights law. The ESEA was part of President Johnson's "War on Poverty." According to the US. Department of Education, (2018), the bill aimed to shorten the achievement gaps between students by providing each student with equal opportunities to achieve an exceptional education. As mandated by the act, funds are authorized for professional development, instructional materials, resources to support educational programs, and for parental involvement promotion.

The Every Student Succeeds Act (ESSA, U.S. Department of Education, 2018) was reauthorized and signed by former President Obama on December 10, 2015. According to the U.S. Department of Education (2018), the previous version of the law, the No Child Left Behind (NCLB) Act, was enacted in 2002. NCLB represented a significant step forward for our nation's children in many respects, particularly as it shined a light on where students were making progress and where they needed additional support, regardless of race, income, zip code, disability, home language, or background. The law was scheduled for revision in 2007, and over time, NCLB's prescriptive requirements became increasingly unworkable for schools and educators. Recognizing this fact, in 2010, the Obama administration joined a call from educators and families to create a better law that focused on the clear goal of fully preparing all students for success in college and careers.

According to the U.S. Department of Education (2018), ESSA includes provisions in order to ensure the successes of students and students. Below are a few indicators. The law:

- Advances equity by upholding critical protections for America's disadvantaged and high-need students.

- Requires—for the first time—that all students in America be taught to high academic standards that will prepare them to succeed in college and careers.
- Ensures that vital information is provided to educators, families, students, and communities through annual statewide assessments that measure students' progress toward those high standards.
- Helps to support and grow local innovations—including evidence-based and place-based interventions developed by local leaders and educators—consistent with our Investing in Innovation and Promise Neighborhoods.
- Sustains and expands this administration's historic investments in increasing access to high-quality preschools.
- Maintains an expectation that there will be accountability and action to effect positive change in our lowest-performing schools, where groups of students are not making progress, and where graduation rates are low over extended periods of time (U.S. Department of Education, 2018).

Before the federal government started requiring states to test every student (almost) every year as a condition of receiving ESEA money, there wasn't enough data to tell how specific groups of students were performing. States were able to just look at the average scores and assume everything was okay. With results from annual testing, though, it was possible to look deeper into how different groups of students were performing. This subgroup reporting, as it's called, made it obvious that the under-achievement of the most vulnerable students had been masked in the old system of reporting. African Americans, Latinos, Native Americans, English-language learners, students with disabilities and many others were being left out or left behind because schools were not held accountable for their individual progress and growth.

According to the Education Post (2018), federal requirements and expectations in ESEA provide transparency and oversight on states and districts to ensure that there are protections for these vulnerable students, schools, and communities. This provides and targets additional services and support they need to succeed. After decades of inequities, neglect, and inaction at the state level, this law is designed to help states meet their commitments to protect the interests of these children and communities. According to Secretary of Education Betsy DeVos, this is a real opportunity to give flexibility…more flexibility to the states (DeVos, 2017).

As a result of the provisions of the law, the ESSA is expected to help disadvantaged students, ensuring that more targeted instruction and professional development that is strategic and relevant is in place to assist their teachers. Moreover, data points gathered through assessments will be reviewed, as well as development of targeted interventions and the expansion of the Early Childhood offerings. To add, the most important provision to the ESSA legislation is the requirement that all students in the United States be provided access to high academic standards that translates into them being college and career ready.

ESSA provides states with the opportunity to provide students with a high-quality curriculum that will allow them to become college and career ready. According to Goldhaber, Lavery, and Theobald (2015), increasing student access to a high-quality "thinking curriculum," traditionally available to only a privileged few, is an important step toward more equitable schooling. Reporting this kind of information by group may leverage greater access, while also offering a more holistic picture of students' learning (Lankford, Loeb, & Wyckoff, 2002). Through the ESSA legislation, local school districts (LEAs) have been afforded the opportunity to provide what they deem positive and strategic learning situations for the most underserved students. Accordingly, policymakers and educational stakeholders must ensure that standards and curriculum alike provide students with complex thinking and make this the priority while the flexibility through the ESSA is evident.

Implications/Recommendations for Practice

1. School-level stakeholders must take on the responsibility of ensuring that local policy, curricula, and programs include complex thinking skills.

Fowler (2013) described the policy process as the sequence of events that occurs when a political system considers different approaches to public problems, adopts one of them, tries it out and evaluates it (p.14). As a result of this study, it was determined that the New Jersey Student Learning Standards in the area of mathematics Grades 4 & 5 do not provide students with the ability to engage with complex thinking skills when working with specific standards and sub-standards. It is necessary for teachers, administrators, and board of education members to work in tandem to ensure that implementation of curricula, student support services, and additional programming to meet the needs of our most at-risk and advanced learners are present. All stakeholders must demand that unions, members of school boards, and other local politicians with authority over school budgets and policies make strengthening classroom instruction and raising student achievement rather than pet projects or self-interests their predominant priorities (Childress, Elmore, and Grossman, 2006). It is through ensuring that the curricula items are in place to ignite the appropriate pedagogy and practice for students kindergarten through grade twelve that local school boards have played an integral role in the daily operation of local schools. They have been entrusted to determine curriculum, manage personnel, balance budgets, and set policies regarding discipline and safety. In addition, local school boards can strengthen their roles by reviewing their own policies, clarifying their goals and practices, implementing procedures, undertaking more systematic training, and partnering with teacher and administrator organizations to influence state educational policies rather than to state-generated proposals (Hadderman, 1988). With that being said, local school boards must empower administrators and teachers to ensure that complex thinking situations take place for the students' acquisition.

According to Tienken and Orlich, (2013), the whole philosophy behind the standards movement is that students are passive vessels into which what is to be learned is poured. Standards ignore that students have an active role to play in learning. Learning is a mechanistic process, not an organic process. Under this fallacy, "schools are assembly lines of knowledge" and students are sped through on a conveyor belt and learning is done to them as they pass through. Standards ignore the human side of learning entirely and view it as a process to which students are subjected (p. 12).

According to Zhao (2012), to prepare global, creative, and entrepreneurial talents, education should at first not harm any child who aspires to do something or suppress his curiosity, imagination, and desire to be different, imposing upon him or her contents and skills judged to be good for him or her by an external agency and thus depriving of the opportunities to explore and express oneself (p. 17). Local boards of education must support curriculum that is established but furthermore has supplemental resources for varying learner types as well as professional development opportunities for teachers to plan, prepare, and thus execute with fidelity.

2. School level administrators must infuse complex thinking into all parts of the curriculum and culture.

The majority of schools today are facing increasing pressure to produce good employees and thus are working hard at what is believed to produce good employees with prescribed standardized curricula, lock-step pacing guides, and standardized tests (Zhao, 2012). Today more than ever, individuals must be able to perform non-routine, creative tasks if they are to succeed. While skills like self-direction, creativity, critical thinking, and innovation may not be new to the 21st century, they are newly relevant in an age where the ability to excel at non-routine work is not only rewarded, but also expected as a basic requirement (Partnership for 21st Century Skills, 2010). Rotherham and Willingham (2009) recommend the following: First, leaders must ensure instructional programs are focused not just on skills. Second, schools need to revamp how they think about human capital and professional development. Third, schools must provide for new assessments that accurately measure rich learning and more complex tasks (p. 18).

Dewey (1902) proposed that the learner gain knowledge and construct meaning from the interaction between his or her own experiences and ideas that he or she comes into contact with. Kolb (1984) described the Lewinian Experimental Learning Model as interpreted by his analysis. There are four stages of experimental learning (Kolb et al 1971 p. 28): 1) Concrete experience 2) Testing implications of concepts in new situations 3) Formation of abstract concepts and generalizations and 4) Observations and reflections. Dewey (1938) stated that learning through experience allows for more concrete thinking. Aikin's (1942) Landmark Eight-Year Study emphasized five critical principles essential to the development of creative thinking: 1) strong emphasis on the student, 2) personal experiences, 3) different development styles, 4) problem solving and making prior knowledge connections, and 5) the ability to approach problems through different lenses. An inquiry and problem-based learning curriculum can be the answer to helping students build creativity and critical thinking skills that are absent from the current intended curriculum. Inquiry and problem-based learning will promote Aiken's (1942) "strong emphasis on the student" and assist students in comprehending the language, reasoning, and understanding of ideas and their complex connection to current and past-acquired knowledge.

The Assessing and Teaching of 21st Century Skills study (Cisco et al., 2010) stated that creativity, critical thinking, problem solving, decision making, and learning are amongst the most important skills needed to succeed in the 21st century. The ideas of creativity within inquiry and problem-based learning in education date back to the works of John Dewey (1916) and the Cardinal Principles of Secondary Education (1918). The Cardinal Principles of Secondary Education (1918), often thought of as "education's Declaration of Independence," advocated for a more hands-on, democratic, experiential, and problem-finding curriculum (Tienken & Orlich, 2013, p. 9). The Cardinal Principles provided the opportunity for students to think more critically as well as think creativity. This thinking allowed for the emergence of the new student.

Critical thinking is considered fundamental to 21st-century learning (Ananiadou and Claro, 2009; Gardner, 2008; P21, 2013; Redecker et al., 2011; Trilling and Fadel, 2009; Tucker and Codding, 1998). Critical-thinking skills is an essential skill outside of formal education. Today's citizens need to be able to compare evidence, evaluate competing proposals, and make responsible decisions (NEA, 2010). According to the Partnership for 21st Century Learning (2011), when students leave school there are two formative ways to solve problems in the real world:

1) Solve different kinds of non-familiar problems in both conventional and innovative ways
2) Ask significant questions that clarify various points of view and lead to better solutions

Critical thinking is a particular domain that has been defined in detail through Gubbins' *Matrix of Critical Thinking* (Legg, 1990), (Facione, P., and the McREL Institute Marzano, R. J., and others, 1992). Critical thinking also has been described in the following ways:

- Goal-directed, reflective, and reasonable thinking, as in evaluating the evidence for an argument of which all the relevant information may not be available (Cotton, 1997; Crowl et al., 1997; Facione, 1998; Lewis & Smith, 1993; Patrick, 1986).
- An essential component in metacognitive processes (Crowl et al., 1997).
- Analysis, inference, interpretation, explanation, and self-regulation; requires inquisitive, systematic, analytical, judicious, truth-seeking, open-minded, and confident dispositions toward critical-thinking processes (Facione, 1998).
- The disposition to provide evidence or reasoning in support of conclusions, request evidence or reasoning from others, and perceive the total situation and change one's views based on the evidence (Cotton, 1997).

According to Dewey (1933), thinking does not occur spontaneously but must be "evoked" by "problems and questions" or by "some perplexity, confusion or doubt." The observations or "data at hand cannot supply the solution; they can only suggest it" (p. 15). Furthermore, it is this "demand for the solution" (p. 14) that steadies and guides the entire process of reflective thinking; the "nature of the problem fixes the end of thought, and the end controls the process of thinking" (p. 15).

As students become aware of their thinking processes, they realize how their own personal makeup can play a role in how they make their choices and interpret situations (Jacobs, 1995; Kahneman, Slovic & Tversky, 1982). Factors such as culture, experience, preferences, desires, interests, and passions can radically alter the decision-making process (Kahneman et al., 1982). Nevertheless, with time and more experience in systematic thinking, individuals and groups can develop the principles to guide decision making so that "a certain manner of interpretation gets weight, authority" as long as "the interpretation settled upon is not controverted by subsequent events" (p. 126).

As this study and related studies that suggest the lack of complex thinking within the New Jersey Student Learning Standards, districts should adjust their intended curriculum for the purpose of expanding their complex thinking skills. Stakeholders within the process of updating curricula have the influence to ensure that complex thinking skills are embedded within district-enacted curriculum. As a result of this stakeholder buy-in, the responsibility of the principal is to ensure that the enacted curriculum is upheld and executed on a daily basis. The overarching goal of ensuring the enacted curriculum is upheld and executed must take time to professionally develop staff, but furthermore be a presence when the rollout of the curriculum is taking place as the instructional leader of the building.

Curriculum teams must review the current curriculum and make the recommendation that New Jersey Learning Standards are taken apart and analyzed in smaller parts; this includes the sub-standards as well. If the "know-how" of curriculum standards and the dangers of functional fixedness are understood during the creation of curriculum standards, these standards can potentially increase "originality and flexibility," two of the critical ingredients of creative and strategic thinking, by ensuring that a mix of cognitive levels appears throughout the standards in each subject and for each grade level (Runco & Chand, 1995, p. 245). If deeper levels of cognitive demand are absent and content is repetitive in nature, standards can jeopardize complex efforts to help students become creative and original thinkers (Runco & Chand, 1995, p. 245).

According to Tienken, (2016 p. 25), one way to inject creativity and strategic thinking into curricula is to add activities that focus on socially conscious problem solving. Problem-based activities derived from issues found in American society, as well as international issues, have a long track record of providing students opportunities to engage in creative and strategic thinking, while also producing superior results on traditional measures of academic achievement (Aikin, 1942; Boyer, 1987; Dewey, 1938; Isaac, 1992).

Critical-thinking skills must be incorporated into curriculum standards. Standards should be reviewed and revised by school administrators in order to provide critical-thinking educational experiences for students K-12. Continued professional development in the curriculum writing is necessary. Stakeholders such as school leaders and teachers must be trained in the Webb et al., (2005) Depth of Knowledge in order to design the standards and culminating objectives and skills. The aforementioned stakeholder groups should use Webb's Depth of Knowledge in order to evaluate the effectiveness of instructional lessons, assessments, and objectives. According to Tienken (2016), school leaders, in collaboration with their professional staff, might endeavor to revise and customize existing objectives and activities in their state-mandated ELA and math curricula to generate more creative and strategic thinking opportunities for students (p.25). Additionally, understanding the steps of the curriculum writing process is also necessary just as the revision of curriculum standards to include critical-thinking skills is necessary.

Dewey (1916) was an advocate of inquiry and problem-based learning. An inquiry and problem-based learning curriculum can promote critical thinking, problem solving, creativity, and innovation, essential skills needed to succeed in the 21st century (Trilling & Fadel, 2009, pp. 96-97). An inquiry and problem-based curriculum can help students to reorganize and restructure existing knowledge and "provides a structure for discovery that helps students internalize learning and leads to greater comprehension" (Delisle, 1997, p. 1). Researchers contended that "creativity involves the ability to integrate, reorganize, or restructure existing knowledge structures" (Charlton & Bakan, 1988, p. 315). Chand (1995) believed that problem finding is a critical part of "creative cognition" (p. 244).

As aforementioned, the New Jersey Student Learning Standards are a subset of the Common Core State Standards. Curriculum writing teams must review the standards and revise them into smaller subsets rather than the overarching standard expectation that currently arises. Standardization of curriculum should not be the focus. Instead, the non-standardization of curriculum should be the focus.

Curricula expectations and output do not have to be standardized. Fear mongers and standardization followers masquerading as education leaders and reformers need not halt progress toward better education opportunities for all students. Educators at the local level have it within their power to defy standardization and change the trajectory of education for millions of students (Tienken, 2016).

As noted by Smith and Tyler (1942), the "fundamental purpose of schooling is to affect changes in students" and it is the design and development of curricula embedded with unstandardized skills and dispositions, organized around a problem-focused core, and aligned to the Curriculum Paradigm, that produces those changes. Curricula, and schooling in general, should be and can be unstandardized (p. 11).

Problem Based Learning modules have become engrained within the curricula structure. PBL, as it is known in the acronym form, is a student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem found in trigger material (Schmidt, Rotgans, & Yew, Elaine, 2011). According to Schmidt, Rotgans, & Yew, 2011), the PBL process does not focus on problem solving with a defined solution, but it allows for the development of other desirable skills and attributes. This includes knowledge acquisition, enhanced group collaboration, and communication. The PBL process was developed for medical education and has since been broadened in applications for other programs of learning. The process allows for learners to develop skills used for their future practice. It enhances critical appraisal, literature retrieval, and encourages ongoing learning within a team environment (pgs. 792-793).

According to Delisle (1997), the roots of problem-based learning can be traced to the progressive movement, especially to John Dewey's belief that teachers should teach by appealing to students' natural instincts to investigate and create. Dewey (2016) wrote that "the first approach to any subject in school, if thought is to be aroused and not words acquired, should be as unscholastic as possible" (Dewey, 1916, 1944, p. 154). For Dewey, students' experiences outside of school provide us with clues for how to adapt lessons based on what interests and engages them (Delisle, 1997).

Early stages of adopting problem-based learning initiatives should allow schools to think more creatively as well as allow for further higher-order thinking. The Genius Hour is a problem-based learning strategy that was explored. According to (Heick, 2014) the Genius Hour in the classroom is an approach to learning built around student curiosity, self-directed learning, and passion-based work. In traditional learning, teachers map out academic standards, and plan units and lessons based around those standards. In Genius Hour, students are in control, choosing what they study, how they study it, and what they do, produce, or create as a result. As a learning model, it promotes inquiry, research, creativity, and self-directed learning.

Google provided staff members with the opportunity to self-explore and work on projects that they are interested in for 20% of their given day. According to (Heick, 2014), the study and work is motivated intrinsically, not extrinsically. The big idea for Google is that employees motivated by curiosity and passion will be happier, more creative, and more productive, which will benefit the company in terms of both morale, “off-Genius” productivity, and “on-Genius” performance.

Recommendations for Further Research

It was the intent of this qualitative case study to compare, analyze, and describe the distribution of complex thinking language embedded within the 2008 New Jersey Core Curriculum Content Standards (NJCCCS) and the 2017 New Jersey Student Learning Standards (NJSLS) in mathematics for Grades 4 and 5. This result of this study will lead to conversations by policymakers and educational stakeholders to review the NJSLS as well as the Common Core State Standards and the former New Jersey Core Curriculum Content Standards at the local, state, and national levels. Based on the evidence gathered from this study, I recommend that the NJSLS be reviewed strategically and thus revised to ensure that complex thinking live within each of the standards. As a result of the comparative nature of this study between the former NJCCCS and the current NJSLS, educational stakeholder groups will be encouraged to review the latter set of standards (NJCCCS) as they were found to possess higher levels of cognitive complexity.

The creation of an educational task force must be established and should include practicing administrators and teachers who are currently in the field. The purpose of this task force of practicing professionals is to determine through a review of the standards if the NJSLS can be saved through the incorporation of the complex thinking embedded within the standards or if the standards should be dismissed and new standards established with the mindset that cognitive complexity be embedded within all standards. It is recommended that the standards be revised ensuring that cognitive complexity be embedded within all standards, including sub-standards. The rationale is that students graduating from New Jersey public schools must be able to compete with their counterparts from across the United States as well as the world. Absence of cognitive complexity will not provide our students with an even playing field to compete with their counterparts.

The replication of this study or related studies can be conducted utilizing Hess's Cognitive Rigor Matrix. The study I conducted utilized Webb's Depth of Knowledge. While there is no simple one-to-one correspondence between these complexity schemas to articulate cognitive rigor, the superposition of Bloom's Taxonomy and Webb's Depth of Knowledge Levels was originally expressed in matrix form by Hess (Hess, 2006, 2006b) for use in states where the conversation about cognitive complexity as part of the test design and item development process was just beginning. According to Hess (2006), the CR matrix allows educators to uniquely categorize and examine standards that appear prominently in curriculum and instruction. Finally, further research can be done to analyze the assessed curriculum through conceptual framework such as Hess's Cognitive Rigor Matrix (Hess, Carlock, Jones, & Walkup, 2009) or Webb's Depth of Knowledge, (Webb et al., 2005).

Summation

The purpose of this study was to determine if cognitive complexity levels that yielded a more rigorous approach were included within both the 2008 New Jersey Core Curriculum Content Standards and the 2017 New Jersey Student Learning Standards. If this was in fact the case, it was the role of the researcher to provide evidence of how much was contained within each set of learning standards. The study showed that, overall, New Jersey's former NJCCCS in Grades 4 and 5 mathematics provided more opportunities for cognitive complexity when compared to the more current NJSLS in Grades 4 & 5 mathematics. Through this study, understanding that an intended curriculum (content standards) and cognitive complexity distribution that curriculum can have on instructional pedagogy and practice, I am hopeful that conversations amongst stakeholder groups at both the local and state levels begin to take form and perhaps provide revisions to the New Jersey Student Learning Standards higher cognitive complexity across grade levels. It is the hope of educators holistically that we provide our students with the most rigorous, sound standards that will ensure they are college and career ready as they exit Grade 12.

The Grade 4 and 5 NJSLS mathematics standards did not have any examples of level four extended thinking. The concept of 21st-century skills does not have a precise definition, but is intended to convey the idea that changes in technology and culture are leading to changing demands in the workplace, and so the skills that are required in today's and the future workplace are different from those required in the past (Autor, Levy, & Murnane; 2003; Levy & Murnane, 2004).

According to P21, in addition, workforce skills and demands have changed dramatically in the last 20 years. The rapid decline in "routine" work has been well documented by many researchers and organizations. At the same time, there has been a rapid increase in jobs involving non-routine, analytic, and interactive communication skills. Today's job market requires competencies such as critical thinking (P21, 2014, p. 5). Some commentators from business, economics, and education circles argue that the types of higher-order thinking skills that students need to be globally competitive include creative thinking and strategic thinking. For example, the IBM Corporation (2012), the United States Council on Competitiveness (2012), the Institute for Management Development (2012), the Organisation for Economic Cooperation and Development [OECD] (2013), Pink (2006), Robinson (2011), and Zhao (2012), and others identified variations of creative and/or strategic thinking they believe are important skills that high school graduates need in order to access better options for college, careers, and global economic competitiveness.

Similarly, Cisco Systems Inc., Intel Corporation, Microsoft Corporation, and the University of Melbourne (2010) drew similar conclusions from The Assessing and Teaching of 21st Century Skills (ATC21S) study. They found higher-order thinking related to greater global competitiveness. The results from the ATC21S identified and categorized skills that future employees will need in order to remain viable in the global economy. The ATC21S study divided the skills into four categories, one of which was based exclusively on creative and strategic thinking:

- Ways of thinking: creativity, critical thinking, problem solving, decision making, and learning
- Ways of working: communication and collaboration
- Tools for working: information and communications technology (ICT) and information literacy
- Skills for living in the world: citizenship, life and career, and personal and social responsibility.

According to the Organisation for Economic Cooperation and Development (2010), changes in the labor market have increased the need for all individuals to attain higher levels of education. However, additional years of formal education might not be enough. Many advanced economies rely on people who possess skills and dispositions that transcend content knowledge and discipline-centered school subjects. Creativity, innovation, and collaboration are some skills and dispositions deemed important for the 21st-century globalized economy. Skilled jobs are increasingly centered on solving unstructured problems and effectively analyzing information. In addition, artificial intelligence (AI) is increasingly substituting for manual labor and being infused into most aspects of life and work.

Preparing for the Future

According to SAS (2017), artificial intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs, and perform human-like tasks. Most AI examples that you hear about today, from chess-playing computers to self-driving cars, rely heavily on deep learning and natural language processing. Using these technologies, computers can be trained to accomplish specific tasks by processing large amounts of data and recognizing patterns in the data.

AI automates repetitive learning and discovery through data. But AI is different from hardware-driven, robotic automation. Instead of automating manual tasks, AI performs frequent, high-volume, computerized tasks reliably and without fatigue. For this type of automation, human inquiry is still essential to set up the system and ask the right questions (SAS, 2017). There are benefits to the AI being integrated into the educational arena. Teachers and students have a wide range of tools available, ranging from Google searches, in which alternate search terms are instantly suggested, citation generators, plagiarism checkers, and even Siri has become a popular tool for searches. An astounding amount of information is generated instantly, far more advanced from thirty years ago and society's reliance on card catalogs, calculators, and books (Poth, 2018).

AI also makes knowledge storage increasingly obsolete and makes critical thinking, creativity, problem solving, adaptability, and innovative thinking more important. Curriculum standards that lack consistent opportunities for students to develop higher-order thinking might be preparing students for the past, not the future in terms of economic viability. Unfortunately, things like the Common Core are already obsolete because everything in terms of Core or the New Jersey Student Learning Standards can already be accomplished by artificial intelligence. Students have the ability to Google or use Siri to find responses to questions without referencing standards or their teachers. According to Dickson (2017), traditionally, schools adopt a one-size-fits-all approach to teaching. But students learn at different paces and have different progress rates. Meanwhile, teachers often find it hard to identify and deal with the educational needs of students attending their classes. This is a problem that Artificial Intelligence is solving. Machine-learning algorithms, programs that glean patterns from data and provide insights and suggestions help teachers find gaps in their teachings and point to where students are struggling with subject matter; hence, why things like the Core or NJSLS are already obsolete.

John Dewey rejected the notion that schools should focus on repetitive, rote memorization and proposed a method of "directed living" in which students would engage in real-world, practical workshops to demonstrate their knowledge through creativity and collaboration (Miettinen, 2000). The American Society for Training and Development (2010) identified innovative thinking and action, the ability to think creatively, and the ability to generate new ideas and solutions to challenges at work "as crucial competencies and skills students will need to succeed in the global economy" (p. 13). The National Education Association (NEA) (2012), the largest public educator special interest group in the U.S., warned its members that their students will not be able to meet the varied demands of a global economy and join the 21st-century workforce unless schools prepare them with the skills to create and innovate (p. 24). The workforce is a critical component to any organization. It is the dedicated and skilled tech employees who help to ensure growth, global competitiveness, continued innovation, and economic impact for the tech sector and the country.

In essence, educator sectors cannot be passive when it comes to influencing educational policy. The overall goal in educational reform is to have students who are college and career ready. The detrimental impact of standardization will have lasting effects on New Jersey's students. It is vital that cognitive complexity is considered in the development of intended curriculum. Students must be in the position to receive experiences that allow for the development of their complex thinking skills. These experiences will provide millennials with an education that will lead them toward a college and career ready trajectory.

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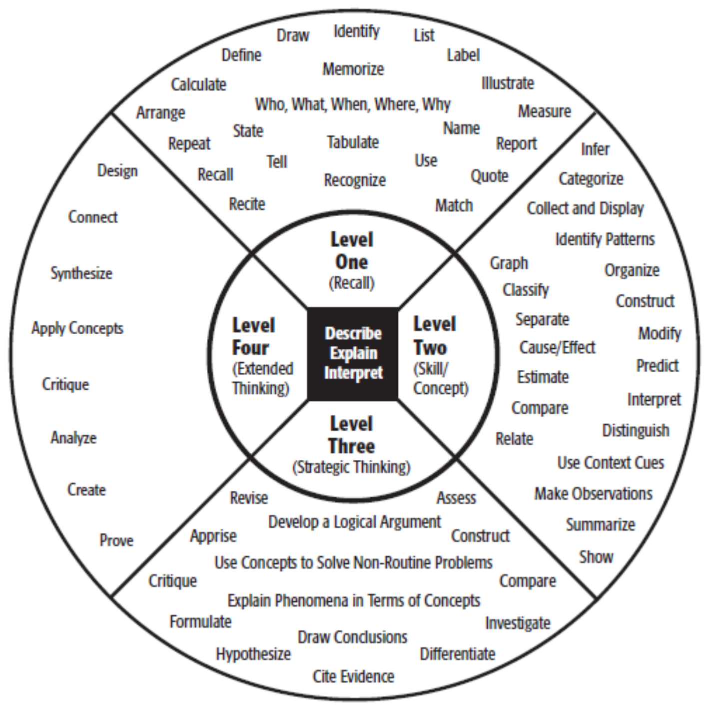
Appendix A: Webb's Depth of Knowledge Wheel

Depth of Knowledge (DOK) Levels



Level One Activities	Level Two Activities	Level Three Activities	Level Four Activities
Recall elements and details of story structure, such as sequence of events, character, plot and setting. Conduct basic mathematical calculations. Label locations on a map. Represent in words or diagrams a scientific concept or relationship. Perform routine procedures like measuring length or using punctuation marks correctly. Describe the features of a place or people.	Identify and summarize the major events in a narrative. Use context cues to identify the meaning of unfamiliar words. Solve routine multiple-step problems. Describe the cause/effect of a particular event. Identify patterns in events or behavior. Formulate a routine problem given data and conditions. Organize, represent and interpret data.	Support ideas with details and examples. Use voice appropriate to the purpose and audience. Identify research questions and design investigations for a scientific problem. Develop a scientific model for a complex situation. Determine the author's purpose and describe how it affects the interpretation of a reading selection. Apply a concept in other contexts.	Conduct a project that requires specifying a problem, designing and conducting an experiment, analyzing its data, and reporting results/ solutions. Apply mathematical model to illuminate a problem or situation. Analyze and synthesize information from multiple sources. Describe and illustrate how common themes are found across texts from different cultures. Design a mathematical model to inform and solve a practical or abstract situation.

Webb's Depth of Knowledge (Webb, 2005)

Appendix B: Coding NJCCCS Grade 4

Standard Number	Standard	Level
4.1.4 A. Number Sense Coding	1.Building upon knowledge and skills gained in preceding grades, students will use real life experiences, physical materials, and technology to construct meanings for numbers	2 New Life Experiences in order to conduct and construct (DOK)
	● Whole numbers through millions	2 To construct meaning from real life is a 2 (DOK)
	● Commonly used fractions (denominators ,3,4,5,6,8,10,12, and 16) as a part of a whole, as a subset of a set and as a location on a number line	2 New Life Experiences in order to conduct and construct (DOK)
	● Decimals through the hundredths	2 New Life Experiences in order to conduct and construct (DOK)
	2. Demonstrate an understanding of place value and concepts	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	3. Demonstrate a sense of the relative magnitudes of numbers	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	4. Understand the various uses of numbers	2 Describing non-trivial numbers; carrying out experimental procedures (HESS CRM)
	● Counting, measuring, labeling, and locating	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	5. Use concrete and pictorial models to relate whole numbers, commonly used fractions, and decimals to each other and to represent equivalent forms of the same number.	1 Calculate, measure, apply a rule. Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	6. Compare and order numbers	2
	7. Explore settings that give rise to negative numbers. ● Temperatures below O, debts ● Extension of the number line	1 One step, well-defined, straight algorithmic procedures (DOK)
4.1.4B. Numerical Operations Coding	1. Develop the meanings of four basic arithmetic operations by modeling and discussing a large variety of problems	2 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	● Addition, subtraction: joining, separating, comparing	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)

	• Multiplication: repeated addition, area/array • Division: repeated subtraction, sharing	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	2. Develop proficiency with basic multiplication and division number facts using a variety of fact strategies and then commit them to memory.	1 Calculate, measure, apply a rule. (HESS CRM)
	3. Construct, use, explain procedures for performing whole number calculations and with:	2 Describing Non-Trivial Patterns- Visualization skills are explored here (DOK)
	• Pencil-and-paper	2 Describing Non-Trivial Patterns- Visualization skills are explored here (DOK)
	• Mental math	2 Describing Non-Trivial Patterns- Visualization skills are explored here (DOK)
	• Calculator	2 Describing Non-Trivial Patterns- Visualization skills are explored here (DOK)
	4. Use efficient and accurate paper procedures for computation with whole numbers	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	• Addition of 3-digit numbers	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	• Subtraction of 3-digit numbers	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	• Mult. of 3-digit numbers	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	• Division of 3-digit numbers by 1-digit numbers	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	5. Construct and use procedures for performing decimal addition and subtraction.	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	6. Count and perform simple computations with money.	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	• Standard dollars and cents notation	1 Recall, Observe, & Recognize facts, principles, and properties (HESS CRM)
	7. Select pencil-and-paper, mental math, or a calculator as the appropriate computation method in a given situation depending on the context and numbers.	2 Describing Non-Trivial Patterns- Visualization skills are explored here (DOK)
	8. Check the reasonableness of results	2 Describing Non-Trivial Patterns-

	of computation.	Visualization skills are explored here (DOK)
	9. Use concrete models to explore addition and subtraction with fractions.	1 Solve linear equations. Solve one step problem (HESS CRM)
	10. Understand and use the inverse relationships between addition and subtraction and between multiplication and division.	2 Describing Non-Trivial Patterns-Visualization skills are explored here (DOK)
4.1.4 C Estimation Coding	1. Judge without counting whether a set of objects has less than, more than, or the same number of objects as a reference set.	2 Extend a pattern, specify, and explain relationship (HESS CRM)
	2. Construct and use a variety of estimation strategies for estimating both quantities and the results of computations	2 Make and explain estimates (HESS CRM)
	3. Recognize when an estimate is appropriate and understand the usefulness of an estimate as distinct from an exact answer.	2 Make and explain estimates (HESS CRM)
	4. Use estimation to determine whether the result of a computation is reasonable.	2 Make and explain estimates (HESS CRM)
4.2.4A. Geometric Properties Coding	1. Identify and describe spatial relationships of two or more objects in space. ● Direction, orientation, and perspectives ● Relative shapes and sizes ● Shadows of everyday objects	2 Extend a pattern, specify, and explain relationship (HESS CRM)
	2. Use properties of standard 2 and 3 dimensional shapes to identify, classify, and describe them ● Vertex, edge-face, side, angle ● 3D Figures ● 2D Figures ● Inclusive Relationships-squares are rectangles, cubes are rectangular prisms.	2 Making observations and collecting data. Interpretation information (DOK)
	3. Identify and describe relationships among 2 dimensional shapes ● Congruence ● Lines of Symmetry	2 Making observations and collecting data. Interpretation information (DOK)
	4. Understand and apply concepts involving lines, angles, and circles ● Point, line, line segment, endpoint ● Parallel, perpendicular ● Angles ● Circles	2 Making observations and collecting data. Interpretation information (DOK)

	5. Recognize, describe, extend, and create space-filling patterns	3 Drawing conclusions from observations; citing evidence and developing a logical argument for concepts (DOK)
4.2.4.B Transforming Shapes Coding	1. Use simple shapes to cover an area (Tessellations).	2Making observations and collecting data. Interpretation information (DOK)
	2. Describe and use geometric transformations (slide, flip, turn)	2 Making observations and collecting data. Interpretation information (DOK)
	3. Investigate the occurrence of geometry in nature and art.	4 Designing and conducting experiments and projects. Making connections between a finding and related concepts and phenomena (DOK)
4.2.4C. Coordinate Geometry Coding	1. Locate and name points in the first quadrant on a coordinate grid.	1 Locate points on a grid or number line (HESS CRM)
	2. Use coordinates to give or follow directions from one point to another on a map or grid.	2 Organize or order data (HESS CRM)
4.2.4D Units of Measurement Coding	1. Understand that everyday objectives have a variety of attributes, each of which can be measured in many ways.	2 Identify the various ways of measurement (DOK)
	2. Select and use appropriate standard units of measure and measurement tools to solve real life problems	3 Use concepts to solve non-routine problems. Use and show reasoning, planning, and evidence (HESS CRM)
	● Length-Fractions of an inch (1/8, ¼, ½) mile, decimeter, kilometer	1 Recall/identify conversions among representations or numbers e.g., customary and metric measures (HESS CRM)
	● Area-Square Inch, square centimeter	1 Recall/identify conversions among representations or numbers e.g., customary, and metric measures (HESS CRM)
	● Volume-Cubic Inch, cubic centimeter	1 Recall/identify conversions among representations or numbers e.g., customary and metric measures (HESS CRM)
	● Weight-Ounce	1 Recall/identify conversions among representations or numbers e.g., customary and metric measures (HESS CRM)
	● Capacity-Fluid ounce, cup, gallon, millimeter	1 Recall/identify conversions among representations or numbers e.g., customary and metric measures (HESS CRM)
	3. Solve problems involving elapsed time.	2. Using Webb's DOK, the students are only required to solve problems.

		This is at a minimum a level 2. If the students were asked to solve two step problems, I could then move this indicator to Level 3.
	4. Develop and use personal referents to approximate standards of measure.	2 Categorize, classify materials based on characteristics, Construct models given criteria (HESS CRM)
	5. Incorporate estimation in measurement activities	2 Make and explain estimates, extend a pattern (HESS CRM)
4.2.4E Measuring Geometric Objects Coding	1. Determine the area of simple two-dimensional shapes on a square grid	2 Though determine area seems routine, incorporating that into a two dimensional design where area has to be solved is more than just routine. Level Two involves visualization of skills (DOK)
	2. Distinguish between perimeter and area and use each appropriately in problem-solving situations.	2 Distinguishing aspect moves this from just a habitual response (DOK)
	3. Measure and compare the volume of 3 Dimensional objects using materials such as rice or cubes.	2 Although measuring and comparing is a routine activity at a level 1, students utilizing cubes and rice brings this to a level 2 (DOK)
4.3.4 A Patterns Coding	1. Recognize, describe, extend, and create patterns.	2 The CREATE aspect moves this to a 2, beyond recall.
	● Descriptions using words, number sentences/expressions, graphs, tables, variables (e.g shape, blank, or letter)	1 Recall, observe, & recognize facts. Represent math relationships in words, pictures, and symbols (HESS CRM)
	● Sequences that stop or that continue infinitely	1 Identify a trend or pattern (HESS CRM)
	● Whole number patterns that grow or shrink as a result of repeatedly adding, subtracting, multiplying by, or dividing by a fixed number	1 Recall, observe, & recognize facts (HESS CRM)
	● Sequences can often be extended in more than one way (e.g., the next term after 1, 2, 4…could be 8 or 7, or…)	2 This goes to create again beyond meaning a 2 (DOK)
4.3.4 B. Functions and Relationships Coding	1. Use concrete and pictorial models to explore the basic concept of a function.	1 Basic concepts; this allows for recalling of information (DOK)
	● Input/output tables, T-Charts	2 Interpreting Data from a simple graph (HESS CRM)
	● Combining two function machines	2 Extend a pattern, specify, and explain relationships (HESS CRM)
	● Reversing a function machine	2 Extend a pattern, specify, and explain relationships (HESS CRM)
4.3.4 C Modeling	1. Recognize and describe change in quantities	2 This seems more like it could cross over into a 2 (DOK)

	● Graphs representing change over time. ● How change in one physical quantity can produce a corresponding change in another.	
	2. Construct and solve simple sentences involving any one operation.	2 Construct models given criteria. Make basic inferences or logical predictions from data/observations (HESS CRM)
4.3.4 D Procedures	1. Understand and use the concepts of equals, less than, and greater than in simple number sentences ● Symbols (=, <, >)	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
	2. Understand, name, and apply the properties of operations and numbers	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
	● Commutative (e.g., 3x7=7x3)	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
	● Identify element for multiplication is 1 (e.g., 1x8=8)	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
	● Associative (e.g., 2x4x25 can be found by first multiplying either 2x4 or 4x25)	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
	● Division by zero undefined	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
	● Any number multiplied by zero is zero	1 Evaluate an expression. Recall, observe, and recognize fact, principles, or properties (HESS CRM)
4.4.4 A Data Analysis	1. Collect, generate, organize, and display data in response to questions, claims, or curiosity	3 This could be analysis (DOK)
	● Data collected from around the school environment	3This has the potential to be a 3 (DOK) based on the ability to organize and collect data from varying sources
	2. Read, interpret, construct, analyze, generate questions about, and draw inferences from displays of data	3 Compare information within or across data sets or texts. Explain, generalize, or connect ideas using supporting evidence (HESS CRM)
	● Pictograph, bar graph, line	2 Predicated on generating and

	plot, line graph, table	drawing inferences
	● Average (mean), most frequent (mode), middle term (median)	1 Recall, observe, & Recognize facts, principles, properties (HESS CRM)
4.4.4 B Probability	1. Use everyday events and change devices, such as dice, coins, and unevenly divided spinners, to explore concepts of probability.	2 Specify and explain relationships cause/effect as an example (HESS CRM)
	● Likely, unlikely, certain, impossible, fair, unfair	2 Specify and explain relationships cause/effect as an example (HESS CRM)
	● Most likely, less likely, equally likely	2 Specify and explain relationships cause/effect as an example (HESS CRM)
	● Probability of tossing “heads” does not depend on outcomes and express them as fractions	2 Specify and explain relationships cause/effect as an example (HESS CRM)
	2. Determine probabilities of simple events based on equally likely outcomes and express them as fractions	2 Specify and explain relationships cause/effect as an example (HESS CRM)
	3. Predict probabilities in a variety of situations (e.g., given the number of items of each color in a bag, what is the probability that an item picked will have a particular color) ● What students think will happen ● Collect data and use that data to predict the probability (experimental) ● Analyze all possible outcomes to find the probability (theoretical)	3 This could lead to conjecture so it could be a 3 (CRM)
4.4.4 C Discrete Mathematics-Systematic Listing and Counting	1. Represent and classify data according to attributes, such as shape, color, and relationships	2 This goes beyond retrieving information (CRM)
	● Venn Diagrams	2 Comparing data requires first identifying characteristics of objects or phenomena and then grouping or ordering objects (DOK)
	● Numerical and alphabetical order	1 Recall, observe, and recognize facts principles, and properties (HESS CRM)
	2. Represent all possibilities for a simple counting situation in an organized way and draw conclusions from this representation	2 Comparing data requires first identifying characteristics of objects or phenomena and then grouping or ordering objects (DOK)
	● Organized lists, charts, tree	2 Requires to the students to make

	diagrams	it, not only look at it (DOK)
	● Dividing into categories (e.g., to find the total number of rectangles in a grid, find the number of rectangles of each size and add the results)	1 Apply an algorithm or formula. Recall, observe, and recognize facts (HESS CRM)
4.4.4 D Discrete Mathematics-Vertex Edge Graphs and Algorithms	1. Follow, devise, and describe practical sets of directions (e.g., to add two 2-digit numbers)	2 Devise is the key term here that moves this to 2
	2. Play two person games and devise strategies for winning the game.	3 Use concepts to solve non-routine problems. Make and justify conjectures (HESS CRM)
	3. Explore vertex-edge graphs and tree diagrams ● Vertex, edge, neighboring/adjacent number of neighbors ● Path, circuit (i.e. path that ends at its starting point)	4 Relate mathematical or scientific concepts to other content areas, other domains, or other concepts (HESS CRM)
	4. Find the smallest number of colors need to color a map or a graph	3 Develop a scientific/mathematical model for a complex situation. Generalize a pattern. Use concepts to solve non-routine problems (HESS CRM)

Appendix C: Coding NJCCCS Grade 5

Standard Number	Standard	Level
4.1.5 A Number Sense	1. Use real-life experiences, physical materials, and technology to construct meanings for numbers.	2 Specify and explain relationships e.g., non-examples; cause and effect. Construct models given criteria (HESS CRM)
	• All fractions as part of a whole, as a subset of a set, as a location on a number line, and as divisions of whole numbers.	2 Specify and explain relationships e.g., non-examples; cause and effect. Construct models given criteria (HESS CRM)
	• All decimals	2 (Specify and explain relationships e.g., non-examples; cause and effect. Construct models given criteria HESS CRM)
	2. Demonstrate a sense of relative magnitudes of numbers.	2 Noticing or describing non-trivial patterns and numbers (DOK)
	3. Recognize the decimal nature of United States currency and compute with money.	1 Recall. Observe, and recognize facts (HESS CRM)
	4. Use whole numbers, fractions, decimals to represent equivalent forms of the same number.	1 Read, write, and compare numbers decimals, whole numbers (HESS CRM)
	5. Develop and apply number theory concepts in problem solving situations • Primes, factors, multiples	3 Requires reasoning, planning, using evidence. More demanding reasoning identified here (DOK)
	6. Compare and order numbers	1 Read, write, and compare numbers. Recall, observe, & recognize facts (HESS CRM)
4.1.4 B Numerical Operations	1. Recognize the appropriate use of each arithmetic operation in problem situations	1 Read, write, and compare numbers. Recall, observe, & recognize facts (HESS CRM) Simple recognition/identification

	2. Construct, use, and explain procedures for performing addition and subtraction with fractions and decimals with ● Paper-and-pencil ● Mental mathematics ● Calculator	Level 2 Use models/diagrams to represent or explain mathematical concepts (HESS CRM)
	3. Use an efficient and accurate pencil-paper procedure for division of a 3-digit number by a 2-digit number.	Level 2 Describing Non-Trivial Patterns-Visualization skills are explored here (DOK)
	4. Select pencil-and-paper, mental mathematics, or a calculator as the appropriate computation method in a given situation depending on the context and numbers.	Level 2 Select a procedure according to criteria and perform it (HESS CRM)
	5. Check the reasonableness of computations	Level 2 Select a procedure according to criteria and perform it (HESS CRM)
	6. Understand and use the various relationships among operations and properties of operations.	Level 2 Specify and explain relationships (HESS CRM)
4.2.5 A Geometric Properties	1. Identify, describe, compare, and classify polygons ● Triangles by angles and sides ● Quadrilaterals, including squares, rectangles, parallelograms, trapezoids, rhombi ● Polygons by number of sides ● Equilateral, equiangular, regular ● All points equidistant from a given point form a circle.	Level 2 Classifying and organizing data (DOK)
	2. Identify similar figures	Level 1 Recall, observe, & recognize facts, principles, properties (HESS CRM)

		One step operations are identified here (DOK)
	3. Understand and apply the concepts of congruence and symmetry (line and rotational)	Level 2 Use models/diagrams to represent or explain mathematical concepts (HESS CRM)
	4. Understand and apply concepts involving lines and angles ● Notation for line, ray, angle, line segment ● Properties of parallel, perpendicular, and intersecting lines ● Sum of the measures of the interior angles of a triangle is 180 degrees	Level 2 Select a procedures according to criteria and perform it (HESS CRM)
4.2.5 B Transforming Shapes	1. Use a translation, a reflection, or a rotation to map one figure onto another congruent figures.	Level 2 Compare and contrast figures or data. Solve routine problems applying multiple concepts or decision points (HESS CRM)
	2. Recognize, identify, and describe geometric relationships and properties as they exist in nature, art, and other real world settings.	Level 4 Relate mathematics or scientific concepts to other content areas, other domains, or other concepts (HESS CRM)
4.2.5 C Coordinate Geometry	1. Create geometric shapes with specified properties in the first quadrant on a coordinate grid.	Level 3 Use concepts to solve non-routine problems. Describe, compare, and contrast solution methods (HESS CRM)
4.2.5 D Units of Measurement	1. Select and use appropriate units to measure angles and area.	Level 2 Select a procedure according to task needed and perform it (DOK)
	2. Convert measurement units within a system (e.g., 3 feet =____inches)	Level 2 Goes beyond habitual because they have to recognize/determine which conversion formula to use by analyzing the units/comparing the units and whether to X or divide, etc. and then apply those (DOK)
	3. Know approximate	Level 1 Make conversions among

	equivalents between the standard and metric systems (e.g., kilometer is approximately 6/10 of a mile.)	representations or numbers, or within and between customary and metric measures (HESS CRM)
	4. Use measurements and estimates to describe and compare phenomena.	Level 2 (Though conversations and measurements are a level 1, the students being asked to describe and compare based on a phenomena bring this standard to a Level 2 DOK)
4.2.4 E Measuring Geometric Objects	1. Use a protractor to measure angles.	Level 2 Though conversations and measurements are a level 1, the students being asked to describe and compare based on a phenomena bring this standard to a Level 2 (DOK)
	2. Develop and apply strategies and formulas for finding perimeter and area ● Square ● Rectangle	Level 3 The develop part allows for Level 3 if the teacher takes advantage of it. I can image multiple ways to calculate and apply an original formula for those (DOK)
	3. Recognize that rectangles with the same perimeter do not necessarily have the same areas and vice versa.	Level 1 Apply algorithm or formula e.g., area/perimeter (HESS CRM)
	4. Develop informal ways of approximating the measures of familiar objects (e.g., use a grid to approximate the area of the bottom of one's foot.)	Level 3 Complete original thinking on the part of the student based on going beyond what they already know. This could be synthesis in the hands of a skilled teacher (DOK)
4.3.4 A Patterns	1. Recognize, describe, extend, and create patterns involving whole numbers.	Level 3 The describe a pattern is "generalizing" a pattern (DOK)
	● Descriptions using tables, verbal rules, simple equations, and graphs	2 Identify a pattern. Follow simple procedures (HESS CRM)
4.3.5. B Functions and Relationships	1. Graph points satisfying a function from T-charts from verbal rules, and from simple equations.	2 Interpret data from a simple graph.
	2. Describe arithmetic	Level 2 Specify and explain relationships

	operations as functions, including combining operations and reversing them.	(HESS CRM)
4.3.5 C Modeling	1. Draw freehand sketches of graphs that model real phenomena and use such graphs to predict and interpret events. ● Changes over time ● Rates of change	3 Requiring reasoning, using evidence to complete a task. These activities are not simple tasks; rather more complex scenarios that require further critical thinking (DOK)
	2. Use number sentences to model situations. ● Using variables to represent unknown quantities ● Using concrete materials, tables, graphs, verbal rules, algebraic expressions/ equations	3 Requiring reasoning, using evidence to complete a task. These activities are not simple tasks; rather more complex scenarios that require further critical thinking (DOK)
4.3.5 D Procedures	1. Solve simple linear equations with manipulatives and informally ● Whole-number coefficients only, answers also whole numbers ● Variables on one side of equation	Level 2 This goes beyond habitual — especially the variables on one side. This is abstract for an 11 year old (HESS CRM)
4.4.5 A Data Analysis	1. Collect, generate, organize, and display data.	Level 2 Organize and order data (HESS CRM)
	● Data generated from surveys	Level 2 (Organize and order data. HESS CRM)
	2. Read, interpret, select, construct, analyze, generate questions about and draw inferences from displays of data.	Level 3 Analysis of data (HESS CRM)
	● Bar graph, line graph, circle graph, table	Level 2 Interpret data from a simple graph. Make basic inferences or logical predictions from data/observation (HESS

		CRM)
	• Range, median, and mean	Level 2 Interpret data from a simple graph. Make basic inferences or logical predictions from data/observation (HESS CRM)
	3. Respond to questions about data and generate their own questions and hypotheses.	Level 3 Analyze similarities and differences between procedures or solutions. Make and justify conjectures (HESS CRM)
4.4.5 B Probability	1. Model situations involving probability using simulations with spinner and dice and theoretical models.	Level 3 Use concepts to solve non-routine problems. Explain, generalize, or connect ideas using supporting evidence (HESS CRM)
	2. Determine probabilities of events. • Event, probability of an event • Probability of certain events is 1 and of impossible event is O	Level 2 Noticing or describing non-trivial patterns, explaining the purpose and use of experimental procedures (DOK)
	3. Determine probability using intuitive, experimental, and theoretical methods. • Given numbers of various types of items in a bag, what is the probability that an item of one type will be picked? • Given data obtained experimentally, what is the likely distribution of items in the bag?	Level 2 Noticing or describing non-trivial patterns, explaining the purpose and use of experimental procedures (DOK)
4.4.5 C Discrete Mathematics-Systematic Listing and Counting	1. Solve counting problems and justify that all possibilities have been encumbered without duplication.	Level 3 Explain thinking/reasoning when more than one solution or approach is possible (HESS CRM)
	• Organized lists, charts, tree diagrams, tables	Level 3 Use and show reasoning, planning, and evidence (HESS CRM)

	2. Explore the multiplication principle of counting in simple situations by representing all possibilities in an organized way.	Level 2 Making observations and collecting data; classifying organizing and comparing data (DOK)
4.4.5 D Discrete Mathematics Vertex-Edge Graphs and Algorithms	1. Devise strategies for winning simple games (e.g., start with two piles of objects, each of two players in turn removes any number of objects from a single pile, and the person to take the last group of objects wins) and express those strategies as sets of directions.	Level 4 Select or devise approach among many alternatives to solve a problem (HESS CRM)

Appendix D: Coding NJSLS Grade 4

Standard Number	Standard	Level
4.OA	**A. Use the four operations with the whole numbers to solve problems.**	
	1. Interpret a multiplication equation as comparison, e.g., interpret 35 = 5x7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations.	1 Recall, observe, & recognize facts. Rational is that the information is interpreted is from previous grade levels (HESS CRM)
	2. Multiply or divide to solve word problems involving multiplicative comparisons, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem, distinguishing multiplicative comparison from additive comparison.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	3. Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.	3. This standard is requiring reasoning, planning, using evidence than simply solving multi-step word problems (DOK)
	B. Gain familiarity with factors and multiples.	
	4. Find all factor pairs for a whole number in range 1-100. Recognize that a whole number is a multiple of each of its factors. Determine whether a given whole number in the range 1-100 is a multiple of a given one-digit number. Determine whether a given whole number in the range 1-100 is prime or composite.	1 Recall, observe, & recognize facts. Rational is that the information is interpreted is from previous grade levels (HESS CRM)
	C. Generate and analyze patterns.	
	5. Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that	3 Requiring thinking, planning, using evidence (DOK)

	were not explicit in the rule itself. *For example, given the rule "add 3" and the starting number 1, generate terms in the resulting of the sequence and observe that the terms appear to alternate between odd and even numbers. Explain informally why the numbers will continue to alternate in this way.*	
4.NBT	**A. Generalize place value understanding for multi-digit whole numbers**.	
	1. Recognize that in a multi-digit whole number, a digit in one place represents ten times what it represents in the place to its right. For example recognize that 700÷ 70=10 by applying concept of place value and division.	1 Recall, observe, & recognize facts. Rational is that the information is interpreted is from previous grade levels (HESS CRM)
	2. Read and write multi-digit whole numbers using base-ten numerals, number names, and expanded form. Compare two on meanings of the digit in each place, using >, =, and< symbols to record the results of comparisons.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	3. Use place value understanding to round multi-digit whole numbers to any place.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	B. Use place value understanding and properties to perform multi-digit arithmetic.	
	4. Fluently add and subtract multi-digit whole numbers using standard algorithm.	1 Recall, observe, & recognize facts. Rational is that the information is interpreted is from previous grade levels (HESS CRM)
	5. Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)

	6. Find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays and/or area models.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
4.NF	**A. Extend understanding of fraction equivalence and ordering.**	
	1. Explain why a fraction a/b is equivalent to a fraction (n× a) / (n×b) by using visual fraction models, with attention to how number and size of the parts differ even though the two fractions themselves are the same. Use the principle to recognize and generate equivalent fractions.	3 Requiring thinking, planning, using evidence (DOK)
	2. Compare two fractions with different numerators and denominators, e.g., by creating common denominators or numerators, or by comparing to a benchmark fraction such as ½ Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the comparisons with symbols >, =, or <, and justify the conclusion, e.g., by using a visual fraction model.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	B. Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.	
	3. Understand a fraction a/b with a> 1 as a sum of fraction 1/b.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	a. Understand addition and subtraction of fraction as joining and separating parts referring to the same whole.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	b. Decompose a fraction into a sum of fractions with the same denominator in more than way, recording each decomposition by	3 Requires reasoning, planning, and using evidence (DOK)

	an equation. Justify decompositions, e.g., by using a visual fraction mode. Examples: 3/8=1/8 + 1/8 + 1/8; 3/8 = 1/8 + 2/8; 21/8= 1 + 1 + 1/8.	
	c. Add and subtract mixed numbers with like denominators, e.g., by replacing each mixed number with an equivalent fraction, and/or by using properties of operations and the relationship between addition and subtraction.	1 Recalling information (DOK)
	d. Solve word problems involving addition and subtraction of fractions referring to the same whole and having like denominators, e.g., by using visual fraction models and equations to represent the problem.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	4. Apply and extend previous understandings of multiplication to multiply a fraction by a whole number.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	a. Understand a fraction a/b as a multiple of 1/b.	1 Recalling of information (DOK)
	b. Understand a multiple of a/b as a multiple of 1/b, and use this understanding to multiply a fraction by a whole number.	2 Includes the engagement of some mental processing beyond an habitual response. (DOK)
	c. Solve word problems involving multiplication of a fraction by a whole number, e.g., by using visual fraction models and equations to represent the problem.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	C. Understand decimal notation for fractions, and compare decimal fractions.	
	5. Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with	2 Includes the engagement of some mental processing beyond an habitual response (DOK)

	respective denominators 10 and 100.	
	6. Use decimal notation for fractions with denominators 10 or 100.	1 Recalling of Information (DOK)
	7. Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions, e.g., by using a visual model.	2 Includes the engagement of some mental processing beyond an habitual response (DOK) Also, making observations as well as interpretation of data (in this case decimals).
4.MD	**A. Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.**	
	1. Know relative sizes of measurement units within one system of units including km, m, cm. mm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two column table.	1 Recalling of information & Recognition of Facts (HESS CRM)
	2. Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	3. Apply the area and perimeter formulas for rectangles in real world and mathematical problems.	2 Application moves this from a 1 to a 2.
	B. Represent and interpret data.	
	4. Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Solve problems	2 Includes the engagement of some mental processing beyond an habitual response (DOK)

	involving addition and subtraction of fractions by using information presented in line plots. For example, from a line plot find and interpret the difference in length between the longest and shortest specimens in an insect collection.	
	C. Geometric measurement: understand concepts of angle and measure angles.	
	5. Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement:	1 Includes the recall of information such as a fact and definitions (DOK)
	a. An angle is measured with reference to a circle with its center at the common endpoint of the rays, by considering the fraction of the circular arc between the points where the two rays intersect the circle. An angle that turns through 1/360 of a circle is called a "one- degree angle," and can be used to measure angles.	
	b. An angle that turns through n one-degree angles is said to have an angle measure of n degrees.	1 Includes the recall of information such as a fact and definitions (DOK)
	6. Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	7. Recognize angle measure as additive. When an angle is decomposed into non-overlapping parts, the angle measure of the whole is the sum of the angle measures of the parts. Solve addition and subtraction problems to find unknown angles on a diagram in real world and mathematical problems, e.g., by using an equation with a symbol for the unknown angle measure.	2 Includes the engagement of some mental processing beyond an habitual response (DOK) This can go to an emergent level 3 extending the knowledge by thinking concretely to solve problems by finding unknown angles.
4.G	**A. Draw and identify lines and angles, and classify shapes by properties of their lines and angles.**	

	1. Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.	1 Recalling information and recognition of facts (HESS CRM)
	2. Classify two-dimensional figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size. Recognize right triangles as a category, and identify right triangles.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)
	3. Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.	2 Includes the engagement of some mental processing beyond an habitual response (DOK)

Appendix E: Coding NJSLS Grade 5

5th Grade Standards			
Operations and Algebraic Thinking 5.OA			
	A. Write and Interpret Numerical Expressions	DOK	Notes
1.	Use parentheses, brackets, or braces in numerical expressions, and evaluate expressions with these symbols.	1	The highest demand for students to successfully meet this expectation recall and use routine methods (DOK)
2.	Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them. For example, express the calculation “add 8 and 7, then multiply by 2” as 2 × (8 + 7). Recognize that 3 × (18932 + 921) is three times as large as 18932 + 921, without having to calculate the indicated sum or product.	1	The highest demand for students to successfully meet this expectation recall and use routine methods (DOK)
B.	Analyze Patterns and Relationships		
1.	Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane. For example, given the rule “Add 3” and the starting number 0, and given the rule “Add 6” and the starting number 0, generate terms in the resulting sequences, and observe that the terms in one sequence are twice the corresponding terms in the other sequence. Explain informally why this is so.	2	Basic inferences or logical predictions from data/observations (HESS CRM)
	Number and Operations in Base Ten		
A.	Understanding the Place Value System		
1.	Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.	1	Recall, observe, & recognize facts, principles, properties (HESS CRM)

2.	Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.	2	Specify and explain relationships. Construct models when given criteria (HESS CRM)
3.	Read, write, and compare decimals to thousandths. a. Read and write decimals to thousandths using base-ten numerals, number names, and expanded form, e.g., 347.392 = 3 × 100 + 4 × 10 + 7 × 1 + 3 × (1/10) + 9 × (1/100) + 2 × (1/1000). b. Compare two decimals to thousandths based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.	2	Noticing or describing non-trivial patterns, explaining the purpose and use of experimental procedures (DOK)
4.	Use place value understanding to round decimals to any place.	1	Recall, observe, & recognize facts, principles, and properties (HESS CRM)
	Perform operations with multi-digit whole numbers and with decimals to hundredths		
1.	Fluently multiply multi-digit whole numbers using the standard algorithm.	1	Recall, observe, & recognize facts, principles, and properties (HESS CRM)
2.	Find whole-number quotients of whole numbers with up to four-digit dividends and two-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.	2	Solve routine problems applying multiple concepts or decision points (HESS CRM)

3.	Add, subtract, multiply, and divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.	2	Solve routine problems applying multiple concepts or decision points (HESS CRM)
	Number and Operations-Fractions 5.NF		
A.	**Use equivalent fractions as a strategy to add and subtract fractions.**		
1.	Add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference of fractions with like denominators. For example, 2/3 + 5/4 = 8/12 + 15/12 = 23/12. (In general, a/b + c/d = (ad + bc)/bd.)	2	Solve routine problems applying multiple concepts or decision points (HESS CRM)
2.	Solve word problems involving addition and subtraction of fractions referring to the same whole, including cases of unlike denominators, e.g., by using visual fraction models or equations to represent the problem. Use benchmark fractions and number sense of fractions to estimate mentally and assess the reasonableness of answers. For example, recognize an incorrect result 2/5 + 1/2 = 3/7, by observing that 3/7 < 1/2.	2	Solve routine problems applying multiple concepts or decision points (HESS CRM)
B.	**Apply and extend previous understandings of multiplication and division to multiply and divide fractions.**		

1.	Interpret a fraction as division of the numerator by the denominator (a/b = a ÷ b). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g., by using visual fraction models or equations to represent the problem. For example, interpret 3/4 as the result of dividing 3 by 4, noting that 3/4 multiplied by 4 equals 3, and that when 3 wholes are shared equally among 4 people each person has a share of size 3/4. If 9 people want to share a 50-pound sack of rice equally by weight, how many pounds of rice should each person get? Between what two whole numbers does your answer lie?	2	Solve routine problems applying multiple concepts or decision points (HESS CRM)
	Apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction.	2	Solve routine problems applying multiple concepts or decision points (HESS CRM)
A.	Interpret the product (a/b) × q as a parts of a partition of q into b equal parts; equivalently, as the result of a sequence of operations a × q ÷ b. For example, use a visual fraction model to show (2/3) × 4 = 8/3, and create a story context for this equation. Do the same with (2/3) × (4/5) = 8/15. (In general, (a/b) × (c/d) = ac/bd.)	3	Use concepts to solve non-routine problems (HESS CRM)
B.	Find the area of a rectangle with fractional side lengths by tiling it with unit squares of the appropriate unit fraction side lengths, and show that the area is the same as would be found by multiplying the side lengths. Multiply fractional side lengths to find areas of rectangles, and represent fraction products as rectangular areas.	3	Solve routine problems applying multiple concepts or decision points (HESS CRM)
2.	**Interpret multiplication as scaling (resizing) by:**		
A.	Comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication.	2	Specify and explain relationships (HESS CRM)

B.	Explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence $a/b = (n \times a)/(n \times b)$ to the effect of multiplying a/b by 1.	3	Explain, generalize, or connect ideas using supporting evidence (HESS CRM)
3.	Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem.	3	Drawing conclusions from observations; citing evidence and developing a logical argument for concepts (DOK)
4.	Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions.	2	Extend a pattern-goes beyond recall (DOK)
A.	Interpret division of a unit fraction by a non-zero whole number, and compute such quotients. For example, create a story context for $(1/3) \div 4$, and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that $(1/3) \div 4 = 1/12$ because $(1/12) \times 4 = 1/3$.	3	Interpreting information with a creation of a story context moves this to a level 3 (DOK)
B.	Interpret division of a whole number by a unit fraction, and compute such quotients. For example, create a story context for $4 \div (1/5)$, and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that $4 \div (1/5) = 20$ because $20 \times (1/5) = 4$.	3	Interpreting information with a creation of a story context moves this to a level 3 (DOK)
C.	Solve real world problems involving division of unit fractions by non-zero whole numbers and division of whole numbers by unit fractions, e.g., by using visual fraction models and equations to represent the problem. For example, how much chocolate will each person get if 3 people share 1/2 lb of chocolate equally? How many 1/3-cup servings are in 2 cups of raisins?	3	Interpreting information with a creation of a story context moves this to a level 3 (DOK)

	Measurement and Data 5.MD		
A.	**Convert like measurement units within a given measurement system**		
1.	Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.	1	Make conversations among representations or numbers or, within and between customary and metric measures (HESS CRM)
	Represent and interpret data		
2.	Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Use operations on fractions for this grade to solve problems involving information presented in line plots. For example, given different measurements of liquid in identical beakers, find the amount of liquid each beaker would contain if the total amount in all the beakers were redistributed equally.	2	Select appropriate graph and organize & display data (HESS CRM)
C.	**Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition**		
1.	Recognize volume as an attribute of solid figures and understand concepts of volume measurement. a. A cube with side length 1 unit, called a “unit cube,” is said to have “one cubic unit” of volume, and can be used to measure volume. b. A solid figure which can be packed without gaps or overlaps using n unit cubes is said to have a volume of n cubic units.	2 2 2	Specify and explain relationships (HESS CRM) Specify and explain relationships (HESS CRM) Specify and explain relationships (HESS CRM)
2.	Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and non-standard units.	1	The highest demand for students to successfully meet this expectation recall and use routine methods (DOK)

3.	Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.	3	Use concepts to solve non-routine problems. Describe, compare, and contrast solution methods (HESS CRM)
A.	Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication.	2	Make and record observations, solve routine problems by applying multiple concepts or decision points (HESS CRM)
B.	Apply the formulas $V = l \times w \times h$ and $V = B \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole number edge lengths in the context of solving real world and mathematical problems.	3	Use concepts to solve non-routine problems, make and justify conjectures (HESS CRM)
C.	Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real world problems.	3	Use concepts to solve non-routine problems, make and justify conjectures (HESS CRM)
	Geometry 5.G		
A.	**Graph points on the coordinate plane to solve real-world and mathematical problems.**		
1.	Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).	1	Locate points on a grid or number on a number line (HESS CRM)

2.	Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.	2	Retrieve information from a table, graph, or figure and use it solve a problem (HESS CRM)
B.	**Classify two-dimensional figures into categories based on their properties**		
1.	Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.	2	Compare and contrast figures or data. Categorize, classify materials, data, figures based on characteristics (HESS CRM)
2.	Classify two-dimensional figures in a hierarchy based on properties	2	Compare and contrast figures or data. Categorize, classify materials, data, figures based on characteristics (HESS CRM)