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Critical Thinking in Curriculum: Designing an Instrument to Measure Identified Features

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CRITICAL THINKING IN CURRICULUM: DESIGNING AN INSTRUMENT TO MEASURE IDENTIFIED FEATURES

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This thesis is dedicated to

My future students

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ABSTRACT
CLAIRE GERSHON: Critical Thinking in Curriculum: Designing an Instrument to Measure Identified Features
(Under the direction of Dr. Brooke Whitworth)

Critical thinking is an increasingly important skill in our society and should be cultivated through education. Therefore, the curricula used in our schools should support students in developing critical thinking skills. This study aims to understand what aspects of curricula promote critical thinking, how to measure it, and whether or not current curricula meet these standards. After reviewing the literature, elements of curricula were identified as beneficial in promoting critical thinking. In teacher curricula materials, these are educative features such as identifying misconceptions, explanations of how to use formative assessment, and explanations of pedagogy. In student curricula materials, these educative features are language, DOK levels, and the problems and questions asked. These features were used to design a rubric and overall analysis to measure the potential for critical thinking within curricula. These tools were used to evaluate 3 curricula. Most of the materials did not support critical thinking. The identified elements of critical thinking support are not present in many curricula materials being used in schools today. Additional work is needed to ensure critical thinking is present in curricula if it is a skill we value for our students. In addition, future research will need to continue examining how we measure critical thinking in curricula and our classrooms.

Keywords: *critical thinking, curriculum, educative curriculum, mathematics curriculum, curriculum analysis*

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Chapter I: Introduction

Critical thinking skills are a necessity of everyday life. With an increasingly competitive workforce, being able to solve problems and apply knowledge is crucial to contributing to society (Huitt, 1998). In addition, scoring higher on a critical thinking assessment has been linked to having fewer negative life events (Butler, 2012). Critical thinking is identified as one of the four 21st century skills, or skills that are necessary to be successful in modern day society (National Education Association, n.d.). The American Management Association (2012) reported that on a scale from not important to most important, 70% of managers and executives rated critical thinking as most important for employees to help their companies. Critical thinking is especially important when it comes to developing practical mathematics skills. Critical thinking skills are linked to increased mathematical thinking and better performance in mathematics (Sebastian & Huang, 2016; Sriraman & Knott, 2009). As evidenced above, the emphasis on and importance of developing critical thinking skills are increasing in the United States.

Given the crucial nature of critical thinking in today's society, we would expect the importance of this skill to be reflected in what students are learning in school. There is a large body of evidence suggesting critical thinking is a skill that can be taught and nurtured through education (Abrami et al., 2015; Butler, 2012). Assuming critical

thinking is an important skill and can be taught, we might expect there to be an emphasis on critical thinking in curricula; however, this is often not the case. Many math problems identified as supporting critical thinking are actually just word problems that use algorithms already introduced to students and do not require students to think critically (Paul, 1992). This misconception that all word problems are critical thinking problems is reflected in curricula being used in schools today. Studies have found mathematics curricula being used are not meeting the level of critical thinking education standard require (Polikoff , 2015). With the strong connection between mathematics and critical thinking and the increasing need of critical thinking skills, this is a problem.

With this in mind, it is important to consider the best way to measure critical thinking in mathematics curricula. Having a way to measure the potential for critical thinking in mathematics curricula would provide a better understanding of whether or not curricula are capable of providing students with the tools necessary to practice this essential skill. In addition, an evaluation instrument of critical thinking in curricula could then support teachers and administrators in selecting curricula for schools to appropriately address this standard. In order to design an evaluation instrument, it is necessary to determine what curricula looks like that supports critical thinking. Additionally, it is important to figure out a way to measure the potential of supporting critical thinking so there is a clear standard of what curricula with critical thinking support looks like. This study aims to identify what features of mathematics curricula contribute to critical thinking, how critical thinking can be measured, develop an

evaluation instrument, and utilize that instrument to determine whether or not critical thinking is present in mathematics curricula currently being used in schools.

Chapter II: Literature Review

Curriculum plays an important role in education. In the literature review below, studies examining aspects of good curricula and how to measure its effectiveness are presented (e.g. Fuentas & Ma, 2018). Additionally, a review of studies exploring how critical thinking plays a large role in success in mathematics and in life are examined (e.g. Sebastian & Huang, 2016; Sriraman & Knott, 2009). These studies have looked at what critical thinking looks like and how to define it. However, there is very little research looking at how to measure critical thinking potential in curricula. The importance of critical thinking in mathematics education indicates that more research needs to be done to determine how to measure if mathematics curricula are meeting critical thinking standards.

Effective Educative Curriculum

The quality of instructional materials used by a school has a direct effect on student learning (Chingos & Whitehurst, 2012). There is evidence to support instructional materials being almost as big of an indicator of student success as teacher quality (Chingos & Whitehurst, 2012). However, there are many challenges when it comes to designing effective curriculum materials. According to Davis and Krajcik (2005), when designing educative curriculum, or curriculum that emphasizes teacher learning, there are different elements writers must think about in order to make it effective. They identified the need for curriculum to not only support furthering content knowledge for teachers, but to also include pedagogical reasoning for the way content is presented. By including

the reasoning for the pedagogy, the teacher then becomes more equipped to both modify the current curriculum and develop his or her own lessons.

Another element necessary for teacher learning is including tools to help teachers anticipate and understand different student responses to properly interpret whether a student has misconceptions or not (Davis & Krajcik, 2005). In one study, educative materials were added to lessons in a science curriculum for half of the teachers in a school and the other half worked with no additional support. Results indicated adding in opportunities for teacher learning in the curriculum increased student performance (Arias, Smith, Davis, Marino, & Palincsar, 2017). Because teacher effectiveness can be dependent on instructional success, ensuring curriculum develops both student and teacher learning is crucial. By determining what factors make effective educative curriculum, both curriculum designers and school districts will be better able to identify if curriculum is effective.

Aligning Curriculum with Standards

Whenever a new set of standards is released, one of the main problems is ensuring new curriculum aligns with the intentions of those standards. Schools cannot achieve what policy makers intended when writing standards if they are not provided with quality instructional materials to go along with them (Hill, 2001). Hill (2001) sat in on a school district designing curriculum based on state standards modified from the NCTM standards. The study found many of the original goals of NCTM were not the same goals as the curriculum designers, primarily due to an incorrect translation of the standards by the district. For any curriculum aiming to align with a set of standards, it is important to evaluate whether or not the core goals of the standards are being represented properly.

For example, when the NCTM standards were released in 1991, a study was done that determined the textbooks and curriculum supposedly aligned with the standards were not aligned (Herbel-Eisenmann, 2007). The findings of this study determined the equity goals aligned in the standards were not being met by the curriculum. Thus, one goal in designing curriculum needs to be ensuring it aligns with the intentions of the standards.

More recently, when the Common Core State Standards were introduced, they were created with multiple goals. They were intended to prepare students for post-high school life by encouraging conceptual understanding and focusing on deeper knowledge of fewer topics (Conley, 2014). Since the introduction of the Common Core Standards in 2009, there have been many textbooks and curricula designed to aid schools in aligning their teaching with the standards. Quite a few studies have analyzed these to determine whether or not they actually accomplish the goals of Common Core. Polikoff (2015) analyzed four fourth grade textbooks for misalignments with the standards and found that only 28% to 40% of the textbook content was aligned correctly with the standards when looking at both content and cognitive demand.

Another study looked at how well three Common Core textbook series aligned with the standards for area measurement throughout elementary school (Choi, Runnalls, & Hwang, 2019). Their research found the curriculum not only did not include research-based methods of the teaching area, but also introduced concepts in the wrong grade level per the standards. These studies determined there were large amounts of misalignment between the textbooks and the Common Core Standards. However, the curricula looked at in these studies only represent a small portion of textbooks and curricula available. Taken together these studies demonstrate the need for more research to determine what

curricula are and are not aligned with the standards to better help districts understand what instructional materials to use.

Critical Thinking

One of the key goals emphasized by the Common Core State Standards is critical thinking (Conley, 2014); therefore, to be aligned with the standards, curricula must also emphasize critical thinking. For the purposes of this literature review, critical thinking will be defined according to the National Council for Excellence in Critical Thinking (1987) as "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (para.1). Critical thinking requires students to take familiar information and use it in unfamiliar scenarios.

Critical thinking has been shown to have many benefits on students mathematical thinking (Sebastian & Huang, 2016; Sriraman & Knott, 2009). A study analyzing the results of Program for International Student Assessment (PISA) 2012, a test comparing 510,000 15-year-old-students from 65 countries, found a positive relationship between mathematical creativity and mathematical performance (Sebastian & Huang, 2016). This study inferred that teachers who foster creative thinking in mathematics also encourage higher mathematical performance. Another study also found creativity must be included in critical thinking, and there is no correct procedure to achieve critical thinking (Sriraman & Knott, 2009). This study concluded mathematics naturally lends itself to critical thinking when students are encouraged to prove their mathematical reasoning and

question others in a critically reflective way. The results from these studies show critical thinking is a crucial element of students learning practical applications of mathematics.

Although research has shown the importance of including critical thinking in a mathematics class, there are challenges in figuring out how to implement it in the classroom. There have been quite a few studies done with the intent of answering this question (e.g. Sriraman & Knot, 2009; Abrami et al., 2015). Sriraman and Knott (2009) did a study where they proposed a realistic problem to college pre-service teachers and identified three main areas of mathematical critical thinking that should be prevalent: reasoning in ratios, estimating, and problem solving using community and culture. They suggest this should be done by introducing a topic through exploration which involves purposeful activities and skilled questioning. Additionally, they found pre-service teachers used no sophisticated critical thinking when solving the problem, implying one obstacle in obtaining the desired level of critical thinking in students lies with a lack of understanding in teachers. This implies the need for educative curriculum to emphasize how to think critically. Abrami and colleagues (2015) synthesized materials studying critical thinking and determined the most effective critical thinking intervention is a combination of class discussion based on quality teacher questions, authentic problem solving, and mentorship. Taken together, the results from these studies imply critical thinking is facilitated through authentic learning and quality teacher questioning followed by discussion.

For the purposes of this study, the elements of instruction that contribute to critical thinking will be considered (Figure 1). The ideal critical thinking lesson would begin with an exploration of topics before introduction to a standard algorithm. It would

then provide chances for students to apply what they learn in new situations. Finally, students would analyze and provide justifications for their work and what they learned. Therefore, effective instructional materials will design lessons that lead students through these processes. The curriculum needs to have supports for exploration, application, and analysis. This should be seen in the design of the lesson, the supports put into place for teachers, and the questions and problems being asked of the students.

Figure 1. Ideal Progression of a Critical Thinking Lesson

How to Measure Effectiveness of Curriculum

There have been many studies done to determine the best way to evaluate curriculum. For example, Fuentes and Ma (2018) did a comprehensive evaluation of research on curriculum and developed *Teacher Learning Opportunities in Mathematics Curriculum Materials,* a framework covering seven different features of educative curriculum. The framework evaluates how different areas of teacher knowledge are covered in the curriculum. These areas of knowledge are mathematics content, student thinking, disciplinary discourse, assessment, differentiated instruction, technology, and community. Using this framework can help determine whether curriculum is meeting the needs of teacher learning.

Additionally, state departments of education release lists of adopted textbooks that meet certain standards. They also provide tools for schools to analyze their curriculum. For example, Mississippi has a Quality Instructional Materials Tool from EdReports on the Mississippi Department of Education website. This tool is a rubric that

provides specific criteria and indicators to be scored. The cumulative score then determines if it meets expectations, partially meets expectations, or does not meet expectations. Adopting a framework like one of these can be useful in determining if a curriculum is effective. A rubric identifying important elements of critical thinking provides a source of data to evaluate curriculum. This is necessary if curriculum reviewers want to accurately categorize curricula by how well it incorporates elements of critical thinking.

How to Measure Critical Thinking in Curriculum

Evaluation tools that measure critical thinking in curricula are currently not readily available and there is little evidence curricula addresses critical thinking appropriately (Polikoff, 2015). Polikoff (2015) found that even though 11% of the standards call for the top two levels of cognitive demand on a scale of 1-5, around 90% of the textbooks studied emphasized memorization and procedures as opposed to high cognitive-demand. This study found no evidence the textbooks called for the same levels of critical thinking as the standards require. The majority of textbooks were completely focused on low cognitive demand tasks and did not emphasize critical thinking.

Because critical thinking is not easily measured it can be difficult to quantify when analyzing curricula. One tool to measure alignment in terms of critical thinking is the Survey**s** of Enacted Curriculum (Porter, McMaken, Hwang, & Yang, 2011). Figure 2 shows one way to categorize the cognitive demand in curriculum which can then be used to give a score on an alignment index (Porter et al., 2011).

Other studies have analyzed different aspects of curricula applicable to measuring critical thinking. For example, O'Keefe and O'Donoghue (2013) analyzed three textbook

series using Halliday's functional grammar analysis to identify how language plays a role in the effectiveness of mathematics textbooks. The study categorized words as either "inclusive" imperatives which encourage students to think or "exclusive" imperatives where students are asked to demonstrate a task. "Inclusive" imperatives include words like "prove" and "explain" where students are involved in the task, whereas "exclusive" imperatives include words like "draw" or "write" where students are following specific steps and directions. Identifying these words in curriculum can help determine how deeply students will be thinking during the lesson. Used in conjunction, these studies can help develop a larger understanding of how to quantify critical thinking potential in curricula. Analyzing language and identifying levels of cognitive demand are necessary to determining whether or not curricula is encouraging critical thinking aligned with Common Core standards.

	Categories of Cognitive Demand				
Topics	Memorize	Perform procedures	Demonstrate understanding	Conjecture, generalize, prove	Solve nonroutine problems
Multistep equations					
Inequalities					
Linear, nonlinear relations					
Rate of change/ slope/line					
Operations on polynomials					
Factoring					

Figure 2. Design of the Surveys of Enacted Curriculum: Defining content at the intersection of topics and cognitive demand. Reprinted from *Common Core Standards: The New U.S. Intended Curriculum*, by Porter et al., April 1, 2011, retrieved from https://doi-org.umiss.idm.oclc.org/10.3102/0013189X11405038.

Another way to quantify critical thinking is through using the Depth of Knowledge (DOK) scale (Webb, 1997). The DOK level of a task or problem refers to the cognitive level and level of critical thinking involved (Wyse & Viger, 2011). Webb created 4 levels of cognitive demand: 1) Recall and Reproduction, 2) Skills and Concepts, 3) Short Term Strategic Thinking, and 4) Extended Thinking. The level of critical thinking increases from the first level to the fourth level, with levels three and four being where higher order thinking tends to become prevalent (Webb's Depth of Knowledge Guide). Using the DOK level is more effective than using other scales of cognitive level like Bloom's taxonomy because it is easier to identify and categorize due to more widely applicable categories (Paige, Smith, & Sizemore, 2015). This suggests that aligning tasks in curriculum with their respective DOK levels may help determine the critical thinking level and cognitive demand.

The nature of questioning in curriculum is also important to consider. Well-developed questions can help promote critical thinking and are a necessary component to helping teachers prompt students in their thinking (Sasson, Yehuda, & Malkinson, 2018). Both the questions that are asked in students textbooks and the questions the teacher asks are important when considering questioning. One characteristic of a good question is if it asks students to apply knowledge as opposed to regurgitating facts (Sasson, Yehuda, & Malkinson, 2018). One method of questioning for higher order thinking is the Socratic approach, which involves asking questions without a pre-chosen, specific answer in mind (Nappi, 2017). In other words, questions that encourage critical thinking are open-ended and should be included in effective educative curricula. In order to determine if critical

thinking is evident in curriculum, it is important to evaluate whether or not teacher questioning prompts higher level thinking.

In addition to questioning other elements of educative curriculum aligned with critical thinking can be useful when looking at what to include in evaluation of curriculum,. By explaining why certain decisions are made in the curriculum, teachers can better understand how to use that information to help students think deeply (Davis & Krajcik, 2005). Similarly, looking at how curriculum approaches formative assessment can help determine if supports are in place to help teachers identify and understand misconceptions students might have. Teachers need to be able to understand how to adjust instruction based on student responses so student misconceptions are cleared up quickly. This is especially important when teachers are trying to cultivate critical thinking skills with students, because if they do not understand how students are thinking, they will not be able to properly guide them through the task. Well-designed teacher curriculum will include explanations of both pedagogy and how to adjust for misconceptions students might have.

Critical Thinking Rubric for Evaluating Curriculum

This study created an evaluation rubric to examine both teacher and student curricula to determine if opportunities for students to develop critical thinking are present. There are six elements identified in the rubrics. Each of these elements should be present for curricula providing the ideal support for helping students develop critical thinking (Figure 3).

The elements of curriculum included in the rubric for teacher materials are misconceptions, formative assessment, and pedagogy. These have been chosen because

of their demonstrated importance for educative curriculum as described above. Identifying misconceptions is crucial for helping teachers understand why students are working through problems in certain ways, which is an important skill to help guide critical thinking (Davis & Krajcik, 2005). Formative assessment support is similarly important because it helps teachers find misconceptions and then adjust instruction specifically tailored to what students need. The ability to identify where students are missing key ideas is what will allow teachers to follow similar procedures in problems using critical thinking (Davis & Krajcik, 2005). The final category looked for is how pedagogy is used to further teacher learning. Including explanations of why instructional choices are made can help teachers understand how to effectively use the curriculum to reach the desired conceptual understanding intended by the textbook (Arias et al., 2017).

Effective Curriculum for Critical Thinking					
Curriculum Support for Teachers			Curriculum Support for Students		
Explanation of misconceptions and how to correct them	Explanations for using formative assessments to guide instruction	Explanations of pedagogy	Language includes inclusive commands and open ended questions leading to exploration	DOK level of lesson activities includes levels 3 and 4	Problems and questions have students apply knowledge to new situations and analyze and justify answers

Figure 3. Elements of Effective Curriculum for Critical Thinking

The elements included in the rubric for student materials are language, lesson activities, and problems and questions. These have been chosen because they were

identified as important elements of a lesson that contribute to critical thinking development. Language contributes to critical thinking because the quality of questions asked and the phrasing of directions can determine the level of cognitive demand required (Sasson, Yehuda, & Malkinson, 2018; O'Keefe & O'Donoghue 2013). It is also important to consider the DOK level of lesson activities because measuring the level of cognitive demand being used in each portion of the lesson can give a picture of the amount of critical thinking asked of students (Paige, Smith, & Sizemore, 2015). The final element being looked at is the problems and questions included for students to work out. These are important because by looking at what is being asked and how it is able to be answered, a determination can be made about how much critical thinking is evident in the student textbook (Sasson, Yehuda, & Malkinson, 2018).

Chapter III: Methods

This qualitative exploratory study assesses, scores, and assigns an index of critical thinking to curricula. Qualitative data is used to provide more rich description about the elements of critical thinking present in the curricula. The methods employed are appropriate for an exploratory study (Creswell, 2013) and provide a resource for teachers to use in the future.

Context

All of the curricula analyzed was designed for the 5th grade level in states that adopted the Common Core State Standards. Critical thinking is embedded throughout the Common Core State Standards, specifically in the standards for mathematical practice (Common Core State Standards, 2010). These standards emphasize the importance of students being able to reason through their answers and explain their thinking, both of which are important elements of critical thinking.

Curricula Selected

The curricula were selected to represent a variety of approaches to teaching math according to the Common Core State Standards. The three curricula selected were: *Go Math!, Big Ideas Math,* and *My Math* (Table 1). Each is described in more detail below.

Table 1.

Description of Analyzed Curricula.

Name of Curriculum	**Company**	**Year Published**	**Chapters Analyzed**
Go Math!	Houghton Mifflin Harcourt	2017	1, 2, 4
Big Ideas Math	Big Ideas Learning	2019	1, 5, 6
My Math	McGraw-Hill	2016	1, 3, 6

Big Ideas Math: Modeling Real Life (Larson & Boswell, 2019) is designed to be aligned with the Common Core State Standards and claims to use a "balanced instructional approach of discovery and direct instruction" (Big Ideas Learning, LLC., 2020). Each chapter in the textbook has three stages: *Explore and Grow, Think and Grow,* and *Think and Grow: Modeling Real Life.* According to the textbook, *Explore and Grow* is where students have the opportunity to develop their conceptual understanding of the topic. Then students work on procedural fluency in the *Think and Grow* stage, and then they apply both conceptual understanding and procedural fluency in the *Think and Grow: Modeling Real Life* stage.

My Math (McGraw-Hill, 2016) is designed for the Mississippi College- and Career-Readiness Standards for Mathematics. It is one of three textbooks that has been officially adopted by the state of Mississippi (Mississippi Department of Education, 2019). The curriculum identifies three kinds of activities present throughout the book that are supposedly aligned with conceptual understanding: Investigate the Math, Model the Math, and Talk Math: Collaborative Conversation. Additionally, there are five kinds of activities throughout the book that claim to be work toward application and five kinds of activities that claim to be focused on procedural skill & fluency.

Go Math! (Houghton Mifflin Harcourt, 2017) was written to align with the Common Core State Standards and claims to put an equal emphasis on procedural fluency, conceptual understanding, and application. This curriculum does not explicitly identify what activity types each of these skills is being built through. The program includes a financial literacy aspect for 3rd-6th grade and prioritizes 21st Century Skills, which includes critical thinking and creativity.

For each of the curricula, three chapters on similar content were selected. The first topic selected from all three curricula was on place value. In all three curricula, this topic was covered in chapter one. The next topic chosen was dividing whole numbers. In *Go Math!* this topic is in chapter 2, in *My Math* it is in chapter 3, and in *Big Ideas Math* it is in chapter 6. The final selected topic was multiplying decimals. In *Go Math!* this topic is in chapter 4, in *My Math,* it is in chapter 6, and in *Big Ideas Math* it is in chapter 5.

Data Collection

To determine if the curricula were aligned with The Common Core State Standards in regards to critical thinking, a rubric for measuring critical thinking in curriculum was developed using the literature (e.g. Abrami et al., 2015; O'Keefe & O'Donoghue, 2013) and examples of other curriculum rubrics (e.g. Fuentas & Ma, 2018; Porter et al., 2011). Two rubrics were developed. One for analysis of teacher materials (Appendix A) and one for analysis of student materials (Appendix B). After developing initial rubrics, they were sent to three experts in curriculum, evaluation, and measurement to establish face and content validity (Haynes, Richard, & Kubany, 1995). The rubrics went through two rounds of review. After the first round of review 19 changes were made to the teacher rubric and 15 changes were made to the student rubric. For the teacher

rubric, 6 changes were for consistency and 13 were for clarity. For example, definitions of exclusive and inclusive imperatives were added and directions were reworded for clarity. For the student rubric, 3 changes were for consistency and 12 were for clarity. After the second round, no more changes were suggested and the rubrics were accepted.

The rubrics are color coded, with any green items indicative of items that promote critical thinking and any yellow items indicative of items that do not. On the teacher rubric, yellow items are items that do not provide teacher support in critical thinking. On the student rubric, yellow items represent items that promote procedural fluency as opposed to critical thinking. Additionally, each section of the rubrics asks the reviewer to provide specific evidence for the items being assessed. Providing evidence ensures the reviewer is properly identifying what the rubric is asking for during analysis. After establishing face and content validity for the rubrics they were used to evaluate the three selected curricula.

Teacher Materials Rubric. The rubric for teacher materials looked at misconceptions, formative assessment, and pedagogy. The basis for including each of these lay in their importance to effective educative curriculum discussed above. The rubric compared items that provided teacher support for critical thinking, which were marked in green, to items that did not provide teacher support, which were marked in yellow.

Misconceptions. The misconceptions section of the rubric first identifies whether or not common misconceptions are identified in the curriculum materials for teachers. Each lesson received one point if at least one misconception is identified. It then reviewed whether or not an explanation was given for these misconceptions to help

teachers understand how students who hold these misconceptions might be thinking. The reviewer assigned 0, 1, or 2 points depending on how many misconceptions had accompanying explanations. This helped determine if there was enough information in the curriculum to help teachers understand their students' thinking when solving critical thinking problems, which is vital for making sure students are actually understanding the material (Davis & Krajcik, 2005).

Formative Assessment. The next section on the teacher rubric is formative assessment. Like the misconception analysis, the purpose of this section is to identify if curriculum helps teachers understand areas where they may need to formatively assess. This is important when thinking about critical thinking because if the teacher is able to figure out where misunderstandings are, the teacher can then clarify these to make sure students have the foundational skills necessary to think critically. To measure this, the rubric asks the reviewer to determine both the number of potential formative assessments and the number of potential assessments that indicate how the information gathered from it can be used. The potential formative assessments were marked as yellow because alone they do not have the potential to promote critical thinking, however formative assessments with an explanation of how to use them were marked as green. This is because the addition of an explanation allows it to have the potential to promote critical thinking. This distinction is important because formative assessments are only useful if the teacher knows how to properly analyze the information and adapt instruction accordingly (Davis & Krajcik, 2005).

Pedagogy. The final section on the teacher rubric looks at pedagogy. Pedagogy, in this case, includes both questions that are included for the teacher to ask and explanation

of why choices are made in the curriculum. Because research has found that questioning is a crucial part of critical thinking, it is necessary to look at it when evaluating curriculum for critical thinking (Nappi, 2017). Additionally, explaining why curriculum is set up the way it is allows teachers to better understand the goal of the curriculum, which better helps them guide students in critical thinking. To maximize this, curriculum should directly identify where critical thinking is being used and how to support it. The rubric looks for these features by having reviewers mark the occurrence of open-ended questions, explanations of how to support students in critical thinking, and explanations of why instructional methods are being used. All of these were marked as green because they are aspects of critical thinking and are indicative of curriculum that has strong supports for teachers around critical thinking. These indicators were then compared to indicators that are not maximizing critical thinking. These are close-ended questions and no explanation of pedagogy, which were marked in yellow because they are indicators that the curriculum does not provide support for critical thinking for teachers.

Overall Inclusion of Critical Thinking. In addition, questions were developed to assess the overall inclusion of important qualities of critical thinking in curriculum (Appendix C). For the analysis of teacher materials, the questions focused on two main portions of critical thinking: the supports put into place for teachers to help students and the overall structure of the lesson. To identify supports, the reviewer first identified what general features help teachers with the lesson, and then went further and identified which of those are designed to help critical thinking. These features are important to identify to compare what features are included in the book and if they will actually contribute to critical thinking (Davis & Krajcik, 2005). The reviewer also dissected how the lesson is

structured by categorizing procedural parts of the lesson and parts that involve critical thinking. This was used to see how much of the lesson is actually working toward higher order thinking. Finally, the reviewer identified any missed opportunities for critical thinking. Examples of these would be a lack of exploration time, a lack of open ended questions, or lost opportunities to show work (Abrami et al., 2015).

Student Materials Rubric. The student rubric was designed to look at the student textbook and/or workbook each student is provided. The rubric looked at language, DOK levels, and the problems and questions in the curriculum. The rubric compared critical thinking items, which were marked as green, to procedural knowledge items, which were marked as yellow.

Language. The first section on the rubric is language analysis, which took 10 pages from the text and assigned each sentence on that page to the category it falls under. This is important, because language in textbooks plays a huge role in how deeply students think (O'Keefe & O'Donoghue, 2013). The rubric had the reviewer identify different types of sentences with characteristics that either indicate procedural knowledge, which were marked as yellow, or critical thinking, which were marked as green. Language that promotes procedural knowledge includes factual statements, exclusive commands, definitions, questions with only one possible answer, rhetorical questions, and formulas. Language that promotes critical thinking includes inclusive commands, statements prompting students to choose a method to solve the problem, questions asked about making connections, and questions that lead to time for exploration. Sentences can fall into more than one category. For example, a sentence that provokes critical thinking might have been marked as having an inclusive verb, like

prove, and also being a statement that requires students to form their own conclusion. Identifying how many sentences from a sample of pages from the book actually contribute to critical thinking can give a larger picture of how the book is structured. This language analysis determined if the curriculum had the necessary language for application to contribute to critical thinking by comparing the amount of procedural statements to the amount of critical thinking statements.

Lesson Activities. The next section on the student rubric analyzes the lesson activities. Three in-class tasks were selected from each chapter and then assigned to a DOK level, 1-4 (Webb, 1997). Tasks that received a 3 or 4 involve exploration, application to new situations, and/or justification. Those tasks; therefore, have the potential to involve critical thinking and were marked as green. On the other hand, tasks that received a 1 or 2 involved tasks like recall and/or procedural knowledge and were marked as yellow. Comparing the number of critical thinking tasks to procedural thinking tasks can determine what levels of cognitive thinking students would use throughout the lessons.

Problems and Questions. The final section on the student rubric looks at problems and questions provided to the student. Problems and questions in the texts are important because this is where the majority of practice with the material comes into place (Abrami et al., 2015). If most questions can be answered with a provided formula, by following an example problem, or by only performing a calculation, they are strictly procedural and do not involve critical thinking. These items were therefore marked as yellow. However, if these problems include questions where students have to extend, apply, and justify their knowledge in a new way, they will be thinking critically. These

items were marked as green and were identified on the rubric as questions requiring students to apply learning from the chapter to new situations, questions requiring students to make a decision, questions requiring students to form an argument for their reasoning, questions requiring students to notice patterns, and questions asked before introducing a standard algorithm. Comparing the green items that promote critical thinking to the yellow items that promote procedural fluency helped determine if the homework was laid out in a way to promote critical thinking.

Overall Inclusion of Critical Thinking. Additional questions were developed for the student materials rubric that analyzed a lesson and a corresponding homework set. The lesson questions looked at how the lesson progresses, what supports there are for critical thinking, and where there are missed opportunities for critical thinking. The homework set questions focused on analyzing a problem set designed for homework. These questions looked at how the homework is structured and whether or not it is set up in a way that encourages critical thinking. They also identified missed opportunities for critical thinking. Some examples would be problems that tell the student how to solve them, only having calculation problems, and only having problems that are based off of examples (Sriraman & Knott, 2009). Describing the homework qualitatively gives a clearer picture of what kinds of questions are included on the homework and how they build off of the lesson. These questions provided a more complete picture of whether or not the student materials are designed for critical thinking or not.

Data Analysis

The three selected curricula were analyzed using the rubrics described above. The teacher rubric yielded an overall rating of teacher guidance in critical thinking. The

student rubric yielded an overall index of student guidance in critical thinking. In addition, answers to the additional questions about the curricula provide rich description for understanding if and/or how the curricula support critical thinking.

Categorization of Data. The data were first divided into categories by items that items that contributed to critical thinking and items that did not. Items that did not contribute to critical thinking were indicated with a yellow heading, while critical thinking columns were indicated by a green heading. On the teacher rubric, yellow items that did not contribute to critical thinking were items that did not support teacher learning. On the student rubric, yellow items that did not contribute to critical thinking were items that promoted procedural fluency. In general, the items that contributed to critical thinking divided by the items that did not yielded a ratio of promotion of critical thinking to non-promotion of critical thinking. The ratio was divided out and provided an index of critical thinking for the examined topic.

Teacher Materials Rubric Analysis. The overall rating of teacher guidance in critical thinking was given using the score from misconception analysis, the index of teacher guidance in formative assessment, and the index of teacher guidance in critical thinking pedagogy. To find the score from misconception analysis (Table 2), the reviewer found the sum from the three green columns on the misconception chart. The higher the score, the more misunderstandings were identified and the more direction teachers were given in determining how to adjust instruction to correct the misconceptions. A curriculum receiving a score of 0 has no common misconceptions identified. The maximum score for one lesson was a 3 and 6 lessons were analyzed per curriculum. Therefore, the maximum score for a text was an 18 on this section. A curriculum that

received the maximum score has at least one common misconception identified per lesson and has an explanation for every identified misconception. Because at least one common misconception should be identified per lesson, a curriculum was considered to have sufficient teacher support if it got a score of 18. However, the number of misconceptions was also taken into account, and if a curriculum received a score of 18 and had over 9 identified misconceptions (an average of at least 1.5 identified misconceptions per page) then it was considered to have excellent teacher support.

Table 2.

Interpretations of Misconception Analysis

Misconception Analysis Score	Amount of Teacher Support
x<18	Not Enough
x=18	Sufficient
x=18 with over 9 identified misconceptions	Excellent

The index of teacher guidance in formative assessment was found by totaling the number of potential assessments provided that indicated how a teacher could use it for a formative purpose for each curriculum and the number of potential assessments provided for each curriculum. The index of teacher guidance in formative assessment was calculated by totaling the number of potential assessments provided that indicate how a teacher could use it for a formative purpose and dividing by the total number of potential assessments provided. This was repeated for each curriculum. A score of 1 indicates that for every formative assessment there is an explanation for how it can guide instruction, a score of 0.5 indicates that half of the assessments have explanations, and a score of 0

indicates that none of the assessments have explanations. To have sufficient support for formative assessment, the curricula must have received at least a score of 0.5. To have excellent support for formative assessment, the curricula must have received at least a score of 1.

To find the index of teacher guidance in critical thinking pedagogy the reviewer used the pedagogy analysis table. For each curriculum, the reviewer added the results from the 10 analyzed pages to get the total of each of column in the chart. Then, the reviewer found the totals of all of the green columns for each curriculum and all of the yellow columns for each curriculum. The index of teacher guidance in critical thinking pedagogy for each curriculum was calculated by dividing the green column total by the yellow column total. The index was measured in a way where 0 represents no critical thinking pedagogical support for the teacher and infinity represents every sentence having pedagogical explanations for critical thinking. The higher the index of teacher guidance in critical thinking pedagogy, the more support the teacher has in helping students succeed with critical thinking (Table 3). A score of 1 indicated that for every 2 pages, one of them contains teacher support for critical thinking. For a curricula to have sufficient support, it must have received at least a score of 1. For a curricula to have excellent support it must have received at least a score of 2.

Table 3

Interpretations of Teacher Critical Thinking Indices: Formative Assessment and Pedagogy

Index as x	Amount of Teacher Support
$x < 1$	Not Enough
$1 \leq x < 2$	Sufficient
$x > 2$	Excellent

To find an overall rating of guidance of teacher guidance in critical thinking, each of the individual elements were considered. The amount of teacher support for misconceptions, formative assessments, and pedagogy was each given a point value (Table 4). Zero points were given for not enough support, 1 point was given for sufficient support, and 2 points were given for excellent support. Six was the maximum possible score, if excellent scores were received for every category. Zero was the minimum possible score with not enough scores for every category. A curriculum that received 0-2 points was considered to have not enough support for teachers, a curriculum that received 3-4 points was considered to have some support for teachers, a curriculum that received 5 points was considered to have sufficient support for teachers, and a curriculum that received 6 points was considered to have excellent support for teachers (Table 5).

Table 4.

Point System for Overall Rating of Teacher Guidance in Critical Thinking

	0 points	**1 point**	**2 points**
Misconception Analysis	Not enough	Sufficient	Excellent
Formative Assessment	Not enough	Sufficient	Excellent
Pedagogy	Not enough	Sufficient	Excellent

Table 5.

Scoring Guide for Overall Rating of Teacher Guidance in Critical Thinking

	0-2 points	**3-4 points**	**5 points**	**6 points**
Overall Rating of Teacher Guidance in Critical Thinking	Not enough	Some	Sufficient	Excellent

Student Materials Rubric Analysis. The average index of student guidance in critical thinking is comprised of the index of critical thinking for language analysis, the index of critical thinking for lesson activities, and the index of critical thinking for problems.

To find the index of critical thinking for language analysis, the reviewer used the language analysis table on the student materials rubric. For each curriculum, the reviewer first added the results from the 10 analyzed pages to get the total of each of the columns in the chart. Then, the reviewer found the totals of all of the green columns for each curriculum and all of the yellow columns for each curriculum. The number found as the total for the green columns divided by the number found as the total for the yellow columns yielded the index of critical thinking for language analysis for each curriculum.

To find the index of critical thinking for lesson activities and the index of critical thinking for problems, the reviewer repeated the same process of dividing the totals from the green columns by the totals of the yellow columns for each book. For the index of critical thinking for lesson activities the reviewer used the analysis of lesson activities table and for the index of critical thinking for problems the reviewer used the analysis of problems and questions table.

The average of the index of critical thinking for language analysis, the index of critical thinking for lesson activities, and the index of critical thinking for problems yielded the average index of student guidance in critical thinking.

Each of the student indices and the average index of student guidance in critical thinking were calculated in a manner so that 0 represents virtually no critical thinking and 1.0 represents material with an equal number of statements requiring procedural knowledge and critical thinking. Progressively higher index numbers represent progressively higher ratios of critical thinking to non-critical thinking material (Table 6). Infinity would represent a book in which every statement and every question would represent critical thinking. In general, chapters or books with indices much below 0.4 will be primarily procedural knowledge and will contain few challenges to the student other than memorization of algorithms and completion of calculations. Conversely, books with very high indices (much in excess of about 1.5) contain virtually nothing but questions provoking critical thinking. In this case, there might not be enough explicit instruction or opportunities to develop procedural knowledge.

Table 6.

Interpretations of Student Critical Thinking Indices

Index as x	Description of curriculum in terms of critical thinking
$0 \leq x < 0.4$	There is almost no critical thinking present
$0.4 \leq x < 1$	There is more procedural fluency than critical thinking, but there is still a good representation of both
$x=1$	There is the same amount of tasks for procedural fluency and for critical thinking
$1< x \leq 1.5$	There is more critical thinking than procedural fluency, but there is still a good representation of both
$x > 1.5$	There is almost no procedural fluency present

Analysis of Questions. To evaluate the results from the overall inclusion of critical thinking sections, the reviewer wrote a summary of the important things noticed when answering the questions. Based on this, the reviewer determined if there was a significant amount of critical thinking, some critical thinking, or no critical thinking in the curriculum. A curriculum with a significant amount of critical thinking should have no more than one missed opportunity for critical thinking and should have examples for every question that asks for indicators of critical thinking. A curriculum with some critical thinking should not have more than 3-4 missed opportunities for critical thinking and should have examples for most questions that ask for indicators of critical thinking. A curriculum with no critical thinking has many missed opportunities for critical thinking and almost no evidence of critical thinking questions.

Overall Analysis To analyze all of the data together, the overall rating of teacher guidance in critical thinking, the average index of student guidance in critical thinking, and the summary from the overall analysis were considered. Each score from each section was given a point value (Table 7). Based on the points given, each curriculum received an overall critical thinking score. The score options were poor, fair, ok, good,

and excellent (Table 8). A curriculum that received a score of poor indicated that the curriculum was substantially lacking critical guidance in at least one area and therefore is not at all set up with the potential for critical thinking. A curriculum that received a score of fair or ok had some potential for critical thinking, but not nearly enough. A curriculum that received a score of good did not have any elements (teacher, student, or overall analysis) that suggested there was no evidence of critical thinking. This means a curriculum with a score of good had at least 2 areas with the highest level of potential for critical thinking and would likely be successful in promoting critical thinking in a classroom. To be considered an excellent curriculum for critical thinking, the curriculum must have received a 6. This would be an overall score of excellent for the overall rating of teacher guidance in critical thinking, a score equal to or higher than 1 for the average index of student guidance in critical thinking, and a rating of a substantial amount of critical thinking based on the overall analysis. This curriculum would have the highest potential for promoting critical thinking in a classroom.

Table 7.

Point System for Overall Analysis

	0 points	1 point	2 points
Overall rating of teacher guidance in critical thinking	Not sufficient	Some OR sufficient	Excellent
Average Index of student guidance in critical thinking	$0 \leq x < 0.4$	$0.4 \leq x < 1$	$x \geq 1$
Overall Analysis	No critical thinking	Some critical thinking	Substantial critical thinking

Table 8.

Scoring Guide for Overall Critical Thinking Score

	0-2 points	**3 points**	**4 points**	**5 points**	**6 points**
Overall Critical Thinking Score	Poor	Fair	Ok	Good	Excellent

Chapter IV: Results

The qualitative data collected through this study were analyzed and the results from analysis are presented below. First the results from the analysis of teacher materials in the curricula are presented, followed by the results from the analysis of student materials. Taken together, the results indicate how much support there is for critical thinking in the curricula selected.

Analysis of Teacher Materials

After collecting the data from the teacher rubric, it was used to determine a cumulative misconception score, an index of teacher guidance in formative assessment, and an index of teacher guidance in pedagogy. These all reflected the amount of teacher support for critical thinking. Each element was given a rating of not enough, sufficient, or excellent. These ratings were then used to calculate the overall rating for teacher guidance in critical thinking for each curriculum.

Misconceptions. A cumulative misconception score was calculated for each curriculum (Table 9). The score for *Big Ideas Learning* was 6. Only 2 out of the 6 lessons include an identified misconception, and each does include an explanation with it. Therefore, *Big Ideas Learning* was given a rating of not enough teacher guidance provided for misconceptions. The scores for *Go Math!* and *My Math* were both 18, meaning they have at least one common misconception identified in each lesson and each misconception has an explanation with it. However, the total number of identified misconceptions for *Go Math!* was 6, or one per lesson, while the total number identified

for *My Math* was 11. *My Math* has an average of 1.833 identified misconceptions per lesson that included explanations, which is more than the average of 1.5 lessons required to be considered excellent. This meant that *My Math* received a rating of excellent while *Go Math!* only received a rating of sufficient.

Table 9.

Misconceptions Analysis Scores.

Curriculum	**Cumulative Misconception Analysis Score**	**Total Identified Misconceptions**	**Average number of misconceptions identified per chapter with explanations**	**Level of Teacher Guidance Provided**
Go Math!	18	6	1	Sufficient
Big Ideas Math	6	2	0.333	Not Enough
My Math	18	11	1.833	Excellent

Formative Assessment. The analysis of formative assessment yielded an index of teacher guidance in formative assessment for each curriculum (Table 10). The index was 0.5 for *Go Math!*,0.553 for *Big Ideas Math*, and 0.363 for *My Math*. These scores are in the range where less than half of the book provides support for teachers. For the formative assessments in these books, less than half of them have explanations for how to use it to guide instruction. In the ideal curriculum, every formative assessment would have a description of how to use it to guide instruction, or a score of 1 on the index. According to the rating system, all of the curricula received a rating of not enough teacher guidance provided for formative assessment.

Table 10.

Formative Assessment Analysis Scores.

Curriculum	**Ratio of potential assessments with indication of how to use it to potential assessments provided**	**Index of teacher guidance in formative assessment**	**Level of Teacher Guidance Provided**
Go Math!	29/58	0.5	Not enough
Big Ideas Math	26/47	0.553	Not enough
My Math	29/80	0.363	Not enough

Pedagogy. Analysis of the pedagogy in the curricula yielded an index of teacher guidance in pedagogy (Table 11). *Go Math!* received 0.818, indicating that more than half of the analyzed pages do not have help for critical thinking, but there is some support included. However, there is not enough support for teacher guidance in pedagogy. *Big Ideas Math* had 16 statements that helped teachers with critical thinking and 8 in columns that didn't support teachers. Therefore, this curriculum received a 2.0 for its index, indicating that for every three pages analyzed, two of them address some category of teacher support in pedagogy for critical thinking suggesting a large amount of guidance for teachers. This curriculum has excellent teacher guidance in terms of pedagogy. *My Math* received a 1.222 for its index, indicating that a little more than half of the analyzed material had pedagogical support for teachers. This curriculum has sufficient teacher guidance in terms of pedagogy.

Table 11.

Pedagogy Analysis Scores.

Curriculum	**Ratio of pedagogical support to no support**	**Index of teacher guidance in pedagogy**	**Level of Teacher Guidance Provided**
Go Math!	9/11	0.818	Not enough
Big Ideas Math	16/8	2	Excellent
My Math	11/9	1.222	Sufficient

Overall Rating of Teacher Guidance in Critical Thinking. Each of the ratings given to the elements of teacher guidance in critical thinking were given points based on the point system for the overall rating of teacher guidance in critical thinking (Table 12). Based on this, *Go Math!* and *Big Ideas Math* each received 2 points, which means they do not contain enough teacher support for critical thinking. *My Math* received 3 points, which means it contains some teacher support for critical thinking. This means none of these curricula have a sufficient or excellent level of teacher guidance for critical thinking.

Table 12.

Levels of Teacher Guidance Provided.

Curriculum	**Misconception Analysis**	**Formative Assessment**	**Pedagogy**	**Overall Level of Teacher Guidance**
Go Math!	Sufficient	Not enough	Not enough	Not enough
Big Ideas Math	Not sufficient	Not enough	Excellent	Not enough
My Math	Excellent	Not enough	Sufficient	Some

Analysis of Student Materials

After collecting the data in the student rubric, that data was used to determine an index of critical thinking for language analysis, an index of critical thinking for lesson activities, and an index of critical thinking for problems and questions. These indices were then averaged to find the average index of student guidance in critical thinking.

Analysis of Language. The analysis of language yielded an index of critical thinking (Table 13). The index for *Go Math!* was 0.287, the index for *Big Ideas Math* was 0.042, and the index for *My Math* was 0.053. All of these scores indicate that based on the language there is almost no critical thinking present. The majority of the language in all three curricula tells students what to do or has them build on procedural fluency. The data suggests the language in these books is not conducive to encouraging critical thinking.

Table 13.

Index of Critical Thinking for Language Analysis.

Curriculum	**Index of Critical Thinking for Language Analysis**	**Interpretation of Index**
Go Math!	0.287	There is almost no critical thinking present
Big Ideas Math	0.042	There is almost no critical thinking present
My Math	0.053	There is almost no critical thinking present

Analysis of Lesson Activities. The analysis of lesson activities yielded an index of critical thinking (Table 14). The index for *Go Math!* was 0.429, indicating there were more lesson activities that promote procedural fluency, but at least a few that promote critical thinking. The indices for *Big Ideas Math* and *My Math* was 0.25, implying that for

the lesson activities in the student workbooks there was almost no critical thinking required.

Table 14.

Index of Critical Thinking for Lesson Activities.

Curriculum	**Index of Critical Thinking for Lesson Activities**	**Interpretation of Index**
Go Math!	0.429	There is more procedural fluency than critical thinking, but there is still a good representation of both
Big Ideas Math	0.25	There is almost no critical thinking present
My Math	0.25	There is almost no critical thinking present

Analysis of Problems and Questions. The analysis of problems and questions yielded an index of critical thinking (Table 15). The index for *Go Math!* was 0.304 and the index for *My Math* was 0.148. Both of these indices fell in the range where the problems and questions had almost no elements of critical thinking present. The index for *Big Ideas Math* was 0.548. This fell in the range where there was more procedural problems than critical thinking problems, but there were some critical thinking problems.

Table 15.

Index of Critical Thinking for Problems and Questions.

Curriculum	**Index of Critical Thinking for Problems and Questions**	**Interpretation of Index**
Go Math!	0.304	There is almost no critical thinking present
Big Ideas Math	0.148	There is almost no critical thinking present
My Math	0.528	There is more procedural fluency than critical thinking, but there is still a good representation of both

Average Index of Student Guidance in Critical Thinking. Averaging the indices for language, lesson activities, and problems and questions yielded an average index of student guidance in critical thinking for each textbook (Figure 5). The index for *Go Math!* was 0.34, the index for *Big Ideas Math* was 0.28, and the index for *My Math* was 0.15 (Table 16). Each book fell in the range that indicated there are almost no critical thinking opportunities available for students. This means that overall, the student materials for each curricula mostly work toward building procedural knowledge.

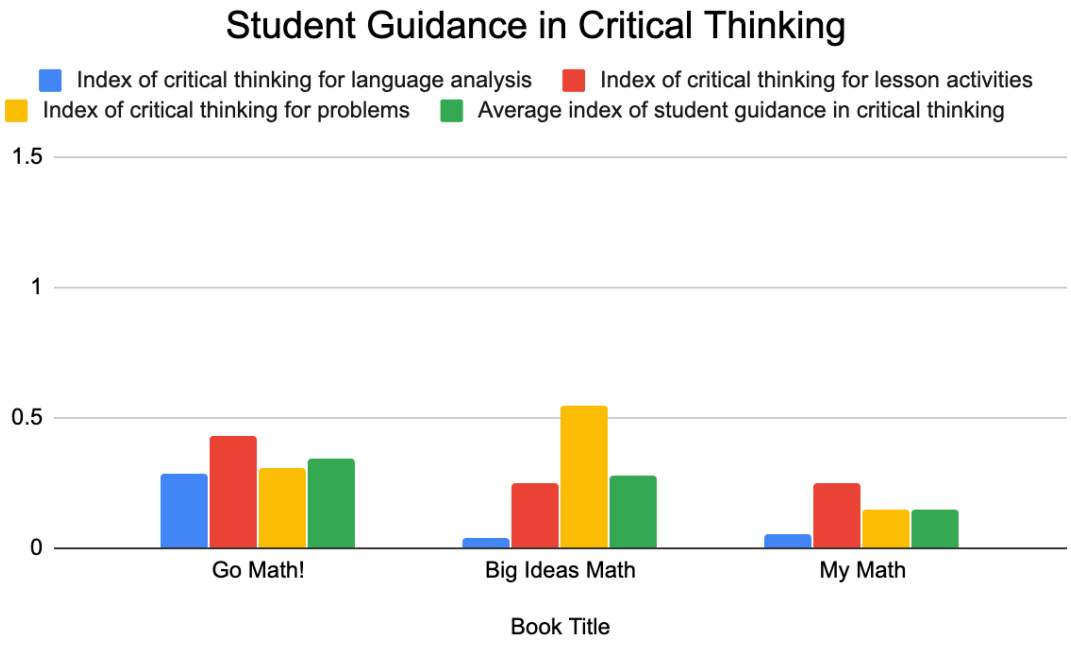

Figure 5. Indices of Student Guidance in Critical Thinking

Table 16.

Average Index of Student Guidance in Critical Thinking

Curriculum	**Index of Student Guidance in Critical Thinking**	**Interpretation of Index**
Go Math!	0.34	There is almost no critical thinking present
Big Ideas Math	0.28	There is almost no critical thinking present

My Math	0.15	There is almost no critical thinking present

Descriptive Analysis

After the additional questions were answered about the curricula, the reviewer wrote a description of whether or not critical thinking opportunities were included in the curricula (for both teacher and student portions). According to this, *Go Math!* is not set up in a way to support critical thinking. There are more than 4 identified missed opportunities for critical thinking and the curriculum is designed around procedural fluency through introduction of standard algorithms at the beginning of each lesson. At the beginning of each problem set, an example problem is worked out, and each of the questions asked can be solved in the same way as the example. This curriculum received a rating of no critical thinking because it had almost no support and the lessons and homework did not support critical thinking.

Big Ideas Math is set up in a way that supports critical thinking. There are almost no missed opportunities for critical thinking. The lesson begins with exploration and allows students to build their own understanding of the concept before moving on to the standard algorithm. At the end of the lesson, students are given chances to apply their learning in a new setting and justify their answers. This curriculum received a rating of substantial critical thinking because it had a large amount of support for critical thinking with almost no missed opportunities.

My Math contains some opportunities for critical thinking and some missed opportunities for critical thinking. The supports put into place for the teachers support critical thinking and the set-up of the lesson provide some opportunities for exploration.

However, the homework and practice problems were modeled exactly after example problems presented in the materials. This curriculum received a rating of some critical thinking because it had good teacher support but the homework was not condusive to critical thinking.

Overall Analysis

Using the data from the teacher rubric, the student rubric, and the descriptive analysis, an overall critical thinking score was assigned (Table 17). This was done using the point system for determining the overall critical thinking score. Based on this system, *Go Math!* received 0 points and *Big Ideas Math* and *My Math* each received 2 points. All of the curricula analyzed received an overall critical thinking score of poor. This means they were all extremely lacking in at least one category and therefore will not be able to support critical thinking in the classroom.

Table 17.

Overall Critical Thinking Score

Curriculum	**Overall Level of Teacher Guidance**	**Average Index for Student Guidance in Critical Thinking**	**Descriptive Analysis**	**Overall Points**	**Overall Critical Thinking Score**
Go Math!	Not Enough	0.34	No critical thinking	0	Poor
Big Ideas Math	Not Enough	0.28	Substantial critical thinking	2	Poor
My Math	Some	0.15	Some critical thinking	2	Poor

Chapter V: Discussion

The goals of this research were to identify what features of curricula contribute to critical thinking, identify how to measure this, develop an evaluation instrument, and use that instrument to evaluate curricula and determine if they are promoting critical thinking. This led to some interesting findings.

Based on the literature and the findings from this study, there are clear elements of curricula that contribute to critical thinking. For the teacher materials, this is evident in their educative features. For teacher materials to promote critical thinking, they should contain common misconceptions with explanations (Davis & Krajcik, 2005), explanations on how to use formative assessments (Davis & Krajcik, 2005), and explanations of pedagogy (Arias et al., 2017). These features can all help promote an understanding of material and the way students think, which in turn can be used to promote critical thinking. Student materials should contain inclusive language that encourages students to make decisions and justify their reasoning (O'Keefe & O'Donoghue, 2014). They should also contain opportunities for exploration and applying knowledge in new settings (Sasson, Yehuda, & Malkinson, 2018). This can be seen through the kinds of problems and questions asked and the DOK levels of activities included (Wyse & Viger, 2011).

This research has many implications. The evaluation instrument that was developed was a rubric with elements of descriptive analysis. This rubric utilized the

identified features of curricula that contribute to critical thinking to determine the curricula's critical thinking potential. In the analysis of overall level of teacher guidance, only *My Math* had some level of teacher guidance for critical thinking. The other two curricula had not enough, which is the lowest level possible. This indicates the need for more educative features in curricula that are shown to support critical thinking and better inclusion of open-ended questions that allow for critical thinking for teachers to ask students (Sasson, Yehuda, & Malkinson, 2018). There is especially the need to look at how formative assessment is being used because all of the curricula received a score of not enough support in this category. This is necessary because including educative features in curricula allows teachers to have a deeper understanding of both the content and how to support students with the content. This knowledge is the basis for teachers to feel confident in supporting students in critical thinking problems.

The analysis for the student guidance in critical thinking revealed similar findings. None of the curricula were found to promote critical thinking. Overall, none of the curricula received a high index (>1) in any of the categories. This implies that student curricula are currently focused primarily on building procedural knowledge.

The descriptive analysis found that *Big Ideas Math* had substantial critical thinking, *My Math* had some critical thinking, and *Go Math!* had no critical thinking. While these results do suggest that some curricula do contain substantial amounts of critical thinking, these results cannot be considered alone. Without the educative features and the features in student curricula that were measured in the rubrics, the curricula has much less potential for critical thinking than it would with those features (Davis & Krajcik, 2005; Polikoff, 2015).

Critical thinking is one of the four most valued skills by employers (American Management Association, 2012) and having the ability to think creatively is linked to higher mathematical performance (Sebastian & Huang, 2016). Therefore, critical thinking should be prioritized in schools, particularly in mathematics. Because curricula is one of the most important indicators of the effectiveness of teachers (Chingos & Whitehurst, 2012), critical thinking should be a main goal in mathematics curricula. However, the findings from the overall analysis of the rubrics and the descriptive analysis found that none of the curricula meet the criteria for promoting critical thinking. This implies the need for redesigning both mathematics curricula and the standards for the mathematics curricula that are being adopted by schools. There is not enough of an emphasis on critical thinking in how textbooks are currently being written and chosen by school districts. Curricula and curricula evaluation instruments should be rewritten to include the identified elements of effective curriculum promoting critical thinking so that students will be set up for success in a world that necessitates critical thinking as a skill (Huitt, 1998; Butler, 2012).

Limitations

This study was limited because the research was only tested on 3 curricula. More textbooks need to be reviewed with this system to determine if it can accurately give a picture of the potential for critical thinking in curricula. In addition, the methods for reviewing identified in this study are largely subjective. Multiple rounds of reviewing the same curriculum by different individuals need to be done to determine if the rubric is designed in a way that will yield accurate results.

Further Studies

Because of the limitations on this research, further studies should be done to determine the best way to measure critical thinking in mathematics curriculum. These studies should focus on wide ranges of curricula to validate the results found in this study. Additionally, studies should be done that look at how to rewrite mathematics curricula so that it promotes critical thinking using the features identified in this study.

LIST OF REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E. Waddington, D. I., Wade, C. A., & Persson, T (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research, 85.(*2), 275-314. https://doi.org/10.3102/0034654314551063

American Management Association. (2012, December). *Critical Skills Survey*. https://www.amanet.org/assets/1/6/2012-critical-skills-survey.pdf

Arias, A. M., Smith, P. S., Davis, E. A., Marino, J. & Palincsar, A. S. (2017). Justifying predictions: Connecting use of educative curriculum materials to students' engagement in science argumentation. *Journal of Science Teacher Education, 28.(*1), 11-35. https://doi.org/10.1080/1046560X.2016.1277597

Butler, H. A. (2012). Halpern critical thinking assessment predicts real-world outcomes of critical thinking. *Applied Cognitive Psychology, 26.(*5), 721-729. https://doi.org/10.1002/acp.2851

Chingos, M. M., & Whitehurst, G. J. (2012. Choosing blindly: instructional materials, teacher effectiveness and the common core. *Brown Center on Education Policy at Brookings.* Retrieved March 21, 2020 from https://www.brookings.edu/

Conley, D. T. (2014). Common Core: Development and substance and commentaries. *Social Policy Report, 28.(*2). https://doi.org/10.1002/j.2379-3988.2014.tb00079.x

National Governors Association Center for Best Practices, & Council of Chief State School Officers. (2010). *Common Core State Standards.* Retrieved from http://www.corestandards.org/

Creswell, J. W. (1998). *Qualitative inquiry and research design: choosing among five traditions.* Thousand Oaks, Calif.: Sage Publications.

Davis, E. A. & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34.(*3), 3-14. https://doi.org/10.3102/0013189X034003003

Defining critical thinking. (2019). The Foundation for Critical Thinking. Retrieved March 14, 2020, from http://www.criticalthinking.org/

Fuentes, S. Q., & Ma, J. (2018). Promoting teacher learning: a framework for evaluating the educative features of mathematics curriculum materials. *Journal of Mathematics Teacher Education, 21.(*4), 351-385. DOI: 10.1007/s10857-017-9366-2

Haynes, S. N., Richard, D. C. S., & Kubany, E. S. (1995). Content validity in psychological assessment: A functional approach to concepts and methods. Psychological Assessment, 7(3), 238–247. https://doi.org/10.1037/1040-3590.7.3.238

Herbel-Eisenmann, B. A. (2007). From intended curriculum to written curriculum: Explaining the "voice" of a mathematics textbook. *Journal for Research in Mathematics Education, 38.(*4), 344-369. DOI: 10.2307/30034878

Hill, H. C. (2001). Content across communities: Validating measures of elementary mathematics instruction. *Educational Policy, 19.(*3), 447-475. DOI: 10.1177/0895904805276142

Hong, D. S., Choi, K. M., Runnals, C. & Hwang, J. (2019). How well aligned are common core textbooks to students' development in area measurement? *School Science and Mathematics, 119.(*5), 240-254. https://doi.org/10.1111/ssm.12336

Houghton Mifflin Harcourt (2017). *Go math!* Houghton Mifflin Harcourt.

Huitt, W. M. (1998). Critical thinking: An overview. *Educational Psychology Interactive.* Retrieved December 3, 2019, from http://www.edpsycinteractive.org/topics/cogsys/critthnk.html

Larson, R. & Boswell, L. (2019). *Big ideas math: Modeling real life.* Big Ideas Learning.

Mississippi McGraw Hill. (2020). *Mississippi McGraw-Hill: My math*. McGraw-Hill School Education, LLC.

Nappi, J. S. (2017). The importance of questioning in developing critical thinking skills. *The Delta Kappa Gamma Bulletin: International Journal for Professional Educators*, 30-42. Retrieved December 3, 2019 from https://cpb-us-e1.wpmucdn.com/cobblearning.net/dist/6/3101/files/2018/05/The-Importance-of-Questioning-2aqkc5j.pdf

National Education Association. *An educator's guide to the "four Cs": Preparing 21st century students for a global society* . National Education Association. http://www.nea.org/assets/docs/A-Guide-to-Four-Cs.pdf

O'Keeffe, L. & O'Donoghue, J. (2014). A role for language analysis in mathematics textbook analysis. *International Journal of Science and Mathematics Education, 13.* 605-630. https://doi.org/10.1007/s10763-013-9463-3

Paige, D. D., Smith, G. S. & Sizemore, J. M. (2015). Conceptualizing rigor and its implications for education in the era of the Common Core. *Cogent Education, 2.(*1). https://doi.org/10.1080/2331186X.2015.1048084

Paul, R. (1992). The critical connection: Higher order thinking that unifies curriculum, instruction, and learning. In A. J. A. Binker (Ed.), *Critical thinking: What every person needs to survive in a rapidly changing world* (pp. 293-308). Foundation for Critical Thinking.

Polikoff, M. S. (2015). How well aligned are textbooks to the common core standards in mathematics? *American Educational Research Journal, 52.(*6), 1185-1211. https://doi-org.umiss.idm.oclc.org/10.3102/0002831215584435

Porter, A., McMaken, J., Hwang, J. & Yang, R. (2011). Common Core standards: The new U.S> intended curriculum. *Educational Researcher, 40.(*3), 104-116. https://doi-org.umiss.idm.oclc.org/10.3102/0013189X11405038

Sasson, I., Yehuda, I., & Malkinson, N. (2018). Fostering the skills of critical thinking and question-posing in a project-based learning environment. *Thinking Skills and Creativity, 29.* 203-212. https://doi.org/10.1016/j.tsc.2018.08.001

Sebastian, J. & Huang, H. (2016). Examinng the relationship of a survey based measure of math creativity with math achievement: Cross-national evidence from PISA 2012. *International Journal of Educational Research, 80.* 74-9. https://doi.org/10.1016/J.IJER.2016.08.010

Sriraman, B. & Knott, L. (2009). The mathematics of estimation: Possibilities for interdisciplinary pedagogy and social consciousness. *Interchange, 40.(*2), 205-223. DOI: 10.1007/s10780-009-9090-7

Textbook Adoption and Procurement. (2019). Mississippi Department of Education. Retrieved March 13, 2020, from https://www.mdek12.org/

Webb, N. L. (1997). Criteria for alignment of expectations and assessments in mathematics and science education. Research monograph no. 6. Retrieved January 7, 2020 from https://eric.ed.gov/?id=ED414305

Wyse, A. & Viger, S. G. (2011). How item writers understand depth of knowledge. *Educational Assessment, 16.(*4), 185-206. DOI: 10.1080/10627197.2011.634286

APPENDICES

APPENDIX A

Analysis of Textbook Alignment for Critical Thinking: Teachers

Textbook Title	Publisher	Publication Year	Chapters Analyzed
Textbook #1:			
Textbook #2:			
Textbook #3:			

Select three chapters from textbook #1. Determine what content each of the chapters is on. Then pick three chapters from textbook #2 and textbook #3 that contain similar information to the three chapters chosen from textbook #1.

Misconception Analysis

Randomly select 6 lessons in **each** book (2 from each chosen chapter). Indicate Yes or No for whether at least one misconception is explicitly identified. Then identify how many misconceptions have been identified. For each explicitly identified misconception, identify whether an explanation is given for at least one or all misconceptions. Then calculate the sum of columns. Under evidence, record how explanations are given for misconceptions for each textbook.

Textbook #1:

Title of Activity	Pages	Is at least one "common" student misconception identified explicitly? (Yes -1/ No -0)	Number of Misconceptions Identified (1 point per misconception)	If yes, are explanations for each identified misconception given? (no explanations given -0; explanations given for some identified misconceptions, but not all -1; explanations given for all identified misconceptions -2)	Sum green columns
1.					
2.					

3.					
4.					
5.					
6.					

Textbook #2:

Title of Activity	Pages	Is at least one "common" student misconception identified explicitly? (Yes -1/ No -0)	Number of Misconceptions Identified (1 point per misconception)	If yes, are explanations for each identified misconception given? (no explanations given -0; explanations given for some identified misconceptions, but not all -1; explanations given for all identified misconceptions -2)	Sum green columns
1.					

2.					
3.					
4.					
5.					
6.					

Textbook #3:

Title of Activity	Pages	Is at least one "common" student misconception identified explicitly? (Yes -1/ No -0)	Number of Misconceptions Identified (1 point per misconception)	If yes, are explanations for each identified misconception given? (no explanations given -0; explanations given for some identified misconceptions, but not all -1; explanations given for all identified misconceptions -2)	Sum green columns

1.					
2.					
3.					
4.					
5.					
6.					

Evidence:

Misconception Explanation Textbook #1:

Misconception Explanation Textbook#2:

Misconception Explanation Textbook #3:

Formative Assessment Analysis

Use the previously selected chapters from each text. Identify all potential assessments in each of the chapters and fill in the columns below. Calculate the index of use of formative assessment in the curriculum by finding the ratio of potential assessments that indicate how it could be used by a teacher for a formative purpose to the total number of potential assessments in the chapter. Under evidence, record at least one example of an identified use of a formative assessment from each textbook. Make sure to describe the formative assessment being used. Calculate the index of teacher guidance in formative assessment by dividing the total of the green column by the total of the yellow column for each book.

Index of teacher guidance in formative assessment Text #1 =

Index of teacher guidance in formative assessment Text #2 =

Index of teacher guidance in formative assessment Text #3 =

Formative Assessment Analysis

Text #	Chapter	Potential assessments provided (yes/no)	Number of potential assessments provided	Number of potential assessments provided that indicate how a teacher could use it for a formative purpose
1				
1				
1				
TOTALS				
2				
2				
2				
TOTALS				
3				
3				
3				
TOTALS				

Evidence:

Formative Assessment Use Textbook #1:

Formative Assessment Use Textbook#2:

Formative Assessment Use Textbook #3:

Pedagogy Analysis

Open each curriculum book to 10 random pages (open the book 10 times). Identify how pedagogy is used by marking all categories that are represented on the page. Calculate the index of pedagogy for teachers=number of checks in green column/ number of checks in yellow column. Record at least one example of explanations of instructional methods and explanations of how to support students in critical thinking under "evidence" below the chart.

Index of teacher guidance in critical thinking pedagogy Text #1 =

Index of teacher guidance in critical thinking pedagogy Text #2 =

Index of teacher guidance in critical thinking pedagogy Text #3 =

Pedagogy Analysis

Text #	Page #	No mention of pedagogy or explanation of why methods are used	Includes closed ended questions (e.g., yes/no, one right answer)	Includes explanation of why instructional methods are used	Includes explanation of how to support students in critical thinking	Includes open ended questions (e.g., multiple possible correct answers)	Fits none of these categories
1							
1							
1							
1							
1							
1							

1							
1							
1							
1							
TOTALS							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
TOTALS							
3							
3							
3							
3							
3							
3							
3							
3							

3							
3							
TOTALS							

Evidence:

Textbook #1:

Examples of explanations of instructional methods:

Examples of explanations of how to support students in critical thinking:

Textbook #2:

Examples of explanations of instructional methods:

Examples of explanations of how to support students in critical thinking:

Textbook #3:

Examples of explanations of instructional methods:

Examples of explanations of how to support students in critical thinking:

Analysis of Textbook Alignment for Critical Thinking: Teachers

Textbook Title	Publisher	Publication Year	Chapters Analyzed
Textbook #1: Go Math!	**Houghton Mifflin Harcourt**	**2017**	**1,2,4**
Textbook #2: Big Ideas Math	**Big Ideas Learning**	**2019**	**1,5,6**
Textbook #3: My Math	**McGraw-Hill**	**2016**	**1,3,6**

Select three chapters from textbook #1. Determine what content each of the chapters is on. Then pick three chapters from textbook #2 and textbook #3 that contain similar information to the three chapters chosen from textbook #1.

Misconception Analysis

Randomly select 6 lessons in **each** book (2 from each chosen chapter). Indicate Yes or No for whether at least one misconception is explicitly identified. Then identify how many misconceptions have been identified. For each explicitly identified misconception, identify whether an explanation is given for at least one or all misconceptions. Then calculate the sum of columns. Under evidence, record how explanations are given for misconceptions for each textbook.

Textbook #1:

Title of Activity	Pages	Is at least one "common" student misconception identified explicitly? (Yes - 1/ No -0)	Number of Misconceptions Identified	If yes, are explanations for each identified misconception given? (no explanations given -0; explanations given for some identified misconceptions, but not all -1; explanations given for all identified misconceptions -2)	Sum green columns
1.Divide by 1-Digit Divisors	**93A-98**	1	Yes: 1	2	3
2.Partial Quotients	**105A-112**	1	Yes: 1	2	3

3.Algebra: Powers of 10 and Exponents	**23A-28**	1	Yes: 1	2	3
4.Multiply by 1 digit numbers	**37A-42**	1	Yes: 1	2	3
5. Investigate-Multiply Decimals and Whole Numbers	**239A-244**	1	Yes: 1	2	3
6.Multiply Using Expanded Form	**251A-256**	1	Yes: 1	2	3

Textbook #2:

Title of Activity	Pages	Is at least one "common" student misconception identified explicitly? (Yes - 1/ No -0)	Number of Misconceptions Identified	If yes, are explanations for each identified misconception given? (no explanations given - 0; explanations given for some identified misconceptions, but not all -1; explanations given for all identified misconceptions -2)	Sum green columns
1. Place Value with Whole Numbers	**T-9-T-15**	1	1	2	3

2.Place Value with Decimals	**T-27-T-32**	0	No: 0	0	0
3.Use models to multiply decimals and whole numbers	**T-187-T-192**	1	Yes: 1	2	3
4.Use Partial Products to multiply decimals	**T-205-T-210**	0	0	0	0
5.Relate Multiplication and Division	**T-237-T-242**	0	0	0	0
6.Estimate Quotients	**T-249-T-254**	0	0	0	0

Textbook #3:

Title of Activity	**Pages**	**Is at least one "common" student misconception identified explicitly? (Yes - 1/ No -0)**	**Number of Misconceptions Identified**	**If yes, are explanations for each identified misconception given? (no explanations given - 0; explanations given for some identified misconceptions, but not all -1; explanations given for all identified misconceptions -2)**	**Sum green columns**

1.Represent Decimals	**29A-34**	1	2	2	3
2.Place Value Through Thousandths	**43A-47A**	1	3	2	3
3.Relate Division to Multiplication	**157A-162**	1	1	2	3
4.Two Digit Dividends	**169A-174**	1	1	2	3
5.Multiply Decimals	**403A-408**	1	2	2	3
6.Estimate Quotients	**429A-434**	1	2	2	3

Evidence:

Misconception Explanation Textbook #1:
Error: Students May Add Regrouped Digits before multiplying the next place value

Springboard to Learning: Remind students that the regrouped digit is added to the product of the next place and not to the factor in the next place. Point out that the regrouped digit is already part of a product.

Misconception Explanation Textbook#2:
Common Error: Watch for a misplaced zero in Exercise 2. If students write the zero at the end, have them read just the last period aloud to see it is erroneously 580.

Misconception Explanation Textbook #3:
When estimating quotients, students may choose different ways to estimate. Students may want to use rounding only, but this is not always the best way to estimate.

Formative Assessment Analysis

Use the previously selected chapters from each text. Identify all potential assessments in each of the chapters and fill in the columns below. Calculate the index of use of formative assessment in the curriculum by finding the ratio of potential assessments that indicate how it could be used by a teacher for a formative purpose to the total number of potential assessments in the chapter. Green items identify characteristics of curriculum that will help teachers understand their students' thinking, while yellow columns do not help teachers. Under evidence, record at least one example of an identified use of a formative assessment from each textbook. Make sure to describe the formative assessment being used. Calculate the index of teacher guidance in formative assessment by dividing the total of the green column by the total of the yellow column for each book.

Index of teacher guidance in formative assessment Text #1 = 29/58=0.5

Index of teacher guidance in formative assessment Text #2 = 26/47=0.553

Index of teacher guidance in formative assessment Text #3 = 29/80=0.363

Formative Assessment Analysis

Text #	Chapter	Potential assessments provided (yes/no)	Number of potential assessments provided	Number of potential assessments provided that indicate how a teacher could use it for a formative purpose
1	1	yes	20	10
1	2	yes	20	10
1	4	yes	18	9
TOTALS			58	29
2	1	yes	12	7
2	5	yes	17	10
2	6	yes	18	9
TOTALS			47	26

3	1	yes	20	7
3	3	yes	31	12
3	6	yes	29	10
TOTALS			80	29

Evidence:

Formative Assessment Use Textbook #1:
Quick Checks: tells how to differentiate instruction if students miss certain problems (used for 9/10 formative assessments)

Formative Assessment Use Textbook#2:

Formative Assessment Use Textbook #3:
Diagnose student errors, concept check gives specific problem numbers to check certain concepts, and suggested differentiated instruction

Pedagogy Analysis

Open each curriculum book to 10 random pages (open the book 10 times). Identify how pedagogy is used by marking all categories that are represented on the page. Calculate the index of pedagogy for teachers=number of checks in green column/ number of checks in yellow column. Record at least one example of explanations of instructional methods and explanations of how to support students in critical thinking under "evidence" below the chart.

Index of teacher guidance in critical thinking pedagogy Text #1 = 9/11=0.818

Index of teacher guidance in critical thinking pedagogy Text #2 = 16/8=2

Index of teacher guidance in critical thinking pedagogy Text #3 = 11/9=1.222

Pedagogy Analysis

Text #	Page #	No mention of pedagogy or explanation of why methods are used	Includes closed ended questions (e.g., yes/no,	Includes explanation of why instructional methods are used	Includes explanation of how to support students in critical thinking	Includes open ended questions (e.g., multiple possible	Fits none of these categories

			one right answer)			correct answers)	
1	109		X				
1	131	X				X	
1	119B	X				X	
1	17		X	X			
1	30	X	X				
1	38	X	X				
1	46		X	X	X		
1	252		X	X			
1	236	X			X	X	
1	233A			X			
TOTALS		5	6	4	2	3	0
2	T-6		X	X	X	X	
2	T-16		X	X			
2	T-33		X	X			
2	T-183			X			
2	T-208		X	X			
2	T-212		X	X			
2	T-224		X	X	X		
2	T-243			X		X	
2	T-250		X	X	X	X	
2	T-252		X	X			

TOTALS		0	8	10	3	3	0
3	58	X			X		
3	44		X			X	
3	11A			X			
3	175B	X		X			
3	184	X		X		X	
3	192			X			
3	406		X	X			
3	428		X			X	
3	438	X	X				
3	446		X	X	X		
TOTALS		4	5	6	2	3	

Evidence:

Textbook #1:

Examples of explanations of instructional methods:

Examples of explanations of how to support students in critical thinking:

Textbook #2:

Examples of explanations of instructional methods:

Examples of explanations of how to support students in critical thinking:

Textbook #3:

Examples of explanations of instructional methods:

Exercise 20 asks students to build upon their understanding of concepts needed to answer the chapter's essential questions

Examples of explanations of how to support students in critical thinking:

If students are struggling to come up with a real-world problem, remind them that they can always represent money as a decimal

APPENDIX B

Analysis of Textbook Alignment for Critical Thinking: Students
Grade Level: Elementary (K-6)
This is designed for use with student workbooks that accompany math curriculum

Textbook Title	Publisher	Publication Year	Chapters Analyzed
Textbook #1:			
Textbook #2:			
Textbook #3:			

Select three chapters from textbook #1. Determine what content each of the chapters is on. Then pick three chapters from textbook #2 and textbook #3 that contain similar information to the three chapters chosen from textbook #1.

Language Analysis

From the selected chapters, randomly select 10 pages total with at least 10 lines of text on them. Take more than 10 sentences of text and assign each sentence to one of the categories below **(select all that apply**). More than one check can be in a box (If more than one sentence on the page fits in that category).Calculate the index of student involvement for the text = (total of green columns)/(total of yellow columns). Record at least one analyzed sentence from a yellow category and one from a green category for each textbook under "evidence" below the chart (if none exist, write n/a). Identify what columns you put the sentence under.

Index of critical thinking for language analysis Text #1 =

Index of critical thinking for language analysis Text #2 =

Index of critical thinking for language analysis Text #3 =

Language Analysis

Text #	Page #	Factual Statement	Exclusive commands (write, add, subtract)	Definitions/ Formulas	Questions with only one possible answer	Rhetorical Questions	Background Information for Context	Inclusive commands (prove, explain)	Statement prompting students to choose a method to solve the problem.	Question asked about making connections Ex: What could you design	Question leading to time for exploration Ex: What if we did _____	None of the above

										to fix…? How is this topic related to another topic?	? Try it.	
1												
1												
1												
1												
1												
1												
1												
1												
1												
1												
1												
TOTALS												
2												
2												
2												
2												
2												
2												
2												
2												
2												
2												
2												

TOTALS												
3												
3												
3												
3												
3												
3												
3												
3												
3												
3												
TOTALS												

Evidence:

Textbook #1

Sentence

Columns Marked

Sentence:

Columns Marked

Textbook #2

Sentence

Columns Marked

Sentence:

Columns Marked

Textbook #3

Sentence

Columns Marked

Sentence:
Columns Marked

Analysis of Lesson Activities

Randomly select 3 in-class tasks from each chosen chapter of each textbook (9 total for each book). Assign them to a different Depth of Knowledge (DOK) level based on the descriptions below. Calculate the index of critical thinking for the lesson activities = number of checks in green columns/number of checks in yellow columns . Under "evidence" put an example of a task from each DOK level from each of the textbooks (if none exist for a certain DOK level, just write N/A)

Index of critical thinking for lesson activities Text #1 =

Index of critical thinking for lesson activities Text #2 =

Index of critical thinking for lesson activities Text #3 =

Analysis of Lesson Activities

Text #	Page #	DOK 1: Activities require students to perform simple calculations or follow a set of procedures	DOK 2: Activities make students decide how to approach the problem, involving interpreting and developing relationships among concepts	DOK 3: Activities have more than one correct response or approach. Students must explain and justify their thinking	DOK 4: Activities usually occur over a period of time. Students must demonstrate reasoning, planning, and developing connections within and beyond a content area.	Fits none of these categories
1						
1						
1						
1						
1						
1						
1						
1						

1						
1						
TOTALS						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
TOTALS						
3						
3						
3						
3						
3						
3						
3						
3						
3						

3						
TOTALS						

Evidence:

Textbook #1

DOK 1 Task Description:

DOK 2 Task Description:

DOK 3 Task Description:

DOK 4 Task Description:

Textbook #2

DOK 1 Task Description:

DOK 2 Task Description:

DOK 3 Task Description:

DOK 4 Task Description:

Textbook #3

DOK 1 Task Description:

DOK 2 Task Description:

DOK 3 Task Description:

DOK 4 Task Description:

Analysis of Problems and Questions

Randomly select 1 homework assignment from each chosen chapter and identify all problems/questions on the page. Mark **any** category that applies to the question. There can be more than one check per column (If more than one question from the page fits in that category). Calculate the index of critical thinking for the problems and questions= number of checks in green columns/number of checks in yellow columns . Record at least one analyzed question/problem from a yellow category and one from a green category for each textbook under "evidence" below the chart (if none exist, write n/a). Identify what columns you put the sentence under.

Index of critical thinking for problems Text #1 =

Index of critical thinking for problems Text #2 =

Index of critical thinking for problems Text #3 =

Analysis of Problems and Questions

Text #	Page #	Question is structured the same as an exampl	Question is asked after introducing a standar	Question is a calculation	Question requires student to apply	Questions requires students to make a	Question requires students to form	Question requires students to notice	Question is asked before introducing a standar	Fits none of these categories

		e problem	d algorithm		learning from the chapter to new situations	decision	an argument for their reasoning	patterns	d algorithm	
1										
1										
1										
TOTALS										
2										
2										
2										
TOTALS										
3										
3										
3										
TOTALS										

Evidence:

Textbook #1

Question/Problem:

Columns Marked

Question/Problem:

Columns Marked

Textbook #2

Question/Problem:

Columns Marked

Question/Problem:

Columns Marked

Textbook #3

Question/Problem:

Columns Marked

Question/Problem:

Columns Marked

Analysis of Textbook Alignment for Critical Thinking: Students
Grade Level: Elementary (K-6)
This is designed for use with student workbooks that accompany math curriculum

Textbook Title	Publisher	Publication Year	Chapters Analyzed
Textbook #1: Go Math!	**Houghton Mifflin Harcourt**	**2017**	**1,2,4**
Textbook #2: Big Ideas Math	**Big Ideas Learning**	**2019**	**1,5,6**
Textbook #3: My Math	**McGraw-Hill**	**2016**	**1,3,6**

Select three chapters from textbook #1. Determine what content each of the chapters is on. Then pick three chapters from textbook #2 and textbook #3 that contain similar information to the three chapters chosen from textbook #1.

Language Analysis

From the selected chapters, randomly select 10 pages total with at least 10 lines of text on them. Take more than 10 sentences of text and assign each sentence to one of the categories below (**select all that apply**). More than one check can be in a box (If more than one sentence on the page fits in that category). Calculate the index of student involvement for the text = (total of green columns)/(total of yellow columns). Record at least one analyzed sentence from a yellow category and one from a green category for each textbook under "evidence" below the chart (if none exist, write n/a). Identify what columns you put the sentence under.

Index of critical thinking for language analysis Text #1 = 25/87= 0.287

Index of critical thinking for language analysis Text #2 = 4/96=0.042

Index of critical thinking for language analysis Text #3 = 4/75=0.053

Language Analysis

Text #	Page #	Factual Statement	Exclusive commands (write, add, subtract)	Definitions/ Formulas	Questions with only one possible answer	Rhetorical Questions	Background Information for Context	Inclusive commands (prove, explain)	Statement prompting students to choose a method to solve the problem.	Question asked about making connections Ex: What could you design to fix…?	Question leading to time for exploration Ex: What if we did _____ ? Try it.	None of the above

										How is this topic related to another topic?		
1	29		XX		XXXX	X	XX					
1	50	XX	XXXXX	X				X				
1	74		XXXXX	XX	X		XX		X		X	
1	85		XXXXX		XXX		XX					
1	94	XXXXXX	XX	X	X				X			
1	102				XXXX		XXXXX	X	XXX			
1	108		X		XX		XXX	XX	XX		X	
1	232B		XXX				XX	XXXX	X		X	
1	257		XX		XXXX		XXXX			X		
1	274				XX		XXXXX	X	XXX			
TOTALS		8	26	4	21	1	27	9	11	2	3	0
2	24		XXXX		XX		XXXX					
2	42		XXX		XXXX		XX				X	
2	6	X	X		XXXX XXXX							
2	202		XXXX		XXXX		XX					
2	186		X		XXXX		XXX	X	X			

2	224	XXXXX	XXX		X		X					
2	244		XXXXXXX	XXX	X							
2	250		XXXXXXXXXX									
2	252		XXXX		XXX		XXX					
2	270				XXXXX		XXXX	X				
TOTALS		6	36	3	32	0	19	2	1	0	1	0
3	23		XXXXX	XX	XXX							
3	27	X	XXXX		XXXXX							
3	61		XXX		XXXXX		XX					
3	157	X	X	X	XXXXX		XX					
3	163		XXXXXXX		XX		X					
3	170		XXXXX	X	XX		XX					
3	176		XXX		XXXXXX		X					
3	391	XXX	XXX		XXXX							
3	394		XXX		XX		XX	XX	X			
3	414				XXXXX		XXXXX			X		
TOTALS		4	25	0	31	0	15	2	1	1	0	0

Evidence:

Textbook #1

Sentence: Write the multiplication sentence with the unknown factor that you found.
Columns Marked: Exclusive commands

Sentence: What pattern do you see in the number sentences and the exponents?
Columns Marked: Question asked about making connections

Textbook #2

Sentence Divide 214 by 12 to find how many egg cartons you need
Columns Marked: Exclusive commands

Sentence:
Columns Marked:

Textbook #3

Sentence: Divide the tens
Columns Marked: Exclusive commands

Sentence: Explain your reasoning.
Columns Marked: Inclusive commands

Analysis of Lesson Activities

Randomly select 3 in-class tasks from each chosen chapter of each textbook (9 total for each book). Assign them to a different Depth of Knowledge (DOK) level based on the descriptions below. Calculate the index of critical thinking for the lesson activities = number of checks in green columns/number of checks in yellow columns . Under "evidence" put an example of a task from each DOK level from each of the textbooks (if none exist for a certain DOK level, just write N/A)

Index of critical thinking for lesson activities Text #1 = 3/7= 0.429

Index of critical thinking for lesson activities Text #2 = 2/8= 0.25

Index of critical thinking for lesson activities Text #3 = 2/8= 0.25

Analysis of Lesson Activities

Text #	Page #	DOK 1: Activities require students to perform simple calculations or follow a set of procedures	DOK 2: Activities make students decide how to approach the problem, involving interpreting and developing	DOK 3: Activities have more than one correct response or approach. Students must explain and	DOK 4: Activities usually occur over a period of time. Students must demonstrate reasoning, planning, and developing connections within	Fits none of these categories

			relationships among concepts	justify their thinking	and beyond a content area.	
1	274			X		
1	271			X		
1	255		X			
1	255	X				
1	122		X			
1	114	X				
1	106		X			
1	40			X		
1	29	X				
1	18	X				
TOTALS		4	3	3	0	
2	246		X			
2	238	X				
2	205			X		
2	181			X		
2	267		X			
2	263	X				
2	251		X			
2	30	X				
2	15		X			
2	6	X				
TOTALS		4	4	2	0	
3	411	X				
3	357	X				

3	330	X				
3	380	X				
3	398		X			
3	414			X		
3	418		X			
3	235			X		
3	44	X				
3	52		X			
TOTALS		5	3	2		

Evidence:

Textbook #1

DOK 1 Task Description: Draw a model to find the product. (Located right next to an identical example)

DOK 2 Task Description: Word problem with one right answer but that can be approached in multiple ways.

DOK 3 Task Description: What if you multiplied 2.8 X 1.74? What would be the place value of the product? Explain your answer.

DOK 4 Task Description: N/A

Textbook #2

DOK 1 Task Description: Solving 68/4

DOK 2 Task Description: Deciding how many $20 bills the ATM has it if starts with $10,000 and 80 $20 bills are withdrawn

DOK 3 Task Description: Use an area model to explore how to use partial products to multiply decimals

DOK 4 Task Description: N/A

Textbook #3

DOK 1 Task Description: Following explicit steps to solve problem

DOK 2 Task Description: Without using models, explain why 2 tenths times 3 tenths is equal to 6 hundredths. Use place value in your explanation.

DOK 3 Task Description: How does the exponent of each power of ten often correspond with placing a decimal?

DOK 4 Task Description: N/A

Analysis of Problems and Questions

Randomly select 1 homework assignment from each chosen chapter and identify all problems/questions on the page. Mark **any** category that applies to the question. There can be more than one check per column (If more than one question from the page fits in that category). If you need to look at previous pages to determine whether it is structured the same as an example problem or if it is asked after introducing a standard algorithm, that is allowed. Calculate the index of critical thinking for the problems and questions= number of checks in green columns/number of checks in yellow columns . Record at least one analyzed question/problem from a yellow category and one from a green category for each textbook under "evidence" below the chart (if none exist, write n/a). Identify what columns you put the sentence under.

Index of critical thinking for problems Text #1 = 17/56=0.304

Index of critical thinking for problems Text #2 = 17/31=0.548

Index of critical thinking for problems Text #3 = 4/27=0.148

Analysis of Problems and Questions

Text #	Page #	Question is structured the same as an example problem	Question is asked after introducing a standard algorithm	Question is a calculation	Question requires student to apply learning from the chapter to new situations	Questions requires students to make a decision	Question requires students to form an argument for their reasoning	Question requires students to notice patterns	Question is asked before introducing a standard algorithm	Question asks students to solve multiple ways	Fits none of these categories
1	27	XXXXXX		XXXXXXXX				XX			
1	123	XXXXXXXXX		XXXXXXXXX	XX		X			X	
1	237	XXXXXXXXXXX		XXXXXXXXXX			X	XXXXXXXXX			
TOTALS		27	0	29	2	0	2	12	0	1	0
2	19	X		XXXXXXXX	XX	XX	X	X			X
2	227		XX	XXXXXX	X	XXX					

2	283	XXXXXX		XXXXXXX	XX	XXX	X			X	X
TOTALS		7	2	22	5	8	2	1	0	1	2
3	53	XXXXXXX XXXXX		XXX		XX	XX				X
3	199	XXXXXX									X
3	401	XX	XXXX								
TOTALS		20	4	3	0	2	2	0	0	0	2

Evidence:

Textbook #1

Question/Problem: 1,650/55

Columns Marked Structured like example, calculation

Question/Problem:Choose a problem that you solved in the lesson and solve the problem using the partial quotients method. Compare the methods to solve the problems. Name the method you like better, and explain why.

Columns Marked: solve multiple ways, justify reasoning

Textbook #2

Question/Problem: 5343/13

Columns Marked Structured like example, calculation

Question/Problem:Work of "student" shown, and asked if they are correct. Explain. Show how to check your friend's answer 2 different ways

Columns Marked: Make decision, solve multiple ways, justify reasoning

Textbook #3

Question/Problem: Is 3.976 greater than, less than, or equal to 4.007

Columns Marked Structured like example, calculation

Question/Problem:George was weighed at the doctor's office. The scale read 67.20 pounds. The doctor wrote 67.2 pounds on George's chart. Did the doctor make a mistake? Explain to a friend.

Columns Marked: Make decision, form argument

APPENDIX C

Analysis of Teacher Materials:

Take one lesson from one of the analyzed chapters for each book and answer the following questions:

1. Describe any parts of the lesson that allow students to explore before being taught the standard algorithm or a procedure of steps.
2. What features are there to support teachers in teaching the lesson?
3. How do these features support critical thinking?
4. Describe the lesson and identify what parts are procedural and what parts involve critical thinking.
5. Identify where critical thinking opportunities were missed. (Examples: Missed chances for open ended questions, teacher gives answer without exploration time, etc).

Analysis of Student Materials:

1. Take a lesson from one of the analyzed chapters for each book and answer the following questions:

a. As the lesson progresses, how does the way students think about the topic change? (What kinds of questions are being asked at the beginning versus the end of the chapter?

b. What supports are in the book to help students think critically? (Are there text boxes identifying how to guide students in thinking? Are there examples of manipulatives that can be used for exploration?)

c. Identify where critical thinking opportunities were missed. (Examples: Introduction of the standard algorithm before chance to explore, too many procedural questions, no opportunity to show work, etc.)

2. Take a homework page each of the analyzed chapters and answer the following questions:

. Is the homework set up in a way to support critical thinking? Why or why not? (Examples of yes: Does it give chances for students to explain their work? Does it have problems with multiple approaches? Do students have to form an argument; Examples of no: All problems are modeled after the example, most problems are calculations)

a. Identify where critical thinking opportunities were missed. (Examples: Only one correct way to get the answer for each question, no word problems with multiple approaches, etc.)

Textbook #1: Go Math!

Analysis of Teacher Materials:

Lesson 4.3: Multiplication with Decimals and Whole Numbers

Take one lesson from one of the analyzed chapters for each book and answer the following questions:

1. Describe any parts of the lesson that allow students to explore before being taught the standard algorithm or a procedure of steps.

N/A

2. What features are there to support teachers in teaching the lesson?

The lesson has clear objectives and essential questions. It lists background knowledge students will need to answer word problems. There are questions to guide the discussion in the classroom with possible answers listed. The teacher edition explains how to walk the students through examples. There is also a box for advanced learners where students write their own problems and then solve a partner's. There is a professional development section before the chapter begins

3. How do these features support critical thinking?

Most of the questions asked support procedural fluency, but there are two questions under the heading "Go Deeper" that support critical thinking. One question asks students to think about why 60.40 and 60.4 are the same answer and the other asks students to think about how using the distributive property to find 5X25 relates to using the distributive property to find 5X2.5. Additionally, one question had students think about the reasonableness of their answers.

4. Describe the lesson and identify what parts are procedural and what parts involve critical thinking.

The lesson is broken up into five sections: engage, explore, explain, elaborate, and evaluate. The engage section is a review of the lesson from the day before and is set up in a procedural way where the teacher talks the students through the steps. The explore section is mostly procedural because the teacher is walking the students through the steps to solve the problem. One of the "Go Deeper" questions is in this section and so there is some critical thinking involved, although there is no mention of exploration time. The explain section is procedural where students are practicing with problems like the examples. The elaborate section has students do word problems using the same procedures they just used, so although it involves applying some knowledge to a new situation it is still largely procedural because they have already been taught how to do it.

5. Identify where critical thinking opportunities were missed. (Examples: Missed chances for open ended questions, teacher gives answer without exploration time, etc).

The professional development at the beginning involves looking at models and how they can be used to understand multiplication. This could have been turned into a chance for exploration for students to try to come to their own understanding of how to solve the problem before being taught it. Additionally, students could have thought about how they could use the distributive property to help them instead of having the steps already written out for them. Even the critical thinking questions do not provide time for students to try it out on their own and explore how they could use the concepts.

Analysis of Student Materials:
Lesson 2.3 Division with 2-Digit Divisors

1. Take a lesson from one of the analyzed chapters for each book and answer the following questions:

a. As the lesson progresses, how does the way students think about the topic change? (What kinds of questions are being asked at the beginning versus the end of the chapter?

The same kinds of questions are being asked. However, at the beginning of the chapter the book provides the steps and the students fill in the blanks to find the answer and then at the end of the chapter students have to do all of the steps on their own. There is also a connect to social studies at the end where students answer 4 questions based on a passage. They have to decide what information to use to answer different questions.

b. What supports are in the book to help students think critically? (Are there text boxes identifying how to guide students in thinking? Are there examples of manipulatives that can be used for exploration?)

There are examples of manipulatives students can use. They show students how to draw pictures to show their thinking, however this is treated as a "standard algorithm" and doesn't have students explore how to do it on their own. There is an exploration portion where students have to analyze one of the steps to explain why the book did what it did.

c. Identify where critical thinking opportunities were missed. (Examples: Introduction of the standard algorithm before chance to explore, too many procedural questions, no opportunity to show work, etc.)

Instead of immediately walking students through the exploration, students could actually have a chance to do it on their own. There could still be some guidance, but the way it is set up now eliminates choice on how to approach the problem.

2. Take a homework page each of the analyzed chapters and answer the following questions:

a. Is the homework set up in a way to support critical thinking? Why or why not? (Examples of yes: Does it give chances for students to explain their work? Does it have problems with multiple approaches? Do students have to form an argument; Examples of no: All problems are modeled after the example, most problems are calculations)

No, the homework is not set up in a way to support critical thinking. The first problem is solved for the students and the rest of the problems could be solved in the exact same way. In fact, most problems tell the students explicitly to follow a certain list of steps to answer the problems. All of the problems are calculations.

b. Identify where critical thinking opportunities were missed. (Examples: Only one correct way to get the answer for each question, no word problems with multiple approaches, etc.)

Instead of providing one way to solve the problem, the homework could have allowed students to explore other ways to solve the problem. The homework could also have given students a chance to think about how they could relate this to multiplication.

Additionally, chances for explanations of reasonableness of answers could have been provided.

Overall, this curriculum does not support critical thinking. It is designed around procedural fluency through introduction of standard algorithms at the beginning of the lesson. There were more than 4 identified missed opportunities for critical thinking.

Textbook #2: Big Ideas Math

Analysis of Teacher Materials:

Lesson 6.3 Estimate Quotients

Take one lesson from one of the analyzed chapters for each book and answer the following questions:

6. Describe any parts of the lesson that allow students to explore before being taught the standard algorithm or a procedure of steps.

The lesson begins with an activity where each student gets a card with either a division problem or an estimate on it. The students have to then match up the estimates with the equation that the estimate would be reasonable for. The curriculum emphasizes that students need to be the ones to explain how they did this. This allows the students time to explore and think about estimating quotients their own way before the standard way is introduced to them.

7. What features are there to support teachers in teaching the lesson?

There are detailed instructions on how to model and support learners in the lesson. Additionally, during the practice part of the lesson there are different examples of where the students could be in the lesson and what misconceptions they might have.

8. How do these features support critical thinking?

The specific directions on how to help students think critically in the lesson allows the teacher to understand exactly how to present the activity designed for critical thinking so that it is as effective as possible.

9. Describe the lesson and identify what parts are procedural and what parts involve critical thinking.

This lesson is divided into 6 parts: dig in (motivate time), explore and grow, think and grow, apply and grow: practice, think and grow: modeling real life, and the closure. Dig in involves critical thinking because it is the activity where the students are given time to explore and explain the concept in their own words. The explore and grow is also critical thinking because it involves the same process as the dig in but without the moving around the room. Think and grow has some critical thinking components (like the open ended questions being asked) but the aim of it is to teach students procedures for solving problems. Apply and grow: practice and think and grow: modeling real life are procedural because at this point students are just practicing the skill in the same way they have been using it. The closure is a critical thinking question where students have the chance to talk to a partner about a new problem.

10. Identify where critical thinking opportunities were missed. (Examples: Missed chances for open ended questions, teacher gives answer without exploration time, etc).

It appears that the lesson is written in a way where no clear opportunities for critical thinking are missed.

Analysis of Student Materials:

5.3 Use Models to Multiply Decimals and Whole Numbers

3. Take a lesson from one of the analyzed chapters for each book and answer the following questions:

a. As the lesson progresses, how does the way students think about the topic change? (What kinds of questions are being asked at the beginning versus the end of the chapter?

The lesson begins with using a model to find 0.23x3 where students are walked through the steps to understand how to use the model and repeated addition to solve a multiplication problem. Then students practice this. Finally, students have the chance to practice with some word problems that present the information in a different way. They are still using the model, but they might have to use it in a different way.

b. What supports are in the book to help students think critically? (Are there text boxes identifying how to guide students in thinking? Are there examples of manipulatives that can be used for exploration?)

After modeling the students are asked to think about how the relationship between addition and multiplication help you find each product. (It has you write about what you just explored). The model introduced at the beginning can be used to solve the critical thinking questions at the end.

c. Identify where critical thinking opportunities were missed. (Examples: Introduction of the standard algorithm before chance to explore, too many procedural questions, no opportunity to show work, etc.)

Students could explore how to use models and the idea of repeated addition on their own first and then could receive specific guidance on the algorithm.

4. Take a homework page each of the analyzed chapters and answer the following questions:

a. Is the homework set up in a way to support critical thinking? Why or why not? (Examples of yes: Does it give chances for students to explain their work? Does it have problems with multiple approaches? Do students have to form an argument; Examples of no: All problems are modeled after the example, most problems are calculations)

Some of the homework is set up to support critical thinking and some of it is procedural. The first 7 problems are procedural because students are following the steps given in an example problem. However, the last 4 questions do support critical thinking because they all present new situations the students have not seen before. The word problems are different than word problems they have solved before. One problem requires comparing how a product changes when a number is changed and has students explain their reasoning.

b. Identify where critical thinking opportunities were missed. (Examples: Only one correct way to get the answer for each question, no word problems with multiple approaches, etc.)

There could have been more critical thinking if the first 7 problems had some sort of critical thinking component like comparing how different answers compare and then looking at why that happens based on the numbers being multiplied.

This curriculum is set up in a way that does support critical thinking. The lesson begins with exploration and allows students to build their own understanding of the concept before moving on to the standard algorithm. At the end of the lesson, students are given chances to apply this learning in a new setting and justify their answers. There are almost no missed opportunities for critical thinking.

Textbook #3:
Analysis of Teacher Materials:
Lesson 3.3
Take one lesson from one of the analyzed chapters for each book and answer the following questions:
11. Describe any parts of the lesson that allow students to explore before being taught the standard algorithm or a procedure of steps.
Students estimate how many fruit snacks they will get if they are divided evenly and then get to check their predictions.
12. What features are there to support teachers in teaching the lesson?
This lesson is scripted so teachers know exactly what to write on the board and how to solve the problem. There are questions labeled with mathematical practices they match (Model with mathematics, reason abstractly, and reason quantitatively)
13. How do these features support critical thinking?
The reason quantitatively question has students think about a situation they have not encountered yet. The reason abstractly question has students think about how to relate multiplication to division.
14. Describe the lesson and identify what parts are procedural and what parts involve critical thinking.
The lesson starts with the students modeling the math. Although this allows time for exploration, it is targeting more procedural skills. The rest of the lesson is divided into how to walk the students through examples. All of these examples are taught for procedural fluency because the teacher is asking close-ended questions to guide students through the problem solving process.
15. Identify where critical thinking opportunities were missed. (Examples: Missed chances for open ended questions, teacher gives answer without exploration time, etc).
The exploration at the beginning could have been followed up by more open ended questions and hypothetical questions for the students to explore. Additionally the amount of close ended questions to guide students through the process could be replaced with some open ended questions about what the students think will happen next.

Analysis of Student Materials:
Lesson 6.3 Multiply Decimals by Whole Numbers

5. Take a lesson from one of the analyzed chapters for each book and answer the following questions:

a. As the lesson progresses, how does the way students think about the topic change? (What kinds of questions are being asked at the beginning versus the end of the chapter?

The students are given two ways of solving the problems. They then use those two ways to perform calculations and solve simple word problems. The brain builder section at the end has students use number sense to place decimal points and explanations with comparing and contrasting multiplying with whole numbers and multiplying with a whole number and a decimal. These allow students to think critically about the topic.

b. What supports are in the book to help students think critically? (Are there text boxes identifying how to guide students in thinking? Are there examples of manipulatives that can be used for exploration?)

The brain builders section at the end has students reflect on what they learned and think about the implications for other problems.

c. Identify where critical thinking opportunities were missed. (Examples: Introduction of the standard algorithm before chance to explore, too many procedural questions, no opportunity to show work, etc.)

There could have been opportunities to work with manipulatives to think about what this process would actually look like. Additionally students could have thought about how they could estimate for reasonableness before the book told them how to.

6. Take a homework page each of the analyzed chapters and answer the following questions:

a. Is the homework set up in a way to support critical thinking? Why or why not? (Examples of yes: Does it give chances for students to explain their work? Does it have problems with multiple approaches? Do students have to form an argument; Examples of no: All problems are modeled after the example, most problems are calculations)

No, all 14 problems are calculations. There are 5 word problems, but they are modeled exactly after problems in the lesson. There is one chance to "explain" to a friend how they solved it and this is the only chance for explanation. There are directions to check for reasonableness, but there is only one blank for the answer so it is not set up in a way on the page where students will actually check their answer for reasonableness or explain how they did.

b. Identify where critical thinking opportunities were missed. (Examples: Only one correct way to get the answer for each question, no word problems with multiple approaches, etc.)

The questions that used calculations could have actually had students have a place to show how they used estimation or another strategy to decide if their answer was reasonable. The word problems could have had students use the information in a new way to solve unfamiliar problems. More than one way of solving the problem could have been required.

This curriculum had some critical thinking. The supports put into place for the teachers supported critical thinking and the set up of the lesson was somewhat conducive to

critical thinking. However, the homework and practice problems did not allow students to think critically. There were some missed opportunities for critical thinking.