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Opportunity to Learn (OTL) and the Alignment of Upper Division Mathematics Learning Outcomes, Textbooks, and the National Assessment in Belize

by

Gabriel Cal

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Department of Secondary Education
College of Education
University of South Florida

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Keywords: written curriculum, cognitive levels, segments, content coverage, high-stakes

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Dedication

This dissertation is dedicated to my loving family, who provided me with words of encouragement, and for having me in their prayers to the Lord to grant me the wisdom throughout my education.

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I wish to give my heartfelt thanks to my committee members who were more than generous with their expertise and valuable time to help me through this rewarding journey. My special thanks go to Dr. Denisse Thompson, my major professor for the support and guidance. Dr. Denisse Thompson has always found time to provide assistance, both with this dissertation and with various other issues that arose over the past four years.

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Abstract

In this study I investigate the degree of alignment among the learning outcomes, textbooks, and the national assessment in Belize. To establish the degree of alignment, Webb's Four Cognitive Levels of Depth of Knowledge was used to analyze the levels of cognitive demand for each curriculum. The degree of alignment of the learning outcomes with the test items and textbooks was used to determine the extent to which the textbooks provide students with the opportunity to study the learning outcomes assessed by the national assessment. The opportunity to learn (OTL) measures addressed were the curricular content coverage and types of instructional segments in the context of the four upper division mathematics textbooks (*Let's Pass Mathematics, Caribbean Primary Mathematics, Active Mathematics – A Student's Workbook, and PSE Mathematics – Practice Problems and Test)* currently used in Belize.

Findings from the study indicate that the relationship among the three types of curriculum varied in the degree of alignment. A strong relationship was noted between the test items of the national assessment and the instructional segments of the textbooks. With respect to the instructional segments from the textbooks and the learning outcomes, only the Standard 5 textbook had strong alignment while the Standard 6 textbooks exhibited lower cognitive levels than the learning outcomes. A similar case was observed between the cognitive levels of the learning outcomes and the test items. The learning outcomes were at a higher level than the test items, resulting in limited alignment. It is to

be noted that the cognitive demand level of the learning outcome set high expectations which fell short of a strong alignment as a result of the high proportions of low cognitive demand levels of the other curricula in the study.

In light of these findings, I recommend that special attention be given to the textbooks, an important component in the curricular link, that play a significant role in providing support for students to study the learning outcomes and in turn the opportunity to do well in the national assessment.

Chapter 1

Introduction

Over the past century, mathematics curricula in the United States have undergone several shifts in content and procedures with less emphasis on computation. Early in the twentieth century, instruction focused on drill and practice, emphasizing rote memorization and procedural understanding (Kloosterman & Walcott, 2007). Around the 1960's, curricula began to focus on meaningful mathematics which led students to investigate the underlying structure of the discipline. In the late 1970s the back-to-basics movement moved curricula back toward procedures and skills. With the publication of the *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM, 1989), a major shift toward problem solving and conceptual understanding was initiated. The latter became known as the reform movement or *Standards* Era.

Advocates of reform envisioned that standards outlining what students should know and be able to do would also spur other reforms that mobilize resources for student learning, such as high quality curriculum frameworks, materials, and assessments tied to the standards (O'Day & Smith, 1993). In response, states across the U.S. have weighed in with their own versions of standards-based reform, including new curricula, testing systems, accountability schemes, and promotion or graduation requirements. The latter approaches taken by most states have resulted in a variety of curriculum materials. More specifically, some of these curricular materials may have been designed for specific purposes: skill remediation, test preparation, competitions, problem solving practice, software enhancement, and hands-on activities (Usiskin, 2010).

The shift in content in the mathematics curriculum is not unique to the U.S. In Belize, the Ministry of Education (MOE) adopted the four pillars proposed in the report of the International Commission on Education for the Twenty First Century appointed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as Belize's foundation of education: learning to live together, learning to know, learning to do, and learning to be. Consequently, the National Comprehensive Curriculum (NCC) and the Primary Selection Examination (PSE) were introduced into the educational system in Belize under the auspices of the Ministry of Education in 1999. Although the NCC continues to be phased in, the PSE is the instrument designed under the NCC to assess each student's general development in the content areas tested. Concomitantly, the PSE serves as the entrance exam for admission to secondary school, specifically high school.

One common educational issue shared by most countries, including Belize, is accountability for results. Underperformance of students in the many content areas of mathematics has contributed to escalating demands for accountability in most schools. However, the focus on accountability is leading to concerns about the fairness of holding students responsible for reaching high academic standards when they have not been provided with the opportunity to learn what the standards expect. On that note, it seems appropriate to pose the question: What factors are contributing to the poor performance of students in mathematics in Belize? Marzano (2003) contends that the number one factor impacting student achievement is a “guaranteed and viable curriculum.”

Anderson (2005) states that one key component of an accountability system is that the system must be built upon aligned components: objectives, assessments, and resources. In addition, Anderson further suggests that the foundation of results-based accountability systems is clear expectations for student learning, both what students are to learn and how that learning is to be demonstrated. Thus, content standards and assessments are the components on which instructional materials such as textbooks must be aligned. When content standards, assessments, and instructional materials [textbooks] are aligned, students have the maximum opportunity to learn the state standards (Anderson, 2005).

As standards, accountability, and equity interact and redefine values embedded in education systems, the measurement of student Opportunity-to-Learn (OTL) and the fundamental role standards play in students’ learning are increasing in significance. Standards homogenize expectations for schooling across social and physical geographies. These standards act as the pillars of accountability that hold schools responsible for student achievement to promote equity in education (Murphy & Datnow, 2003).

Coupled with the standards is the need to focus on assessment, especially when assessment is used to support learning in addition to being used as a measure of learning; it is fundamental to the whole teaching/learning process. The act of assessing can provide students with an opportunity to learn, and specifically, learn important mathematics (Steen, 1999; van den Heuvel-Panhuizen & Fosnot, 2001). However, Steen (1999) suggests that the impact of high stakes assessment is a continuing source of deep anxiety over issues of fairness and appropriate use. Even when assessments consist of items that are psychometrically unbiased, they can have an unbalanced impact because of the context in which they are given (e.g., to students of uneven preparation) or the way they are used (e.g., to award admissions to higher education or scholarships).

Data on students' performance on the national assessment in Belize raise concerns similar to those in other countries. On average, in May of every year, 6,500 school-leaving students, ages 12 to 14 years, take the National Mathematics Examination which is a major component of the Primary Selection Examination (PSE). Scores on the PSE are used by high schools countrywide as an entry requirement. The national mean for mathematics has remained more or less constant over the last six years as shown in Figure 1, with spikes in 2004 and 2008. The results highlighted in Figure 1 indicate that mathematics continues to be an area of significant challenge for students and the educational system in Belize.

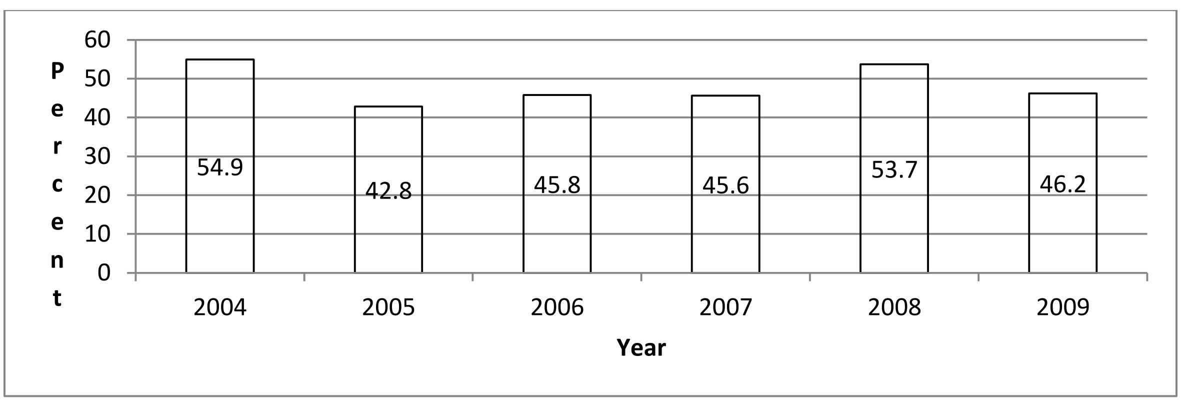

Figure 1. Mean Percent Correct on the Belize Primary Selection Examination 2004-2009

Note. Belize Ministry of Education 2009 Press Release of PSE Results

Notwithstanding the apparent increase in mathematics performance in 2008, the overall performance on the PSE from 2004 to 2009 indicates that students are below the satisfactory level (60-69) and remain at the inadequate level (Grade E, 0-49).

Considering the various social, economic, cognitive, and psychological factors that impact the learning of mathematics, it is difficult to determine which factor or combination of factors contribute to students' poor performance. Nevertheless, examining the textbooks for students' potential opportunity to study the content assessed by the national assessment can be a valuable measure. Examining the textbooks can also be a useful guide to both explain the alignment between the learning outcomes [intended curriculum] and the written curriculum [textbooks] and their alignment with the national assessment in Belize. Hiebert and Grouws (2007) contend that opportunity to learn is "more nuanced and complex than simply exposure to subject matter" and argue that there is a need for a more detailed, richer, and coherent knowledge base of the potential opportunity to learn to inform policy and practice. In agreement with Hiebert and Grouws, an analysis of upper division textbooks to examine the extent textbooks support students' opportunity to study the standards tested on the national assessment would be beneficial to the stakeholders in the education system at large as a first step toward alignment. Subsequent research might determine the extent to which appropriate textbook content is actually enacted in the classroom.

Statement of the Problem

The situations in which schools make decisions about which curriculum materials (e.g., textbooks) are best to promote students' learning tend to vary significantly from place to place (Hudson, Lahann, & Lee, 2010). However, literature suggests that teachers are turning to state standards as their primary guide for identifying what mathematics should be taught and learned by students (Tarr et al., 2006). Such a shift seems to reflect the use of student performance on standardized tests as an indicator of school effectiveness, which seems to be the norm in today's education systems (Fitz-Gibbon & Kochan, 2000).

When high-stakes assessments are used to measure student learning, evidence must be provided that the students have had adequate opportunity to learn the material on which they are being tested. Textbooks are a strong determinant of what students have the opportunity to learn (OTL). However, concerns have been expressed about the quality of textbooks and about their persuasive influence since textbook content is a significant influence on students' opportunity to learn and their subsequent achievement (Robitaille & Travers, 1992). In essence, textbooks are essential in providing students access to knowledge, supporting their achievement, and meeting a specific state's content standards. For students, not having access to appropriate textbooks or textbooks aligned to standards and assessment may have critical consequences in a standards-based educational system (Oakes & Saunders, 2004).

Therefore, the prominent role textbooks play in students' learning calls for the analysis of important factors: content coverage within the books of important mathematics, the nature of mathematical tasks, and alignment with state standards and assessment. Thus, the mathematical content of a textbook is an important aspect to evaluate for its coherence, focus on important mathematics, and extent of coverage across grades (NCTM, 2000). However, a search of the literature found very limited content analysis studies of middle school mathematics textbooks series and their alignment with mathematical standards, cognitive demand frameworks, and national assessments. Furthermore, a search of the limited literature related to curriculum in Belize revealed that there have been no studies on upper division mathematics textbooks and students' opportunity to learn in Belize. As a developing country, Belize has undertaken steps towards the development of its educational system and information on the alignment of curriculum is fundamental in the developmental process of the national curricula.

Purpose of the Study

The purpose of this study is to examine the extent to which upper division mathematics textbooks provide opportunities for students to study the learning outcomes assessed in the national assessment (PSE) in Belize. Another objective is to examine the nature of alignment among the learning outcomes, textbooks, and test items. I achieved these goals by examining all four textbooks presently used in the upper division in Belize on the following criteria: the Belize National Comprehensive Mathematics Curricula and the Belize Primary Selection Examination (PSE (2009-2010)).

The Belize National Comprehensive Mathematics Curriculum (BNCMC) philosophy is translated in learning outcomes which are outlined in the mathematics curriculum guides for specific grade levels. In the upper division, there are 15 learning outcomes (LOs) that students are expected to study as they transition from standard 5 to 6 (grades 7 and 8) and which are assessed in the national assessment.

Of interest in this study is the extent to which students are provided with the opportunity to study the learning outcomes tested in the national assessment. As a first step to achieve such a goal, the alignment of the learning outcomes with the test items and textbooks is necessary to understand the extent to which the textbooks provide students with the opportunities to study the learning outcomes assessed by the national examinations. The opportunity to learn measures that this study addressed are the curricular content (topics) coverage and the types of instructional segments in the context of the four upper division mathematics textbooks currently used in Belize. In addition to the alignment and opportunity to learn measures, the cognitive level of learning outcomes, instructional segments, and the national test items used as a high stakes test in Belize were analyzed.

Because there are important consequences attached to test performance that can dramatically impact students' futures, fairness demands that all students be provided with appropriate opportunities to achieve the desired standards. Policies may provide students the motivation to achieve, but unless the educational system does its job in providing educational opportunities, students will be unable to perform at expected levels.

Research Questions

The study investigated the extent to which currently used middle school mathematics textbooks in Belize provide students with an opportunity to learn the mathematics on which students are assessed. Specifically, the study addresses the following research questions:

1. To what extent are the learning outcomes of the Upper Division Mathematics Curriculum aligned with the national assessment test items?

2. To what extent do the upper division textbooks in Belize provide students with the opportunities to study the learning outcomes of the Upper Division Mathematics Curriculum?
3. To what extent are the cognitive demands of the instructional segments in the upper division textbooks in Belize aligned with the learning outcomes?
4. To what extent are the instructional segments in the upper division textbooks in Belize aligned with the content of the test items of the national examination?
5. What is the nature of alignment of upper division learning outcomes, written curriculum [textbooks], and test items from the national examination in Belize?

Significance of the Study

The Belize educational system has a National Comprehensive Curriculum (NCC) in mathematics. One limitation of the NCC standards is that they only describe general expectations for mathematics content domains for the three Divisions of primary school. Division I - Infant I, II and Standard I (pre-kindergarten to grade 2), Division II - Standards II, III, and IV (grades 3-6), and Division III - Standards V and VI (grades 7-8). For instance, the upper division, Division III (grades 7 - 8), encompasses nine content domains. By the end of the eighth grade, all students are expected to have strong background knowledge of mathematics in nine content areas: Number Concepts, Number Operations, Rate/Ratio/Proportion, Algebra, Graphs and Statistics, Sets, Measurement, Business Math, and Geometry. Content of the nine domains is assessed through a criterion referenced test consisting of 50 multiple-choice items. Based on test score results, the student may or may not be eligible for entry into secondary schools.

Accordingly, students with the highest test scores get accepted into the "high performing secondary schools" and students with the lowest scores only have the option of being accepted in the "low performing schools" or vocational training schools.

To date there is little formal data in Belize regarding the effectiveness of the National Comprehensive Curriculum materials. That is, no study has yet examined how the Learning Outcomes (LOs) documents align with the upper division textbooks and test items. Determining the extent of alignment between the LOs and the mathematics textbooks and the test items is important in developing and improving mathematics textbooks that serve the needs for students in meeting the country's mandated learning outcomes. Independent reviews of textbooks are not readily available. There are no data with which to document the appropriateness of textbooks in conveying the aims and goals of the curriculum or the evidences of progress in the overall components of curriculum in Belize. Thus, this study is significant because it examined (1) the extent to which the learning outcomes align with the test items, (2) the extent to which the textbook provides students opportunities to study the learning outcomes, and (3) the extent to which the textbook content aligns with the 15 learning outcomes specified for the upper division.

The findings of this study, in the framework of opportunity to learn measures, provides Ministry of Education (MOE) policy makers with critical information to inform decision making pertinent to high stakes testing and the allocation of resources to the schools. Likewise, data on students' OTL provide important feedback to schools to stimulate their thinking about the strengths and weaknesses of their curriculum in relation to their priorities for professional development, materials acquisition, and resource allocations.

In summary, textbooks play an important role in assisting teachers in developing the day-to-day lessons for mathematics classrooms. Embedded in the textbooks are the LOs that translate from policy to practice the mathematical content and processes that students should know and be able to do. Together, the textbooks and learning outcomes documents exert a considerable influence on what students have an opportunity to study in the mathematics classrooms. Research has shown that textbooks provide students with the opportunity to learn if there is alignment among the textbook, learning outcomes, and assessment. It is therefore important to know if the learning outcomes pertaining to the nine mathematical domains in the Belize National Comprehensive Mathematics Curriculum (BNCMC) are aligned with the upper division textbooks in Belize in order to determine the extent textbooks provide students with the opportunity to study the mathematics that is assessed by the national examination.

Definitions of Terms

Curriculum

The term "curriculum" is used to describe mathematical topics that comprise a specific course of study—the "what" of mathematics teaching and learning (Stein, Remillard, & Smith, 2007).

Intended Curriculum

The intended curriculum describes the statements contained in state-developed documents such as learning outcomes, grade-level expectations, content standards, curriculum guides, or frameworks (Valverde et al., 2002) that describe the mathematical content and processes students should learn and be able to perform at specific grade levels or at specified points in time (Porter, 2004).

Written Curriculum

Written curriculum is used in this study to describe the mathematical content and processes developed and portrayed in mathematics textbooks.

Assessed Curriculum

Assessed curriculum is used in this study as the content that is assessed to determine achievement (Porter, 2004).

<u>Learning Outcomes</u>

In Belize, schools are provided with this ***National Syllabus*** that translates the ***National Curriculum*** into strategies for accomplishing the National goals. The ***National Syllabus*** provides the basis for the improvement of student learning and growth by specifying the minimum standard of achievement expected of each student within the specified division. Each division has a set of ***learning outcomes*** that describe the general mathematical content and processes students are expected to know or be able to perform as a result of their experiences in learning mathematics.

<u>Opportunity to Learn</u>

Opportunity to learn (OTL) is defined as "whether or not…students have had the opportunity to study a particular topic or learn how to solve a particular type of problem presented by the test" (Floden, 2002).

Alignment

The term "alignment" is used in this study to describe the extent of agreement between the intended curricula in the form of state LOs and the written curricula in the form of upper division mathematics textbooks. Alignment connects to OTL with respect to coverage of topics, instructional segments, and levels of cognitive complexity of instructional segments in the text and test items. In this study, the alignment between LOs, assessment, and content of the mathematics textbooks was documented regarding the following relationships:

(a) The proportion of LOs aligned with instructional segments that correspond with upper division textbooks in Belize.
(b) The proportion of LOs not present in any instructional segments.
(c) The proportion of instructional segments that do not correspond to any of the state's LOs.

Instructional Segment

For this study, an instructional segment is defined as a short selection of material in a textbook that provides emphasis on and coverage for a particular idea or ideas. These segments are classified into one of five types of instructional segments (lesson, pre-lesson, end-of-lesson extra feature, end-of-chapter feature, and chapter review) which is discussed in greater detail in Chapter 3.

High-stakes testing

State testing tied to the developed learning outcomes, which hold consequences for graduation, and entry to higher education for students and schools (Abrams & Madaus, 2003).

Levels of cognitive demand

This study used the levels of cognitive demand developed by Norman Webb (Depth of Knowledge (DOK)) as an alignment method to examine the consistency among the cognitive demands of the learning outcomes, textbook instructional segments, and the cognitive demands of assessment items.

Upper Division

In Belize's Primary Education System, students go through three divisions: lower (infant I, II, and Standard I); middle (Standard II, III, and IV); upper (Standard V and VI). This study used Upper division which equates to U.S. grades 7 and 8.

Primary Education

The primary education in Belize consists of eight years of schooling that include two years of infant classes (Infants I and II) and another six standards (Standards 1 to 6).

Chapter 2

Literature Review

Theoretical Considerations

The theoretical considerations that served to guide the development of this study were derived from a number of different research fields. The first body of research that informed the methods and structure of this study relates to the analyses of textbooks and curriculum and standards. Studies related to textbooks have resulted in researchers deeming the curriculum as represented in mathematics textbooks as “underachieving” (McKnight et al, 1987) while some research that examined state curriculum standards reports glaring weaknesses, including lack of clarity, lack of rigorous content, and lack of agreement with respect to the grade placement of particular topics across states (Klein et al., 2005; Reys, 2006). Thus, studies of textbooks and curriculum standards were examined to determine useful methods and techniques for documenting the alignment of textbooks and state curriculum standards.

The second body of research that informed this study was related to the role of instructional materials such as textbooks and curriculum standards that influence student learning outcomes. Given the critical role that mathematics textbooks play in many mathematics classrooms, it was crucial to analyze those textbooks in order to determine what opportunity they provide students to learn specific mathematical content.

The third research area that informed this study addressed the opportunity to learn indicators identified as important in the context of the written curriculum. Accordingly, learning outcomes (standards) have taken on increased importance in determining what is taught in the mathematics classroom and students' opportunity to learn (Long, 2003). However, textbooks have played an important part in determining the content of classroom instruction (Finn et al., 2004). Given these two sources of mathematics curricula, it seems appropriate and important to study how closely these two types of curriculum align to potentially provide students an opportunity to study the mathematics assessed in the national examinations.

In the following pages, I present the research that served as baseline for my study and how this research on the alignment of learning outcomes, high stakes tests, and the written curriculum [textbooks] in the context of content analysis in mathematics education helps to highlight the importance of addressing the concept of opportunity to learn. Specifically, findings from studies of textbooks that address the indicators which have a direct impact on the opportunity to learn for students were addressed. The latter supports and strengthens the need to conduct the present study in Belize, which also shows how the present study fits into the existing body of research in this area.

Interrelationship in Curricula

Across many nations, including Belize, schools are working to transform the education system by setting rigorous academic standards for students and establishing assessment systems to help ensure that all students achieve those standards. However, improvements in student learning depend on how well assessments, curriculum, and instruction are aligned and reinforce a common set of learning goals. More importantly, student learning depends on whether instruction shifts in response to the information gained from assessments (National Research Council, 2001). Despite the fact that the focus of this study was not on instruction, there is a direct relationship between instruction and the written curriculum [textbook] (Johansson, 2006; Reys, Reys, & Chaves, 2004), which is one of the three components of the educational system, inclusive of the standards and assessment addressed in this study.

The important role of textbooks in mathematics classrooms has long been a staple of education in the United States, as well as in other countries. In the same token, the role of state curriculum documents has also increased in importance due to the accountability measures attached to these documents and related state-mandated assessments (Reys, Dingman, Sutter & Teuscher, 2005). Given the myriad of curriculum interpretations and types found in the literature, it is important to place in perspective the types of curricula addressed in this study: intended, written, and assessed.

Types of Curriculum

Numerous researchers (Porter, 2004; Valverde et al., 2002; Venezky, 1992) have described various types of curriculum as well as the stages that content proceeds through before reaching the student. The curricular chain in this discussion consists of the intended curriculum, the written curriculum, and the assessed curriculum.

The intended curriculum refers to the documents produced by state educational agencies, school curriculum coordinators, or the classroom teachers that specify what should be taught (Glatthorn, 1999). Porter (2004) states that the intended curriculum is most explicitly defined in state curriculum documents as “statements of what every student must know and be able to do by some specified point in time” (p. 1).

The written curriculum refers to the curriculum as it appears in the district adopted textbook, software, and other instructional materials. This form of curriculum, also referred to as the textbook curriculum (Tarr et al., 2006), or the potentially implemented curriculum (Valverde et al., 2002), defines “not only the content of courses but also the sequence of topics and quite often the pedagogical strategies to employ in teaching them” (Venezky, 1992, p. 439). This curriculum provides a day-to-day plan for teachers to use in implementing lessons in their classrooms.

The assessed curriculum is the content upon which students will be tested. The assessed curriculum can refer to nationally administered examinations (i.e., Belize Primary Selection Examination (BPSE)), state-mandated assessments, or district- or teacher-developed tests, such as an end-of-chapter exam (Porter, 2004). Also referred by Glatthorn (1999) as the tested curriculum or the achieved curriculum (Hirsch, Lappan, Reys, & Reys, 2005), this curriculum is the content upon which student achievement will be measured and upon which, in the case of state-mandated assessments, school districts will be held accountable with respect to student learning.

As can be seen from this discussion of the various curriculum types and the curricular chain, textbooks and state curriculum documents provide an important link between the learning outcomes indicated in the intended curriculum and what is actually assessed in the national assessments (i.e., the assessed curriculum). The state curriculum documents outline a specified plan, generally by grade level, to achieve the goals for mathematics education, while the textbook provides a daily guide for teachers in planning instruction for their classroom. According to Biggs (2003), when the curriculum levels (i.e., learning outcomes, textbooks, and assessments) are aligned, students get an opportunity to learn what is expected. Therefore, alignment from the perspective of opportunity to learn is fundamental in a functional standards-based system (Smith & O'Day, 1990).

Opportunity to Learn (OTL)

The concept of OTL has been around for more than 20 years (Stevens, 1993) nevertheless the concept has only been investigated in terms of teacher practices and curricular choices (Herman, Klein, & Abedi, 2000). OTL, the capacity of schools to provide adequate learning opportunities for all students (Bracey, 1995), shifts the focus away from the ends or outputs of schooling (such as test scores) to the inputs of education or the resources provided for helping students reach high standards.

Although originally introduced in the 1960s by educational psychologist John Carroll as students' learning time (cited in Wang, 1998), OTL standards were a political development that received attention in the 1990s (Snow-Renner, 2001). Oakes (1986) helped begin the critical discussion of OTL by describing the roles indicators could play in monitoring educational conditions. As she defined it, an indicator is "a statistic that tells something about the performance or health of the educational system" (p. vii). Oakes argued that the more favorable the conditions of schooling— teacher quality, working conditions, instructional processes, and resources and materials—the stronger and healthier the system. Thus, attention began to shift to what went into an educational system to better analyze and interpret the results.

Porter (1991) followed Oakes, noting that school process indicators were “needed to provide descriptions of educational opportunity...and to explain student outputs” (p. 13). He identified inputs as teacher quality, fiscal resources, and student characteristics. Processes consisted of school-level organizational features (e.g., class size, magnet programs); district, state, and national indicators (e.g., curriculum policies and frameworks, course requirements); and instructional characteristics (e.g., curriculum quality, teaching quality, course-specific resources). In essence, Porter argued that one had to take into account how classroom, school district, and state-level policies worked together (or not) to influence students’ opportunities to learn.

Elmore and Fuhrman (1995) extended the OTL conversation by studying opposing view-points regarding the emphasis on inputs (per-pupil spending, textbooks, teacher training, etc.) versus outputs. They concluded that “opportunity to learn meant providing all students in society equal opportunity to reach ambitious outcomes and that implies that schools must not only have resources but use them well” (p. 438). In the same line of thinking, Stein (2000) stated, “while there has not been unanimous agreement on how to define or measure OTL, scholars have treated this construct as a part of school processes that shape and contribute to student learning” (pp. 290–291). OTL has been linked to broad indicators that can “describe the resources, school conditions, curriculum, and teaching that students experience” (Guiton & Oakes, 1995, p. 326).

According to Furhman (2001), in a standards-based school-system, students are supposed to attain the standards. To evaluate whether students have attained those standards, assessment should be aligned with the standards. In the context of Belize's educational system, learning outcomes (LOs) represent the standards that are typically described in the literature. Thus, the alignment between learning outcomes and assessment is important for students' learning (Anderson, 2002; Biggs, 2003).

A close look at the curriculum types suggests that the intended curriculum (LOs) strongly affects the implemented curriculum and also student learning opportunities. At school, learning opportunities are provided during lessons. Because textbooks contribute to shaping instruction given in classrooms, the impact the textbook has on providing opportunity to learn is evident. On one hand, the textbook reflects the learning outcomes set down by a state or country, and, on the other hand, influences the implemented curriculum by defining the contents to be discussed during mathematics instruction (Schmidt, McKnight, Valverde et al., 1997). Thus, the mathematics textbook as the written curriculum employed in classrooms is among the major factors that affect students' opportunity to learn. Consequently, alignment among the intended, written, and assessed curricula is important for students' opportunity to learn the mathematics.

Indicators of Opportunity to Learn

The following discussion describes the range of measures of opportunity to learn evident in the literature. Most researchers agree that measures of opportunity to learn should include information about the resources, school conditions, curriculum, and teachers' quality (Winfield & Woodard, 1994). However, Floden (2000) noted that OTL can be interpreted in a variety of ways which differ very distinctively in their approach to measuring opportunity to learn. Some interpretations measure OTL as how much emphasis a topic receives in written material (i.e., a curriculum or a textbook) from teachers' reports and surveys, while others measure the quality of instructional delivery using similar approaches.

In the First International Mathematics Study (FIMS), OTL was defined as a measure of "whether or not students have had an opportunity to study a particular topic or learn how to solve a particular type of problem presented by the test" (Husen, 1967, p. 162). In the Second International Mathematics Study (SIMS), OTL was defined as "whether students had been taught the content necessary to answer a particular test item" (Burstein, 1993, p. 35).

Porter (1993b) identified four dimensions for mathematics OTL: the general content areas of mathematics, further breakdowns of each general content area, modes of instruction, and the types and levels of knowledge or skills that students are expected to acquire. Stevens (1993) identified three opportunity-to-learn measures: (1) content coverage, which addresses the coverage of specified topics or learning outcomes in a given grade level; (2) content exposure, which reflects the attention given to learning outcomes; and (3) content emphasis which reflects the relative attention given to the learning outcomes throughout the course (McDonnell, Bernstein, Ormseth, Catterall, & Moody, 1990). With reference to content coverage from Stevens, Porter et al. (1979) suggests that 'content coverage' can be differentiated into 'content covered' and 'content emphasized'. Content covered refers to actual counts made of concepts introduced in the written curriculum. Measures of content emphasized identified in the literature include content coverage as textbook length or number of pages in a textbook devoted to a concept or topic (Good et al., 1978; Barr, 1987; Freeman & Porter 1989). From a different perspective, MacIver et al. (1995) suggests that OTL should include measures of students' access to the core curriculum for their grade level, advanced placement courses, information about college preparation and application process, and understanding and higher order knowledge.

In summary, OTL was originally defined as the overlap between the content students was taught and the content on which they were tested (Anderson, 1990). It first referred to equitable conditions or circumstances within the school or classroom that promote learning for all students. It includes the provision of curricula, learning materials, facilities, teachers, and instructional experiences that enable students to achieve high standards.

Also noted in the studies related to OTL, the measures include teacher characteristics, curriculum goals, content coverage, modes of instruction, and college preparation process. It is worthwhile to note that the OTL measures defined in these studies do not include the written curriculum [textbooks] and the interrelated OTL measures such as mathematical tasks, cognitive demands of tasks, and alignment of learning outcomes with the OTL measures. What follows is research on the role of textbooks in providing an opportunity to learn important mathematics.

Role of Textbooks

Textbooks are frequently used in mathematics classrooms all over the world

(Haggarty & Pepin, 2002; Johansson, 2005). Tyson-Bernstein and Woodward (1991) describe the role of textbooks "as a prominent, if not dominant, part of determining what children have an opportunity to learn" (as cited by Reys, Reys, Tarr, & Chavez, 2006, p. 5). Despite such a prominent role, Haggarty and Pepin (2002), in their analysis of English, French and German mathematics textbooks, concluded that students have varying opportunities to learn depending on the textbook they use. Likewise, Schmidt, McKnight, Valverde et al. (1997) showed that the relative emphasis placed on different mathematical topics in textbooks and curricula differ a great deal among countries.

Researchers note that textbooks have historically played a prominent role in classrooms, often defining the mathematics curriculum that students have an opportunity to learn. Studies also underscore the need to give careful attention to the mathematics content that the textbooks emphasize and how textbooks present it. In addition, textbooks are among the most widely used and trusted written resources by students for school-based learning in all parts of the world (Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996). Particularly, textbooks are used as a source of problems and exercises, as a reference book, and as a teacher in themselves (Howson, 1995). In fact, textbooks capture the process of constructing mathematical topics and skills (Schmidt, McKnight, Valverde, Houang, & Wiley, 1997). Textbooks set the curriculum, and often the facts learned in most subjects. Dole and Shield (2008) see textbook analysis as "a potential means to raise awareness of instruction in key topics within the school mathematics curriculum" and consequently as a vital tool for educational progress.

As textbooks typically provide a sequence of material and activities and instructional ideas for engaging students (Reys, 2004), textbooks have been identified as potential agents of change to transform curriculum (Callopy, 2003; Remillard, 2000). However, such potential would depend upon the extent to which the textbooks align to relevant syllabus documents and educational agendas. On that note, Reys (2004) has argued the need for wise selection of textbooks to support the development of students' mathematics learning and attainment of learning outcomes. In support of Rey's argument, Kulm et al. (2005) state that curriculum materials must be evaluated to determine their effectiveness in helping students achieve important mathematical learning goals for which there is a broad national consensus.

All these reports seem to support the claim that textbooks have a marked influence on what is taught and learned in many mathematics classrooms. Consequently, it will be a worthwhile activity to review the literature on the function of curricular materials [textbooks] that students use to determine the prospects of such resources in impacting students' opportunities to learn mathematics.

Textbooks as the Written Curriculum

Textbooks play a vitally important role in shaping students' views of various school subjects (Valverde et al., 2002). Textbooks themselves reflect particular views of a disciplinary/curricular culture, even if this curricular culture is not necessarily made explicit in the textbooks themselves. Thus, textbooks written in the new or modern mathematics education tradition are likely to differ significantly in both form and content from textbooks inspired by alternative views of mathematics education. Textbooks can be considered a part of the intended curriculum because they often embody specific academic goals for specific sets of students. Such consideration is evident in the Trends in International Mathematics and Science (TIMSS) studies whereby the intended curriculum was represented by the official content standard documents produced by the educational system to inform and guide instruction. The latter considerations have led to a definition of textbooks as the potentially implemented curriculum, recognizing that they serve as a bridge between the official declaration of content standards and the actual activities undertaken in the classrooms (Schmidt, McKnight, & Raizen, 1997)

Data from the largest ever cross-national study of content, pedagogy and other characteristics of the mathematics and science textbooks from 48 countries, which was undertaken as one of three components in the Third International Mathematics and Science Study (Valverde et al., 2002), provided the lens for researchers to understand how textbooks create or constrain students' opportunities to learn complex, problem-solving oriented mathematics. In terms of examining the relationships between mathematics textbooks and achievement, and the role of textbooks in translating policy into practice, the TIMSS researchers adopted the three levels of curriculum discussed earlier – that is, the intended, implemented, and assessed curriculum.

Internationally, the TIMSS textbook study has provided a context for more careful analysis of how textbooks shape opportunities to learn in mathematics. This concern has been given particular impetus since the TIMSS textbook study revealed that, despite bold and ambitious curricular aims of promoting problem solving and mathematics more focused on the real world, the textbooks analyzed in TIMSS did not live up to these goals.

The message from the TIMSS textbook study suggests that there is a mismatch in many countries between reform goals in mathematics and the actual mathematics embodied in textbooks. This observation provides a real challenge for those interested in changing the practice of mathematics education in schools. In conclusion, the findings of the TIMSS textbook study highlight the manner in which mathematics textbooks and other organized resource materials function as a potentially implemented curriculum, and thereby help us understand how textbooks act as mediators between the intention and the implementation of curricula. The following discussion now addresses the function of textbooks which provide another, perhaps more powerful, means of putting in place students' opportunity to learn.

Function of Textbooks

The textbook is seen as an authoritative part of curriculum and also seen as a mediator between the intent of curricular policy and the instruction that occurs in classrooms (Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). Many researchers have analyzed textbooks to understand their potential effect on students' mathematical achievement (Schmidt et al., 1997; Li, 1999; Cai, Lo, & Watanabe, 2002; Zhu & Fan, 2004). However, most existing textbook studies have focused on content analysis (Cai et al., 2002; Carter, Li, & Ferucci, 1997; Fan, 1999), including content-topic coverage and page space devoted to each topic (Schmidt et al., 1997; Tornroos, 2005).

The instructional functions of teaching materials [textbooks] depend on various aspects: their target group, curricular area, textbook type, and the manner in which teachers intend to use these materials (Reints, 2002). Rogiers and Gerard (1998) also claim that textbook functions depend on users, textbook focus, as well as the environment in which the textbook was created. Textbooks considered as a means of knowledge transmission would merely state a number of content topics one after the other for the students to assimilate by simply memorizing and/or learning through a series of similar exercises. However, textbooks, can, and should, fulfill other functions (Rogiers & Gerard (1998). Textbooks are a means to facilitate learning through knowledge transmission as in communication of information to students; development of skills and competencies; consolidation of achievements via exercises; and evaluation of achievements to diagnose difficulties and recommend corrective actions.

The changing conception of textbooks highly influences the role of textbooks and is very much related to changing views and theories concerning the nature of student learning. Under the influence of behaviorist theories, learning was considered to involve the acquisition of knowledge, textbooks were primarily vehicles for transmitting knowledge and therefore focused on the provision of information and congruent activities. Teachers and textbooks were the knowledge authorities and textbooks structured programs of learning for both teachers and students. As learning came to be conceptualized as knowledge construction in constructivist theories, textbooks were increasingly conceptualized as providing opportunities for students to construct understanding through the provision of multiple knowledge sources; multiple sources provided parallel narratives involving written text and illustrations and allowed students to develop their own understandings. Textbooks also increasingly provided students with activities for learning, reflecting constructivist views of the active nature of learning. Among the myriad of functions of textbooks, the notion of encouraging student's self-learning and to support assessment and self-assessment is fundamental. What follows is the perspective of alignment among the types of curriculum discussed earlier.

Curricula Alignment

Figure 2 contains three levels of curriculum: intended curriculum (learning outcomes), written curriculum (textbooks), and assessed curriculum (including standardized tests). The sides of the triangle represent relationships between pairs of curriculum levels: learning outcomes with assessments (side A), learning outcomes with textbooks (side B), and assessments with textbooks (side C).

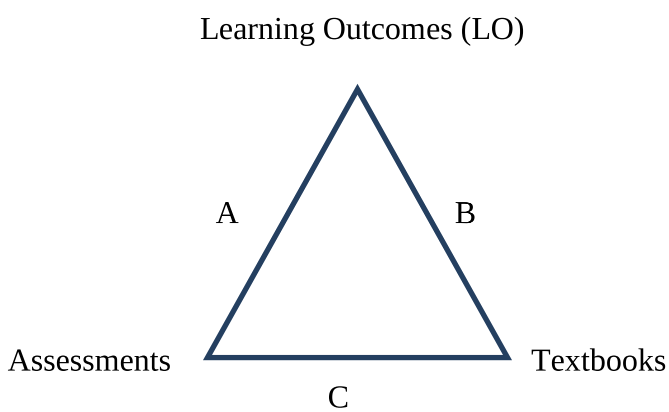

Figure 2. Relationships among Learning Outcomes, Textbooks, and Assessments.

From Figure 2, opportunity to learn, as defined by Burstein & Winters (1994) as 'what students know and can do as a result of their educational experiences' has to do with the relationship between the textbook and assessments (side C). From the latter definition, opportunity to learn studies focus on side C of the triangle. Yet, one important question remains: where does curriculum alignment fit into all of this? Evidently, curriculum alignment is represented by the entire triangle.

According to Anderson (2002), curriculum alignment requires a strong link between learning outcomes and assessments, between learning outcomes and textbooks, and between assessments and textbooks. In other words, opportunity to learn is included within the more general concept of "curriculum alignment."

Curriculum alignment often has been cited as one of the most powerful strategies for improving student achievement (Cawelti & Protheroe, 2003). It presents new challenges and opportunities for schools as they seek to align written curriculum with state standards and assessments (Blank, 2004; Clarke, Stow, Ruebling, & Kayona, 2006).

Alignment of Standards, Written Curriculum and Assessment

From an assessment perspective, OTL means that students must be taught the skills tested on an accountability measure. This type of OTL evidence is based on curricular validity which looks at the match between tested content drawn from state academic standards and classroom curricular materials such as textbooks. Given the perceived and actual close links between high-stakes test results and future educational opportunities, learners and stakeholders in education have focused their attention on the types of knowledge required to do well on high stakes tests. Literature suggests that high stakes testing has a powerful backwash effect on curriculum, shaping both what is taught and how it is taught, and often narrows the frame in terms of what counts as worthwhile knowledge. Good tests may actually broaden and deepen the quality of what is taught. As such, the actual academic effects of tests may be productive or counterproductive (Elwood & Carlisle, 2003; Mehrens, 1989).

Analyzing the intended curriculum's alignment with relevant policy documents is another important step in ensuring opportunities to learn (Porter & Smithson, 2001). Methods at the national and state level have focused primarily on the alignment between the intended and assessed curricula. Webb (1999) addressed the alignment of these curricula by comparing state standards for instruction in mathematics and science to yearly state assessments in those areas. Webb defined alignment as "the degree to which the standards and assessments are in agreement and serve in conjunction with one another to guide the system toward students learning what they are expected to know and do" (p. 4).

La Marca et al. (2000) reviewed and synthesized conceptualizations of alignment and methods for analyzing the alignment between standards and assessments. They identified five dimensions that should be considered, based largely on Webb's (1999) work: (a) Content match, or the correspondence of topics and ideas in the standards and the assessment; (b) Depth match, or level of cognitive complexity required to demonstrate knowledge and transfer it to different contexts; (c) Relative emphasis on certain types of knowledge tasks in the standards and the assessment system; (d) Match between the assessment and standards in terms of performance expectations, and (e) Accessibility of the assessment and standards, so both are challenging for all students yet also fair to students at all achievement levels.

Alignment Models

Alignment methodologies between assessment and standards have been reviewed by Bhola et al. (2003) in terms of their level of complexity. Models reviewed were the Achieve, Survey of Enacted Curriculum (SEC), and Webb. The Achieve model has four dimensions for examining the degree of alignment between assessment and standards: (a) content centrality, (b) performance centrality, (c) challenge, and (d) balance and range (Resnick, Rothman, Slattery, & Vranek, 2003).

(a) *Content centrality* examines the quality of the match between the content of each test question and the content of the related standards.

(b) *Performance centrality* focuses on the degree of the match between the type of performance (cognitive demand) expected by each test item and the type of performance (e.g., select, identify, compare, analyze, represent, use) described by the related standard.

(c) *Challenge* is applied to a set of items to determine whether doing well on the set requires students to master challenging subject matter.

(d) *Balance* examines whether there are enough items to measure a content strand and *range* is a measure of coverage.

The Survey of Enacted Curriculum (SEC) alignment approach analyzes standards, assessments, and instruction using a common content matrix for categorizing the content topics and cognitive demands (Porter, 2002). This approach allows the researcher to create content matrices for standards, assessments, and instruction and to examine relationships between these matrices. In addition to alignment statistics that can be calculated from the matrices, content maps and graphs can be produced to visually illustrate differences and similarities between standards, assessments, and instruction.

Webb's (1997, 1999) alignment model includes several indicators of alignment at the item and test level.

(a) *Categorical concurrence* is the consistency of categories of content in the standards and assessments. The criterion of categorical concurrence between standards and assessment is met if the same or consistent categories of content appear in both the assessment and the standards. For example, if a content standard (or strand) is *measurement* in mathematics; does the assessment have items that target *measurement*? It is possible for an assessment item to align to more than one content standard. For instance, if an assessment item requires students to calculate volume, which is aligned to the content standard of *measurement*, to answer the question the student needs to be able to multiply numbers, which is aligned to the content standard of *operations*.

(b) *Range-of-knowledge* correspondence criterion examines the alignment of assessment items to the multiple objectives within the content standards. The range-of-knowledge numeric value is the percentage of content standards with at least 50% of the objectives having one or more hits. For example, if there are five objectives (e.g., length, area, volume, telling time, and mass) included in the content standard of measurement, a minimum expectation is at least three of the objectives have one or more items related to them.

(c) The *balance of representation* criterion is used to indicate the extent to which items are evenly distributed across the content standards and the objectives under the content standards.

(d) *Depth-of-knowledge* (DOK) examines the consistency between the cognitive demands of the standards and cognitive demands of assessments. Webb identified four levels for assessing the Depth of Knowledge (DOK) of content standards and assessment items. To examine the DOK, all items on the assessment and all academic content standards are rated for DOK. The DOK levels are:

(a) *Recall* (Level 1) which includes the recall of a fact, definition, term, or a simple procedure, as well as performing an algorithm or applying a formula.

(b) *Skill* or *Concept* (Level 2) includes the use of information or conceptual knowledge, two or more steps in solving a task.

(c) *Strategic Thinking* (Level 3) requires reasoning; developing a plan or a sequence of steps, some complexity, more than one possible answer.

(d) *Extended Thinking* (Level 4) requires an investigation, time to think and process multiple conditions of the problem.

Summary of the Curriculum Alignment Models

Models of alignment, Achieve, Webb's (1999) and Porter's (2002), help to evaluate the degree to which educational institutions send a clear and consistent message to teachers on what they are expected to teach and what the institution will assess. Misalignment of expectations (i.e., the learning outcomes) and the test used to evaluate student achievement (i.e., the assessed curriculum) may encourage teachers to distort or reduce students' learning opportunities (e.g., teach to the test). However, most studies on alignment focus on the alignment of curriculum standards and assessments. From the methodologies reviewed by Bhola et al. (2003), the Achieve model and Webb model share similar dimensions, those of content match, cognitive demands and breadth of coverage. It can be noted that very limited studies have focused on standards and the written curriculum which further supports the need to look at the role of textbooks in the following section.

Analyses of Textbooks

Numerous analyses of mathematics textbooks have served not only to inform the research field about the features and structure of textbooks but also to test and provide methods for researchers to use in conducting content analyses of textbooks. Alcazar (2007) investigated the degree of alignment in cognitive demand among the Peruvian national assessment, the mandated curriculum, teaching, and the official textbook. Alcazar used Doyle's four categories of cognitive demand of classroom tasks: Memory, Procedural, Comprehension, and Problem Solving (Doyle, 1983) to analyze the levels of cognitive demand of tasks posed to students at each of the levels of curriculum implementation. According to Alcazar, the test tasks corresponded to the categories of Problem Solving and Comprehension while the mandated curriculum learning outcomes and the textbook exercises corresponded to Comprehension and Application of Algorithms. The study also found that there was a relative alignment between the percentage of learning outcomes in the mandated curriculum and the amount of pages and exercises assigned in the workbook for each content area in the mathematics mandated curriculum (i.e., numbers, geometry and measurement, probability and statistics).

Alcazar's study shared some similarities, as well as differences, in the conduct of the study in terms of the documents used for analysis. Similarities include examining the issues of alignment of cognitive demand between the evaluation tasks in the national test, the learning outcomes in two versions of the mandated curriculum, and exercises and activities in the official textbook. However, the approach used by Alcazar in her study varied considerably from this study in terms of the unit of analysis, analytic framework, collection of data, and analysis of the textbooks.

Alcazar's study used "academic task" as the unit of analysis for each curriculum level and used Doyle's framework (Memory, Procedural, Comprehension, and Problem Solving) to categorize the cognitive demand of each curriculum level. Data collection was done through document analyzes, classroom observations, and in-depth interview of teachers teaching in the second grade elementary school level in the content domain of Number.

The analysis of the textbook in terms of cognitive demand focused on the exercises and activities presented to students in the classroom by the teachers. Videotaped and transcribed teaching sessions were used to look at the cognitive demand in the classroom tasks and the cognitive processes students were expected to use in each learning activity observed. Thus, data on what teachers were doing in class were analyzed to determine the extent to which the teachers were leading learning activities compatible with the test tasks, and the curriculum levels.

Dingman (2007) also conducted a study to describe the extent to which widely used elementary and middle grades mathematics textbooks align to the standards related to fraction concepts and computation. In the textbook analysis, each instructional segment that contained primary emphasis on fraction concepts and computation was documented. The term “instructional segment” was used to describe a short selection of material in a textbook that provides emphasis on and coverage for a particular idea or ideas. Each documented instructional segment was coded as one of the five following types of instructional segments: lesson, pre-lesson, end-of-lesson extra feature, end-of-chapter feature, and game. Results from the study indicated that a high percentage of the state Grade Level Expectations (GLEs) was aligned to a textbook series’ instructional segments at the same grade level. However, the percentage of instructional segments pertaining to fractions providing attention to state GLEs at the same grade level was not strong. In essence, the textbooks contained many instructional segments for the topic of fractions that might be viewed as “extra” because they do not align with state GLEs at the same grade level.

Valverde, Bianchi, Wolfe, Schmidt, and Houang (2002) analyzed the content of the textbooks in their sample according to the characteristics of lessons. These characteristics included the primary nature of lessons (concrete and pictorial vs. textual and symbolic), components of the lesson, and student performance expectations. To measure textbook lessons along these dimensions, the researchers divided lessons into blocks, “classified according to whether they constituted narrative or graphical elements; exercise or question sets; worked examples; or activities” (p. 141). The analysis further revealed that mathematics “textbooks across all populations were mostly made up of exercises and question sets” (p. 143).

Porter (2006) developed a two-dimensional matrix to describe the content of the mathematics curriculum and to provide a tool for comparing the intended, enacted and assessed curricula. This two-dimensional matrix was presented as a rectangular matrix with topics as rows and cognitive demands as columns. Topics are content distinctions such as “add whole numbers” or “point slope form of a line.” Cognitive demands distinguished memorizing; performing procedures; communicating understanding of concepts; solving non-routine problems; and conjecturing, generalizing, and proving.

Mouzakitis (2006) suggests that mathematics textbooks can be analyzed in terms of various aspects of their mathematical content. For instance, the Third International Mathematics and Science Study (TIMSS) considered the content of the textbook to represent the content of school mathematics partitioned into the following categories: numbers, measurement, geometry (position, visualization and shape), geometry (symmetry and congruence), proportionality, functions – relations – equations, data – probability – statistics, elementary analysis, and validation and structure.

Seguin (1989) proposed an analysis of the nature of the textbook content according to the following categories: accuracy, precision, topicality, and objectivity. In conjunction with the categories for the content, Sequin (1989) also identified content structures of textbooks that are important in content analysis. These include the learning experiences, progression of concepts and interdisciplinary aspects of the textbook. As such, the textbook should propose activities which the student can carry out, either under the guidance of the teacher, or on his own, which should be presented in the form of practical applications, either of knowledge or theoretical concepts, or of rules to be learned or even in the form of problems to be solved, information to be sought or experiments. It is through these learning experiments that abilities are really developed. They can take place both within the context of the school, as well as within the physical and social environment of the student.

From the literature on textbook analyzes, the methodological approaches range from alignment of state standards to assessment, learning outcomes (standards) with textbooks, as well as textbook content during instruction, nature of lessons, and mathematical content by topics. The studies on alignment of curricula by Alcazar, Dingman, and Porter clearly use indicators of alignment that are of interest in this study.

More specifically, the research design and methodology employed by these studies in terms of the indicators of alignment include content coverage, and cognitive demand of the learning outcomes (standards), test items, and textbook content. What follows is the literature on the analyses of curriculum standards documents.

Analyses of Curriculum Standards Documents

Although content analyses of textbooks have modeled and utilized a number of procedures to study features of textbooks, there is a growing but still limited number of studies that have analyzed curriculum documents in the form of state standards, learning outcomes (LOs) or grade level learning expectations (GLEs). A study by the Council of Chief State School Officers (Blank & Pechman, 1995) examined the development of state curriculum frameworks and standards documents. The 1995 study concluded that states have differed in their approach to developing standards documents, using various structures, organizations and features included in these documents. Many of these frameworks seemed aligned with the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), and they included process standards, examples of learning expectations, and possible teaching strategies.

Newton, Larnell and Lappan (2006) show the increased attention in the U.S. to aspects of algebra in grades K-8, in this case solving linear equations. Again, there were marked variations in the treatment of the topic. For example, the first appearance of learning expectations related to linear equation solving ranged between kindergarten (often involving finding a missing addend and/or subtrahend in number sentences) and eighth grade. Some learning expectations were very explicit about the type of linear equation solving to be learned, for example: solve two-step (linear) equations involving whole numbers and a single variable (grade 6) versus other more general expectations such as to solve simple linear equations and inequalities (grade 6). The variation noted in algebra was also found with other topics (e.g., computation with fractions) (Reys, 2006).

A review of state-level mathematics curriculum standards by the Center for the Study of Mathematics Curriculum (CSMC) confirms that mathematics learning expectations vary along several dimensions, including grain size (e.g., level of specificity), language used to convey learning goals (e.g., understand, explore, memorize), and the grade placement of specific learning expectations (Reys, 2006). In particular, when mathematics topics are introduced, their trajectory of development across grades and the grade at which students are expected to know and apply particular mathematical content differ dramatically across the states.

In addition, research conducted by the Center for the Study of Mathematics Curriculum (CSMC) recently analyzed the grade placement of particular topics related to number, algebra, and reasoning in state curriculum documents (Reys, 2006). Although the methods differed slightly by topic, researchers analyzing content in the number strand chose particular topics, such as knowledge of basic facts, multi-digit whole number computation, and fraction concepts and computation, and from the 42 states that had developed grade-specific standards documents (also called GLE documents), compiled all learning expectations regarding each specific topic. These learning expectations were coded by grade level based upon an agreed-upon coding scheme that examined the purpose of each learning expectation (i.e., addition of fractions, judging the size of fractions, converting fractions to decimals). Once coding was complete, the analysis was summarized by topic.

Overall, these studies provide insights into the features and qualities of mathematics textbooks and curriculum standards documents as well as methods that can be used to analyze their content. The contents of these two types of curriculum, state standards and textbooks, are of critical importance to student opportunity to learn. For the purpose of this study, the mathematical tasks constitute the content of the textbooks analyzed in terms of coverage and the cognitive demand level for alignment with the learning outcomes.

Role of Learning Outcomes (Standards)

With the publication of *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), a new era of standards and standards-based reform began. This document provided mathematics educators with “a way of articulating a vision for needed change” (Tate, 2004, p. 16). The NCTM followed this document with three other standards documents (NCTM, 1991, 1995, 2000), which further articulated the vision of ideal practice in the areas of teaching, learning, and assessing student knowledge (Tate, 2004). In 2006, NCTM published *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics* (NCTM, 2006), which specifies major mathematical topics that should be the focus of instruction at each grade level for elementary and middle school mathematics education.

Recent efforts to bring more alignment, rigor, and consistency to student ‘proficiency’ and to foster improvement in college-and-career readiness across the U.S., the Common Core State Standards (CCSS), was formally released on June 1, 2010, to provide teachers and parents with a common understanding of what mathematics students are expected to learn as well as appropriate benchmarks for all students. These standards define the knowledge and skills students should have within their K-12 education careers to succeed in entry-level, credit-bearing academic college courses and in workforce training programs.

The Mathematics Common Core State Standards includes an overarching set of standards for mathematical practice and guides instruction at all levels. The standards are: make sense of problems and persevere in solving them; reason abstractly and quantitatively; construct viable arguments and critique reasoning of others; model with mathematics; use appropriate tools strategically; attend to precision; look for and make use of structure; and look for and express regularity in repeated reasoning. These standards were developed with the aim of establishing common educational goals that states could share. The standards were designed to be: focused, coherent, clear, and rigorous; internationally benchmarked; anchored in college and career readiness; and evidence and research-based.

Although the movement to reform education through standards is relatively young, researchers have found that the influence of standards in various aspects of education is apparent. Weiss et al. (2003) reported that for most mathematics lessons taught in the U.S., the teacher is not the authority for decisions regarding what to teach. Rather, state and district policies that are communicated to teachers through curriculum standards have a large influence upon what teachers select to teach.

Floden and Wilson (2004) summarized the effects of the standards-based movement and provided evidence that standards have had a strong effect on policy and practice at the state and local levels, while there is less evidence illustrating standards are having an effect on student achievement. Evidence on practice included teachers giving more attention to areas and topics stressed in the standards documents, although there has not been a noticeable effect on pedagogy. The researchers also found a great deal of variation in the effects of standards within and across states, districts and schools, with some of these variations being attributed to factors such as the clarity and consistency/alignment of standards. With respect to these factors, Floden and Wilson summarize the research findings: Standards have greater influence on classroom practices if teachers see them as providing a consistent, comprehensible message with clear links to instruction. Standards had the most influence when they included links to curriculum materials.

Summary of Analyses of Textbooks and Role of Learning Outcomes

Research has illustrated the important role textbooks play in shaping what students have the opportunity to learn. Researchers have found that the mathematics textbook is relied upon to a large extent in developing the instructional activities, which in turn impacts students' opportunity to learn.

The role and influence of textbooks and curriculum standards is one critical area that needs to be examined by researchers. The research previously discussed guides this study by illustrating the key function the intended, written, and assessed curricula serve in determining what mathematics students have the opportunity to learn. In the following section, I address the methods and instruments used by researchers to study the overall features of both mathematics textbooks and state mathematics curriculum standards documents. This analysis is critical in the development of the methods used in this study.

Textbook Mathematical Tasks

Research on tasks as the primary unit of instruction and learning began in the 1970s and early 1980s (Jones & Tarr, 2007). In addition to content analysis of textbooks (Tornroos, 2005), analyzing textbook problems as a window through which to view students' mathematical experiences and opportunity to learn is another useful idea in educational research (Li, 2000). Mathematical exercises are an important part of the learning process. On the one hand, they consolidate and fix the acquisition of knowledge and the mastery of concepts, encouraging the development of intellectual capacity. On the other, they are a means of evaluating results and progress of students. They can take the form of activities added to a chapter of the textbook, questions (open or multiple choice) on tests or illustrations (maps, diagrams), or practical written work, calculations, problems to be solved and sometimes, drawings. Exercises should cover content already taught and may refer to what has already been learned in a previous chapter. They can also be presented in a context which differs slightly from the content taught, particularly, for an exercise in using and applying concepts.

Exercises should also serve as a method of evaluating learning progress and comprehension of content, in relation to subjects and objectives of a chapter or a section of the textbook. They can be presented with increasing degrees of difficulty (for instance, in mathematics) thus enabling a more accurate evaluation of results. Exercises also assist in verifying aspects of content which need to be revised or reinforced. They are used in nearly all disciplines, each of which can require its own particular form of exercise. Mathematical problems have been analyzed by different approaches. Some researchers analyzed problems through an analytical approach that examined multiple features in problems (e.g., Goldin & McClintock, 1985; Li, 2000; Stigler et al., 1986). Others use a holistic approach in which problems are classified into different categories in terms of a specific feature (e.g., Stein & Smith, Zhu & Fan, 2006). For instance, Stigler et al. (1986) used a classification scheme based on "problem's semantic structure" and "location of unknown quantities". Tabachneck et al. (1995) considered mathematical and contextual factors presented in algebraic problems. In both investigations, the choice and emphasis in different problem factors were a function of the characteristics of the problems being analyzed.

In addition to the mathematical and contextual aspects identified by Tabachneck et al., Zhang (1992) found that the requirements levied by mathematical problems from different nations could dramatically affect students' problem solving task performance. Consequently, a three-dimensional framework has been developed and widely used to analyze mathematical problems in different textbooks. The dimensions are: problem requirements in mathematics, context, and performance. Several categories under each dimension were also identified and used in the analyses of mathematical problems. A description of the dimensions and categories follows: (a) Mathematics Feature which is subdivided into single step and multi-steps, (b) Contextual Feature based on purely mathematical context in numerical or word form or illustrative context such as visual representation, and (c) Performance Requirement which has two subsections with each subsection further subdivided as follows: (1) Response type as numerical answer only, numerical expression, and explanation or solution, and (2) Cognitive requirement as conceptual understanding, procedural knowledge, mathematical reasoning, representation, and problem solving.

It can be noted that the choice and emphasis in different problem analysis is a function of the characteristics of the problems being analyzed. Also, the analyses of textbook problems are feasible and valuable for understanding cross-system variations in curricular expectations in developing students' mathematics competence (Li, 2000; Zhu & Fan, 2006).

Doyle (1988) argues that mathematical tasks from textbooks may be used as a context for promoting mathematical learning experiences. As such, the mathematical tasks influence to a large extent how students think about mathematics and come to understand its meaning. Henningsen and Stein (1997) also argue that different tasks may place different cognitive demands on students. Hiebert et al. (1997) similarly argue that students also form their perceptions of what a subject is all about from the kinds of tasks they do. Thus, the nature of tasks can potentially influence and structure the way students think and can serve to limit or to broaden their views of their subject matter with which they are engaged.

Doyle (1988) defines academic tasks in terms of the goals of the task: (a) the end product to be achieved; (b) a set of conditions and resources available to accomplish the task; (c) the operations involved to reach the goal state; and (d) the importance of the task. Doyle also points to the fact that a task exists at several different levels at once. For example, if one looks only at the level of cognitive mathematical content demand in each task, one may fail to recognize that the task itself might require other levels such as the application of conceptual understanding to a ‘real-world’ problem (Doyle, 1988). Doyle’s work considered individual questions, exercises, or problems as distinct academic tasks. He defined four general categories of academic tasks: memory tasks, procedural or routine tasks, comprehension or understanding tasks, and opinion tasks

(Doyle, 1983). Doyle argued that each of these categories varied in forms in terms of the cognitive operations required to successfully complete tasks contained therein.

C*ognitive Demands of Mathematical Tasks*

Mathematical problems/tasks draw students' attention to particular ways of thinking about and doing mathematics. For example, if the problems students work on present the mathematical ideas as finished products, students will not need to think through the concepts and engage in using them to reason about mathematics, and thereby they may perceive mathematics as a statement of end products—definitions, rules, and procedures—for memorization. Conversely, if problems students work on demand engagement with concepts through reasoning and argument, students will learn mathematics by engaging in mathematical thinking, offering conjectures, responding to one another's ideas (and the teacher's), and defending and justifying their ideas, as opposed to mainly knowing computational procedures and following predetermined steps to compute correct answers (NCTM, 1989, 1991, 2000).

Stein et al. (1996) argue that it is important to examine the cognitive demand required by mathematical tasks because of their influence in learning. Thus, the mathematical tasks with which students become engaged determine not only what substance they learn but also how they come to think about, develop, use, and make sense of mathematics. Indeed, an important distinction that permeates research on academic tasks is the difference between tasks that engage students at a surface level and tasks that engage students at a deeper level by demanding interpretation, flexibility, the shepherding of resources, and the construction of meaning (p. 459). Thus, being aware of the cognitive demand of problems is central in the selection of mathematical tasks from textbooks or in the creation of mathematical tasks.

Summary of the Literature Review

The research reviewed in this chapter provides the foundation for this study. Researchers have illustrated the important role textbooks and curriculum standards play in providing students the opportunity to learn the mathematics to be assessed. Researchers have used a variety of techniques to study the features and content of textbooks and curriculum standards documents, and these techniques have influenced the selection of methods for this study. Researchers have also documented the various ways textbooks and standards shape students' opportunity to learn.

Each of these areas of research has shaped not only my understanding of the phenomenon under examination in this investigation but also the methods and interpretations used to conduct this study. In the following chapter, a description of the guidelines used to select the sample for the learning outcomes, mathematics textbook, and test items for this study is offered. Techniques used to analyze the contents of learning outcomes, textbooks, and test items are discussed, and the methods used to determine the alignment between these types of curricula are outlined.

Chapter 3

Research Design and Methodology

This study was designed to examine the nature of the alignment of the learning outcomes, test items, and the extent to which upper division textbooks in Belize provide support for students to study the learning outcomes assessed in the national examinations. The first step in this study was to examine the nature of alignment between the upper division mathematics textbooks in Belize and the learning outcomes as stated in the Belize National Comprehensive Mathematics Curriculum (2000) and the national assessment items as presented in the Primary Selection Examination (PSE).

In this chapter, I present the method and design of this study in four sections. In the first section I present a brief overview of the educational system in Belize, followed by the five research questions that the study addressed. Then I provide the sample of learning outcomes, textbooks, and test items for the study, and provide rationales for selecting each of the sample documents examined. In the third section, I present the research design and the analytical framework that was used to analyze the degree of alignment among the intended, written and assessed curriculum and the instructional segments identified from the four upper division textbooks. In this section also, the procedures used to describe and document the alignment between these three types of curricula are explained, and the methods used to test the reliability of the procedures are discussed. Lastly, I present the applicability of the framework that I used in my pilot study with specific examples from the textbooks.

Educational System in Belize

The education system in Belize is comprised of three levels: primary, secondary, and tertiary. The language of instruction is English. Belize's education system offers eight years of free primary education that is compulsory for students ages 5-14. Primary education begins with two years of "infant" classes, followed by six "standards". Secondary education is not open to all students, nor is it free to them. Students must academically qualify for secondary schooling (based on PSE scores) and also pay a fee for the schooling. Secondary education is divided into four forms, equivalent to the United States high school system (9^{th} to 12^{th} grades). Some Belizean secondary schools are called high schools and others are called colleges. At the tertiary level, many qualifying students enroll in 6^{th} Form, which is similar to a junior or community college in the United States, providing a program that awards certificates and associate degrees. Qualifying students may also study at the University of Belize (UB). Students may enter the university either directly from secondary schools or from 6^{th} Form.

Belize is a diverse country in terms of its ethnic composition and there tend to be concentrations of particular ethnic groups at specific locations across the country, as well as in the schools. The many different ethnic groups include Caucasian, Creole, Garifuna, German/Dutch, Ketchi, Mayan, Mestizo, and Syrian (Babb, 2002). The largest ethnic groups represented in Belize are Mestizos and Creoles.

Research Questions

The present study investigated the extent to which currently used middle school mathematics textbooks provide students with an opportunity to learn the mathematics on which they are assessed. I accomplished this by addressing the following five research questions:

1. To what extent are the learning outcomes of the Upper Division Mathematics Curriculum aligned with the national assessment test items?
2. To what extent do the upper division textbooks in Belize provide students with the opportunities to study the learning outcomes of the Upper Division Mathematics Curriculum?
3. To what extent are the cognitive demands of the instructional segments in the upper division textbooks in Belize aligned with the learning outcomes?
4. To what extent are the instructional segments in the upper division textbooks in Belize aligned with the content of the test items of the national examination?
5. What is the nature of alignment of upper division learning outcomes, written curriculum [textbooks], and test items from the national examination in Belize?

Sample

Documents analyzed in this study were the 15 learning outcomes stated in the Belize National Comprehensive Mathematics Curriculum for the upper division, the test items contained in the Primary Selection Examination Test booklets from 2009 and 2010, and four textbooks used in the upper division in schools in Belize.

Learning Outcomes

The Belize National Comprehensive Mathematics Curricula (BNCMC) philosophy is highly focused on '*learning'* with increased emphasis on *'learning to learn'*. Past emphasis on simply 'knowing' has shifted to 'learning to know'. As a small developing nation in a "global village", Belize needs to provide its citizens with knowledge and skills necessary to cope with international competition (Ministry of Education, 2000). The learning outcomes outlined in the BNCMC document are, therefore, based on current thinking on the teaching and learning of mathematics. According to the Ministry of Education (MOE), the mathematics curriculum should: be concept oriented; actively involve students in doing mathematics; emphasize the development of mathematical thinking and reasoning; emphasize the usefulness of mathematics (application); extend the range of mathematics to cover more branches; and make use of appropriate technology.

In light of the latter, the Government of Belize, through the Ministry of Education and Sports is committed, by policy, to ensuring appropriate programming to meet the schooling needs of all students. In keeping with the policy, schools are provided with the *National Syllabus* which translates the *National Curriculum* into strategies for accomplishing the National goals. *The National Syllabus***,** therefore, provides the basis for the improvement of student learning and growth by specifying the minimum standard of achievement expected of each student within the specified grade level in relation to the four broad areas of study: Language; Mathematics, Science, Work & Technology; Social

Studies and Personal Development; and the Expressive Arts, Physical Education, and Health.

The Mathematics National Syllabus includes a set of learning outcomes from which schools can develop their curriculum. The learning outcomes are specific statements of what students should be able to do or know and the attitudes they should possess at the end of each grade level. The Learning Outcomes (LOs) and codes used for this study for the upper division are outlined in Table 1.

Table 1

Upper Division Learning Outcomes

Code	Learning Outcome
1	**Number**
1.a	identify the consecutive sequence and position of whole numbers up to ten digits and place value.
1.b	identify properties of prime and composite numbers.
1.c	express equivalent base notations and other number systems.
1.d	apply the concept of rational numbers and irrational numbers to real life situations.
2	**Spatial Relationships and Shapes**
2.a	how to draw and construct three-dimensional objects.
2.b	how to plot the position and movement of two-dimensional shapes.
2.c	how shapes fit together to form patterns.
2.d	infer the relationship between angles in different two-dimensional shapes.

Table 1 (*continued*)

Code	Learning Outcome
3	**Measure, Quantify and Calculate**
3.a	measure, estimate, express and compute distance, weight, time, capacity and temperature and apply to practical situations.
3.b	use and convert money based on its relative value and its use in financial transactions.
3.c	apply algebraic expressions to solve problems.
4	**Estimate and Make Predictions**
4.a	make and apply reasonable approximations by observing and/or using factual data based on meaningful references.
4.b	predict the likely occurrence of an event, through logical reasoning, based on trends.
5	**Data Handling**
5.a	collect, analyze and interpret data and predict probable outcomes.
5.b	apply the concept of "sets" to practical solutions.

Note. Belize National Comprehensive Curriculum (Ministry of Education)

National Examination (Primary Selection Examination)

The Ministry of Education's policy on educational assessment is guided by the belief that assessment is an integral part of the teaching and learning process. As such, National Assessments and Examinations for the most part consist of centrally developed standardized measures covering content selected to reflect national standards and expectations in selected areas of the curriculum.

Thus, *National Assessments and Examinations*[1] are designed for the monitoring of the education system and subsystems nationally and for certification of students.

In particular, the end of primary education assessment is a criterion-referenced examination that certifies student achievement in three subject areas: English, Mathematics and Science.

Two sets of Belize's National Assessment Test (Primary Selection Examination (PSE)) from 2009 and 2010 were examined, where each has 50 operational multiple-choice items. The Department of Assessment provided the test specification document that stipulates the content domains, number of items for each domain, knowledge, understanding, and process skills that the items measure across the content domains. Overall, the 2009 and 2010 tests addressed nine broad mathematics domains: (1) Number Concepts, (2) Number Operations, (3) Rate/Ratio/Proportion, (4) Algebra, (5) Graphs and Statistics, (6) Sets, (7) Measurement (8) Business Math, and (9) Geometry. In addition, there are fifteen learning outcomes that address the nine content domains. A description of the 2009 and 2010 National Assessment (Primary Selection Examination) in Mathematics is in Table 2.

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[1]The Primary Selection Examination is a national exam. Information related to the validity and reliability of the test items was unavailable from the Ministry of Education.

Table 2

Description of 2009 and 2010 Primary Selection Examination (PSE) Test Items

Description of Items	2009 Item Number	2010 Item Number
Lowest Common Multiple of whole numbers	1	
Equality and inequality symbols	2	1
Writing numbers in standard notation	3	4
Identify composite and prime numbers		2
Identifying the fractional part given a number line	4	
Completing a sequence		5
Identifying the fractional part of a region		7, 9
Expressing a number in scientific notation	5	3
Prime factorization	6	
Identifying the place value of a number	7	6
Convert from base 10 to other bases		8
Multiplication of whole numbers		13
Finding probability of an event		24
Measure of central tendency (median)		26
Translating an algebraic expression to words		18, 20
Interpreting data from a graph	8, 25, 26, 27, 28, 45	22, 23
Finding the fractional part of a set	9	
Identifying mixed numbers	10	
Order of operations	11	
Properties of addition: *identity*, commutative	12	
Distributive property of multiplication over addition	13	13
Find the ratio between two amounts	14, 17, 18	14, 15, 17
Rate involving money	15	16, 25
Finding the value of a variable in an equation	16, 19, 21, 22	19, 21
Interpreting exponential notation	20	
Defining a set, subset, union and intersection	23, 24, 29, 30, 31	27, 28, 29, 30, 31
Estimating time elapsed	32	37, 40
Area of triangle and perimeter of 2-D shapes	33, 34, 36	3, 38, 41, 42
Pythagorean theorem	37	
Addition with decimals, time, weight, and money	35, 43, 44	10, 11, 12, 33, 46
Conversion of temperature, weight, and length	38, 39, 41, 42	36, 39
Finding volume and properties of 3-D shapes	40, 47	34
Calculating percentage, discount, and simple interest	46	43, 44, 45
Identify line of symmetry	48	49
Identify types of angles	49, 50	47, 48
Find coordinates of a point in an x-y plane		50

Upper Division Textbooks

Table 3 outlines the distribution of the upper division textbooks available for use in Belize.

Table 3

Textbooks by Standard Level

Upper Division	Textbooks
Standard 5	*Caribbean Primary Mathematics (Level 6)*
Standard 6	*Active Mathematics – A Students' Workbook*
	Let's Pass Mathematics, Progress Tests for the Caribbean
	PSE Mathematics – Practice Problems and Tests with Solutions

In September, 2007 a textbook program was launched in Belize in the primary education level to provide quality and relevant textbooks free of cost for all children attending primary school. These standardized books cover the five core subject areas of mathematics, language arts, science, social studies, and Spanish.

The four books are the officially adopted mathematics textbooks for the Upper Division. Standard 5 includes one textbook which is part of a traditional series revised in 2003 that has been used for at least 2 decades (Ginn - a registered trademark of Pearson Education Limited). The Standard 6 set of textbooks includes 3 student workbooks that are used simultaneously throughout the grade level.

The *Caribbean Primary Mathematics* textbook (Standard 5) uses a spiral approach to learning which stems from a curriculum design in which key concepts are presented repeatedly throughout the curriculum, but with deepening layers of complexity. Consequently, students repeat the study of content domains at different grade levels, each time at a supposedly higher level of difficulty and greater depth.

The *Caribbean Primary Mathematics* textbook has 144 pages with 17 chapters. Each chapter has a number of lessons designed for students to experiment and investigate mathematical concepts. In a particular lesson, mathematical concepts are introduced, explained, practiced, expanded, and reinforced at regular intervals via problem-solving, practical hands-on activities, and assessment opportunities. Table 4 presents information on topics covered in the *Caribbean Primary Mathematics* textbook.

Table 4

Chapter Titles for the Caribbean Primary Mathematics Textbook

Ch.	Title	Ch.	Title
1	Working with Numbers	10	Angle
2	Number Theory	11	Plane Shapes
3	Number Operations	12	Solids
4	Fractions	13	Measurement
5	Decimals	14	Perimeter and Area
6	Percentages	15	Time
7	Ratio and Proportion	16	Volume and Capacity
8	Money	17	Collecting and Representing Data
9	Sets		

The Standard 6 set of textbooks consists of 3 workbooks in which two of the textbooks, *Active Mathematics* - *A Student's Workbook* and *Let's Pass Mathematics* - *Progress Tests for the Caribbean*, have a similar format as the *Caribbean Primary Mathematics*. The *Active Mathematics* textbook has 105 pages sectioned into 10 chapters and the *Let's Pass Mathematics* textbook has 87 pages with 14 chapters. For both textbooks, the development of the lessons are focused on mastery of content, with less emphasis on the development of skills and more emphasis on the nurturing of conceptual understanding. Both textbooks also have review exercises at the end of each lesson and chapter.

The *PSE Mathematics-Practice Problems and Tests with Solutions* textbook has a unique format. It has 148 pages divided into three distinct sections: practice problems, practice tests, and solutions to practice problems and tests, respectively. The Practice Problems section is subdivided into multiple choice and extended response problem solving tasks. For the purpose of this study, the sections that addressed the multiple choice section in the practice problems and the sections that covered practice tests were considered for analysis given that the format conformed to the test items analyzed in this study. The Practice Test section has two sets of tests, each containing 50 test items. Table 5 presents the topics covered in the Standard 6 textbooks.

Table 5

Topics Covered in Standard 6 Textbooks

Topics	Active Mathematics	Let's Pass Math	PSE
Set Theory	X		X
Number Concepts/Operations	X	X	X
Measurement	X	X	X
Integers	X		
Rational Numbers	X	X	
Rate, Ratio & Proportion	X	X	X
Percent & Percentages	X	X	
Graphs & Statistics	X	X	X
Algebra	X		X
Business Math			X
Time		X	
Equations & Inequalities		X	
Squares, Cubes & Roots		X	
Factorization (Highest Common Factor)		X	
Number Patterns		X	
Geometry		X	X

Why Choose the Upper Division?

The upper division was chosen for this study, in part, because it is regarded as a crucial stage for students' transition from primary education to secondary, and secondary education provides a unique opportunity for students to gain access to higher education. Despite the fact that formative assessment on the curriculum is inherent when the spiral approach is used, the results of the Primary Selection Examination administered at the end of upper division is given great attention as a summative assessment of the mathematics content areas and to inform parents, students, school administrators, curriculum and test developers.

Foundation for Alignment and Opportunity to Learn

I developed the framework in Figure 3 and used it to examine the intended curriculum in the form of state Learning Outcomes (LO's) documents, the written curriculum in the form of upper division mathematics textbooks, and the assessed curriculum in the form of high stakes tests (Figure 3).

Inherent in the conceptual framework is the relationships among the three types of curriculum. The framework outlined the links among the three constructs related to curriculum, particularly connecting the opportunity to learn indicators to the written curriculum [textbook] which has a direct link to the learning outcomes and in turn impacts students' performance on the national examination.

It is evident that the textbooks are highly influenced by the two other types of curriculum: the intended curriculum (learning outcomes) and the assessed curriculum (national assessments). Thus, the mathematics textbooks have the potential to provide support to students' opportunity to study the content assessed in the national assessments via the mathematical topics they address, the instructional segments, and the cognitive level demands.

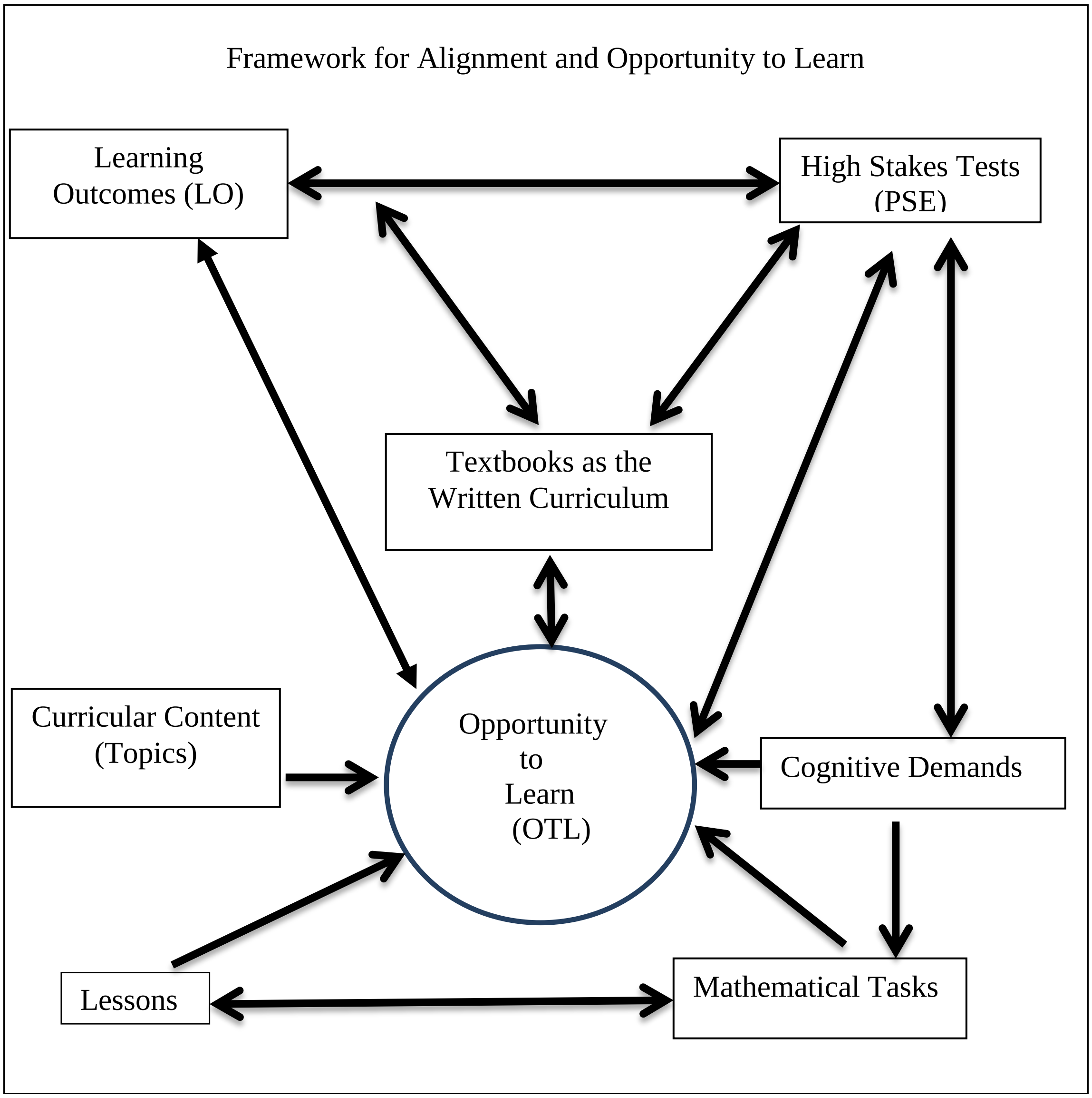


Figure 3. Framework of Alignment of Curriculum and Opportunity to Learn

Note. Adapted from Tarr, Reys, Reys, Chávez, Shih, & Osterlind (2008)

I used the framework to examine the alignment of curriculum and the opportunity students have from the upper division textbooks to study the content in the national test. For the alignment between the three types of curricula, I used Webb's alignment criterion of categorical concurrence (coverage) and four levels of depth of knowledge (DOK). For opportunity to learn, I used the cognitive complexity of the instructional segments in the selected textbooks.

I organized the analytical framework into two areas. The first area is intended to examine the alignment between the three types of curriculum: the intended (LOs), the written curriculum (textbooks), and the assessed (test items) to determine the nature of the alignment. The second is to examine the cognitive demand of the instructional segments in the written curriculum [textbook] and student's opportunity to study the content assessed in the national tests.

I employed methods similar to those of Webb (1997, 2005), Wixson et al., (2002), Dingman, (2007), Alcazar, (2007), and from a pilot study (Appendix A) to examine the extent of alignment between the three types of curriculum: learning outcomes and test items, learning outcomes and textbooks, and textbooks and test items; and the opportunity to learn construct. For the alignment of the learning outcomes and the test items, I first established the coverage where I used a modified version of Webb's model of alignment as used by Wixson et al. (2002). In this modified version, the coverage (replacement for categorical concurrence) criterion addressed the extent to which there is a least one assessment item for each learning outcome.

Then, I used Webb's Four Levels of Depth of Knowledge (DOK) to evaluate the cognitive demands of the assessment items against the cognitive demands of the learning outcomes and the instructional segments from the textbooks. Webb's four levels and description of each level used in this study are summarized in Table 6.

Table 6

Webb's Four Cognitive Levels of Depth of Knowledge (1997)

Cognitive Levels	Description of Cognitive Complexity Levels (CC)
Level 1 (Recall)	Recall of a fact, definition, term, or a simple procedure, as well as performing an algorithm or applying a formula.
Level 2 Skills/Concepts	Use information or conceptual knowledge, two or more steps in solving a task.
Level 3 Strategic Thinking	Requires reasoning, developing plan or a sequence of steps, some complexity, more than one possible answer.
Level 4 Extended Thinking	Requires an investigation, time to think and process multiple conditions of the problem.

I used methods similar to Dingman (2007) and Alcazar (2007) to identify the instructional segments that were used as the unit of analysis from the written curriculum [textbooks]. Dingman (2007) defined an *instructional segment* as a short selection of material in a textbook that provides emphasis on and coverage for a particular idea or ideas. These segments were classified into one of five types: pre-lesson; lesson; end-of-lesson extra feature; end-of-chapter feature; or chapter review.

A pre-lesson is a short investigation that previews a lesson and provide students an opportunity to engage with concrete materials or models to study a concept before it is formally introduced; a lesson is a unit of instruction that is part of a sequence covering a particular topic; end-of-lesson extra feature is a short activity at the end of a lesson such as an extension with technology, an enrichment activity, or a real-world application; end-of-chapter feature is a one or two page activity that uses or applies topics learned earlier from a sequence of lessons; and the chapter review refers to the tests at the end of the chapter.

To identify the instructional segments for this study, each textbook chapter was labeled according to the content domain. The content domain of each chapter was divided in terms of instructional segments as pre-lessons, lessons, end-of-lesson extra features, end-of-chapter feature, and chapter reviews (tests). Each instructional segment was analyzed according to Webb's four levels of Depth of Knowledge.

In the section that follows, I provide detailed descriptions of the type of information that was gathered, how the information was collected, how it was coded, and the process I used to record the information to facilitate reliable analysis. In addition, I illustrate part of the analytical framework with sample data from the 2007 test items that I used for the pilot study to test the appropriateness of the framework for the alignment of the intended curriculum (LOs) and the assessed curriculum (test items).

Depth of Knowledge: Learning Outcomes

Each of the fifteen learning outcomes was coded using Webb's Depth of Knowledge Level in conjunction with the Mathematics Descriptors in Table 7.

Table 7

Mathematics Descriptors of Webb's Four Levels

Level 1 **Recall**	**Level 2** **Skills/Concepts**	**Level 3** **Strategic Thinking**	**Level 4** **Extended Thinking**
a. Recall, observe, or recognize a fact, definition, term, or property b. Apply/compute a well-known algorithm (e.g., sum, quotient) c. Apply a formula d. Determine the area or perimeter of rectangles or triangles given a drawing and labels e. Identify a plane or three dimensional figure f. Perform a specified or routine procedure (e.g., apply rules for rounding) g. Evaluate an expression h. Solve a one-step word problem i. Retrieve information from a table or graph j. Recall, identify, or make conversions between and among representations or numbers (fractions, decimals, and percent), or within and between customary and metric measures.	a. Classify plane and three dimensional figures b. Interpret information from a simple graph c. Use models to represent mathematical concepts d. Solve a routine problem requiring multiple steps, or the application of multiple concepts e. Compare and/or contrast figures or statements f. Construct 2-dimensional patterns for 3-dimensional models, such as cylinders and cones g. Provide justifications for steps in a solution. h. Extend a pattern i. Retrieve information from a table, graph, or figure to solve a problem requiring multiple steps j. Translate between tables, graphs, words and symbolic notation.	a. Interpret information from a complex graph b. Explain thinking when more than one response is possible. c. Make and/or justify conjectures d. Use evidence to develop logical arguments for a concept e. Use concepts to solve non-routine problems f. Perform procedure with multiple steps and multiple decision points g. Generalize a pattern h. Describe, compare, and contrast solution methods i. Formulate a mathematical model for a complex situation j. Provide mathematical justifications k. Solve a multiple step problem and provide support with a mathematical explanation that justifies the answer.	a. Relate mathematical concepts to other content areas. b. Relate mathematical concepts to real-world applications in new situations c. Apply a mathematical model to illuminate a problem, situation d. Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results e. Design a mathematical model to inform and solve a practical or abstract situation f. Develop generalizations of the results obtained and the strategies used and apply them to new problem situations.

Adapted from M. Petit, Center for Assessment 2003, K. Hess, Center for Assessment

The depth of knowledge of the learning outcomes was coded independently by two mathematics education doctoral students and the researcher. Each learning outcome was coded according to the potential levels for assessment with the ceiling level considered as the maximum depth of knowledge. Subsequently, the maximum depth of knowledge was used for the alignment with the test items and textbooks.

Following is an example (Figure 4) to illustrate how learning outcome 5.a (see Table 1) "collect, analyze and interpret data and predict probable outcomes" was coded using Webb's Four Cognitive Levels of Depth of Knowledge.

Potential Levels for Assessment	
Collect data	1
Analyze and interpret data	2
Predict probable outcomes	3
Highest Depth of Knowledge	**3**

Figure 4. Coding of the Learning Outcome 5.a

The learning outcome has the potential to be assessed at different levels based on the performance required by the specific objective. This learning outcome was considered at level 3 (Strategic Thinking) based on the highest potential level of assessment.

Content Coverage of the Test Items

The test items for each set of tests were analyzed based on the content within each of the learning outcomes. As recommended by Wixson et al. (2002), coverage was considered if one test item targeted a learning outcome. Below is an example to illustrate how the test items were coded for item coverage for the learning outcome 1.c.

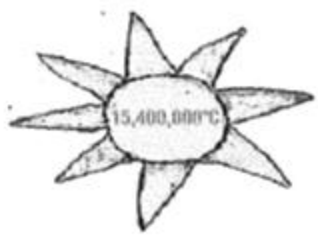
Number
By the end of the Upper Division, pupils should be able to:

1. c express equivalent base notations and other number systems

Figure 5. Coding of Test Item Coverage

Sample Test items # 3 and # 5 from the 2009 Test targeted the content under this learning outcome. Based on the criterion of coverage, there is content coverage by the test items for this learning outcome.

3. The sun's temperature is shown in the drawing below. It is written as



A. fifteen million, four thousand degrees celsius.

B. fifteen thousand, four hundred degrees celsius.

C. fifteen million, four hundred thousand degrees celsius.

D. fifteen hundred thousand, four hundred degrees celsius.

5. The number 20,031 written in Scientific Notation is

A. 2.31×10^2
B. 2×10^4
C. 200.3×10^2
D. 2.003×10^4

Depth of Knowledge: Test Items

Webb's four levels of depth of knowledge were used to determine the cognitive level of the 50 test items for the two sets of PSE from 2009 and 2010. Only two sets of national examinations were used because the template for the tests' table of specifications in Table 8 seemed consistent across the years (2004-2009) in format and structure in the areas of content domain, number of items for each domain, and the knowledge, understanding, and process skills that the items measured across the content domains.

Table 8

Mathematics Table of Specification for the Primary Selection Examination

Content	Knowledge and Understanding		Process Skills			Total
	Recall basic facts, definitions, formulas, etc.	Understand and use symbols, concepts, and routine computation.	Communicate information	Obtain information, make inferences, etc.	Simple problem solving	
Number Concepts	2	4	1	1		8
Number Operations		2			3	5
Rate/Ratio/Proportion		2			3	5
Algebra	2	2				4
Graphs & Statistics			2	1	1	4
Sets	2	1	1	1		5
Measurement	1	3	1	2	4	11
Business Math		1			3	4
Geometry	1	1	1	1		4
Total	8	16	6	6	14	**50**
Percent	16%	32%	12%	12%	28%	**100%**

Note. The content area ‘Algebra’ has been increased by 2 items.

Coding of Test Items Cognitive Levels

Table 9 illustrates how test items were analyzed using the coding instrument or their level of cognitive demand.

Table 9

Test Items Cognitive Levels

Webb's Depth of Knowledge Level	Test Item
Recall	*Which of the following is a composite number?* (Item # 2, 2006)
Skills/Concepts	*Twenty one thousand and ten is written as……* (Item # 7, 2006)
Strategic Thinking	*When $720 is divided in the ratio 3:5, the smaller share ……*(Item # 17, 2006)
Extended Thinking	No item was at this level.

Test items considered at level 1 (recall) required the recall of a definition. Test items considered at level 2 (skill/concepts) required conceptual understanding. Test items considered at level 3 (Strategic Thinking) required a higher level of thinking and reasoning.

Alignment of Learning Outcomes and Test Items

The *Depth-of-Knowledge* alignment criterion between learning outcomes and assessment items measured the extent to which the assessment items were as cognitively demanding within the content area as what the learning outcomes outlined that students were expected to know and do. For consistency to exist between the assessment items and the learning outcomes, as judged in this analysis, at least 50% of targeted learning outcomes needed to be assessed by items of the appropriate complexity. The choice of fifty percent, a conservative cutoff point, was based on the assumption that minimal passing scores for any one learning outcome of 50% or higher would require the student to successfully answer at least some items below or at the depth-of-knowledge level of the corresponding learning outcomes.

Learning outcomes with less than 40% of its assessment items at the depth-of-knowledge level of the learning outcomes were reported as having “limited” alignment. Learning outcomes with 40% - 49%, inclusive, of its assessment items at the learning outcomes depth of knowledge had “moderate” alignment. Learning outcomes with 50% or more of its assessment items at the appropriate depth of knowledge were reported as having “strong” alignment.

Analysis of Textbook’s Instructional Segments

The instructional segments from the textbooks were used as the opportunity to learn indicator in this study. The cognitive demand of the instructional segment was aligned with the cognitive demand of the learning outcomes. The first step in this process was to identify the instructional segments and classify them into their respective types: pre-lessons, lessons, end-of-lesson extra features, end-of-chapter feature, and chapter reviews.

The page number and section of the chapter that contained instructional segments were documented. Then the identified instructional segments were labeled as pre-lesson, lesson, end-of-lesson feature, end-of-chapter feature, or chapter review. Third, the cognitive domain addressed by each instructional segment was documented using

Webb's Depth of Knowledge in conjunction with the mathematical descriptors (see Table 7). Each instructional segment was coded to one or more learning outcomes to determine the extent of coverage and opportunity to learn the content assessed in the national tests. Sections of the textbooks containing definitions and explanations of mathematical facts were not considered for this analysis because the context in which they were presented in the textbooks do not fall into any of the five instructional segments in this study. Table 10 describes the number and percent of instructional segments identified for each textbook used in the study.

Table 10

Number (Percent) of Instructional Segments for each Textbook

Textbook	Types of Instructional Segments					Total	Percent
	Pre-Lesson	Lesson	End-of-lesson Extra Feature	End-of-lesson Chapter Feature	Chapter Review		
CPM	64 (19)	242 (70)	5 (1)	30 (9)	4 (1)	345	45
LPM	33 (35)	48 (51)	0	0	14 (14)	95	13
AM	13 (12)	57 (51)	19 (16)	11 (9)	13 (12)	113	15
PSE	0	207 (100)	0	0	0	207	27
Total	110	554	24	41	31	760	
Percent	14	73	3	5	4		100

Note. CPM = *Caribbean Primary Mathematics*; LPM = *Let's Pass Math*; PSE = *Primary Selection Examination*; AM = *Active Mathematics*

Figure 6 provides an example of an instructional segment from the *Active Mathematics (Student Workbook)* Standard 5 textbook, along with the related codes of instructional segment type, learning outcome addressed, and depth of knowledge. The instructional segment was identified as an enrichment activity which also addressed real world applications as described in the operational definition of an “end-of-lesson feature” (p. 65).

Instructional Segment	Coding
Naming Sets Name the set asked for in each of the following: (a) The set of natural numbers greater than 1 and less than 4. (b) The set of prime numbers less than 5. (c) The set of months whose names each have 4 letters. (d) The set of even numbers between 1 and 13. (e) The set of five fruits found in Belize.	Instructional Segment Type: “end-of- lesson feature”. Learning Outcome: Data Handling: 5.b “apply the concept of sets to practical solutions”. Depth of Knowledge: Level 1

Figure 6. Example of a coded instructional segment, *Active Mathematics*, p. 2. Taken from *Active Mathematics: Student's Workbook*, 2nd Edition (1986), by Belize, Ministry of Education, published by Macmillan Publishers Ltd.

A similar approach was used for the instructional segment in Figure 7 from the *Caribbean Primary Mathematics* Book 6 (Standard 5).

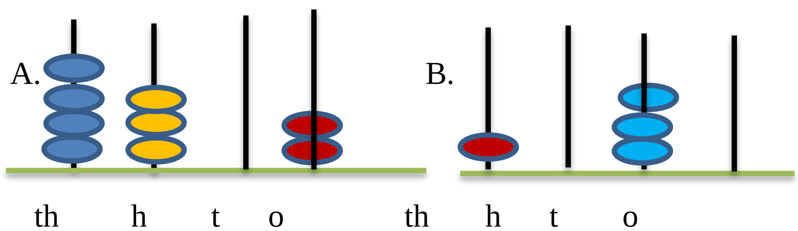
Sample from Textbook	Coding
Place Value Numerals have a different value depending on where they are placed. For example, the *5* in 45 has a value of *5* ones whilst the *5* in 562 has a value of 5 hundreds. A 1. Write the number represented by each picture. 	Instructional Segment Type: Pre-lesson Learning Outcome: Number M1.a "identify the consecutive sequence and position of whole numbers up to ten digits and place value". Depth of Knowledge: Level 2

Figure 7. Example of coded instructional segment, *Caribbean Primary Mathematics* p. 5. Taken from *Caribbean Primary Mathematics Book 6,* Revised Edition (2003), by Benita Byer and Joseph Serieux, published by Ginn.

The instructional segment was identified as a short activity that previewed the lesson on place value and provides students an opportunity to engage with concrete materials or models as described in the operational definition of a "pre-lesson" (p. 65).

Reliability of Coding

This section is divided into three parts. In the first part, the procedures used to monitor the reliability are described. In the second, the reliability of the selection of the instructional segments selection is described. The last part describes the reliability of the coding of the learning outcomes, test items, and instructional segments.

Reliability Procedures

To ensure the reliability of the coding, I used a check-coding method whereby I enlisted the assistance of two of my mathematics education colleagues, *Coder A* and *Coder B,* to assist in determining that the coding categories are consistent and adhere to the criteria of the framework.

Coder A was a Mathematics Education doctoral candidate who had completed all coursework and passed the comprehensive exam. On several occasions, I consulted with the coder during the development of the framework. The doctoral student had read the finalized framework and related documents and was familiar with the procedures for the study.

Coder B graduated with a Ph. D. in Mathematics Education the semester prior to the coding exercise. This coder had read a draft of the dissertation proposal, and thus, was familiar with the goals and procedures of the study framework.

I developed a Training module consisting of five learning outcomes and ten test items (see Appendix H). Working together, the researcher and coders coded the learning outcomes and the test items from the manual. We spent one hour on this discussion/training session. To ensure that the instructional segments were all identified and placed in the correct instructional type, a chapter from each of the textbooks was randomly selected and classified according to the five instructional types. We began coding the actual learning outcomes, test items, and instructional segments following the training session.

As part of the coding exercise, I engaged the coders in a discussion about the alignment exercise and processes of the framework and the coding procedures. Both coders coded the fifteen learning outcomes and the fifty test items from both sets of tests independently. For the instructional segments from the textbooks, each coder coded instructional segments from the two textbooks chosen at random from numbers 1 to 4 placed in a box. Each textbook instructional segment was selected using a stratified sampling approach from the chapters and the type of lessons. Thirty percent of the instructional segments from each textbook coded by the researcher were randomly selected using a random generator and then also coded by the coders. An inter-coder reliability check was performed and the results are reported in Table 11. *Inter-Coder Reliability of Learning Outcomes, Test Items and Instructional Segments*

The 15 learning outcomes, 50 test items from the 2009 and 2010 tests, and the sample of 30% of the instructional segments coded by the researcher for each textbook were used for check-coding. Each coder coded the learning outcomes, test items and instructional segments guided by the data collection instruments: Webb's' Four Levels of Depth of Knowledge and Webb's Mathematical Descriptors. Table 11 documents the level of agreement between my codes and those of *Coder A* and *Coder B*, using Cohen's Kappa estimates.

Table 11

Cohen's Kappa Inter-Coder Reliability Estimates for Learning Outcomes, Test Items, and Instructional Segments

Criterion	Agreement with *Coder A*	Agreement with *Coder B*
Learning Outcomes	.82	1
Test Items		
2009 Test	.92	.89
2010 Test	.97	.92
Instructional Segments		
Primary Selection Examination	.83	
Active Mathematics	.91	
Let's Pass Math		.87
Caribbean Primary Mathematics		.91

Cohen's Kappa coefficient was used as a measure of inter-coder reliability rather than percentage agreement as it takes into account the possibility that the coders agreed by chance. A Cohen's Kappa of 0.7 or higher was used as an acceptable level of agreement (Jacobs et al., 2003). Using Cohen's guidelines for interpreting reliability estimates ($K < 0$ – no agreement; $0.00 \leq K \leq 0.20$ – slight agreement; $0.21 \leq K \leq 0.40$ – fair agreement; $0.41 \leq K \leq 0.60$ - moderate agreement; $0.61 \leq K \leq 0.80$ – substantial agreement; and $0.81 \leq K \leq 1$– almost perfect agreement), the data in Table 11 indicate an almost perfect agreement with *Coder A* and *Coder B* on all aspects of the coding.

Summary of Research Design and Methodology

In this chapter, the research design and the methods used to examine the nature and alignment of the learning outcomes, textbooks and test items to address the research questions for this study have been presented. I presented the fifteen learning outcomes which translate the intended curriculum in Belize and the codes used in this study and the provision and characteristics of each of the Upper division textbooks as the written curriculum. I also described the data collection tool, coding scheme, reliability and validity measures. Data from the instructional segments of each textbook were analyzed based on the cognitive level of each instructional segment. The data collected from the coding were used to analyze and describe the alignment between the learning outcomes and the test items; learning outcomes and textbook; and textbooks and test items, as reported in Chapter 4.

Chapter 4

Results

In this chapter, I present the results of the study. This study was designed to examine the nature of the alignment of the learning outcomes, test items, and the extent to which upper division textbooks in Belize provide support for students to study the learning outcomes assessed in the national examinations. I organized the results by information on the extent the learning outcomes align with the national assessment, the extent textbooks provide students with the opportunities to study the learning outcomes, the extent the cognitive demands of the instructional segments of four textbooks align with the learning outcomes, the extent the instructional segments align with assessment, and the nature of alignment among the three curriculum types. One standard five and three standard six mathematics textbooks were selected, representing the textbooks used in the Upper Division in Belize.

The following research questions guided the development of the study:

1. To what extent are the learning outcomes of the Upper Division Mathematics Curriculum aligned with the national assessment test items?
2. To what extent do the upper division textbooks in Belize provide students with the opportunities to study the learning outcomes of the Upper Division Mathematics Curriculum?

3. To what extent are the cognitive demands of the instructional segments in the upper division textbooks in Belize aligned with the learning outcomes?
4. To what extent are the instructional segments in the upper division textbooks in Belize aligned with the content of the test items of the national examination?
5. What is the nature of alignment of upper division learning outcomes, written curriculum [textbooks], and test items from the national examination in Belize?

This chapter is divided into four major sections. In the first section, the coverage and alignment of the upper division learning outcomes with the national assessment are summarized. The description includes (a) the number of LOs matched with test items; and (b) the cognitive complexity of LOs and cognitive complexity of test items. In the second section, the alignment between the instructional segments of the mathematics textbooks and the learning outcomes is discussed. The description includes (a) types of instructional segments by textbooks; (b) number of instructional segments by content domain; and (c) cognitive complexity of instructional segments and alignment with the learning outcomes. The third section provides a comparison of alignment between the instructional segments and the test items. Section four concludes with the nature of alignment of upper division learning outcomes, written curriculum [textbooks], and test items from the national examination in Belize.

I then present the result to *Research Question 1* by addressing the alignment of the learning outcomes and the test items. This is followed by the result to *Research Question 2* on the extent upper division textbooks in Belize provide students with the opportunities to study the learning outcomes of the Upper Division Mathematics

Curriculum. Next I present the results on the extent the cognitive demands of the instructional segments of the textbooks align with the learning outcomes *(Question 3)* and the extent the instructional segments in the upper division textbooks in Belize aligned with the content of the test items of the national examination (*Research Question 4*). I conclude the section with the results on the overarching question on the nature of alignment of upper division learning outcomes, written curriculum [textbooks], and test items from the national examination in Belize (*Question 5*).

Cognitive Level of Learning Outcomes

As seen in Figure 8, the cognitive levels of the learning outcomes address Webb's four levels to some degree. Almost half of the learning outcomes were at level 2 (skills/concepts) with another third at level 3 (strategic thinking); thus, 80% of the learning outcomes were coded as at level 2 or 3. As noted, few of the learning outcomes were at level 1 (recall) or 4 (extended thinking).

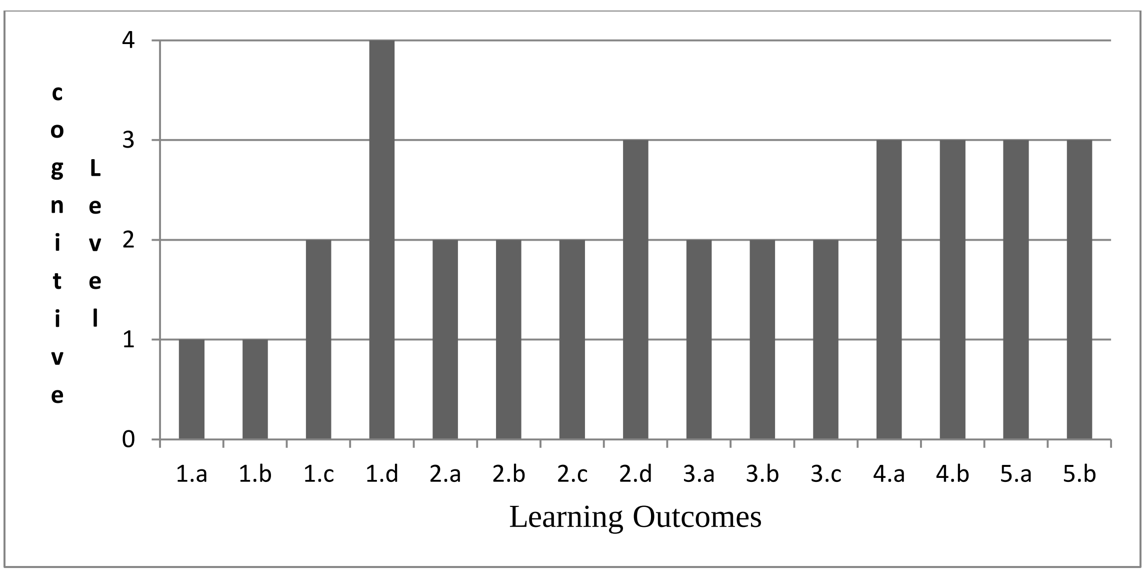


Figure 8. Cognitive Levels of the Learning Outcomes

Cognitive Level of Test Items

Figure 9 documents the cognitive level of the 2009 and 2010 Test Items. The cognitive level of the test items varied across the two forms. The 2009 test had 19 (38%) of the items at level 1, 30 (60%) at level 2, and only 1 (2%) at level 3. The 2010 test had 26 (52%) at level 1, 24 (48%) at level 2, and no items at level 3. Neither test had items at level 4. A cursory look at the test item level may suggest that the 2009 test was more challenging in terms of the cognitive demand.

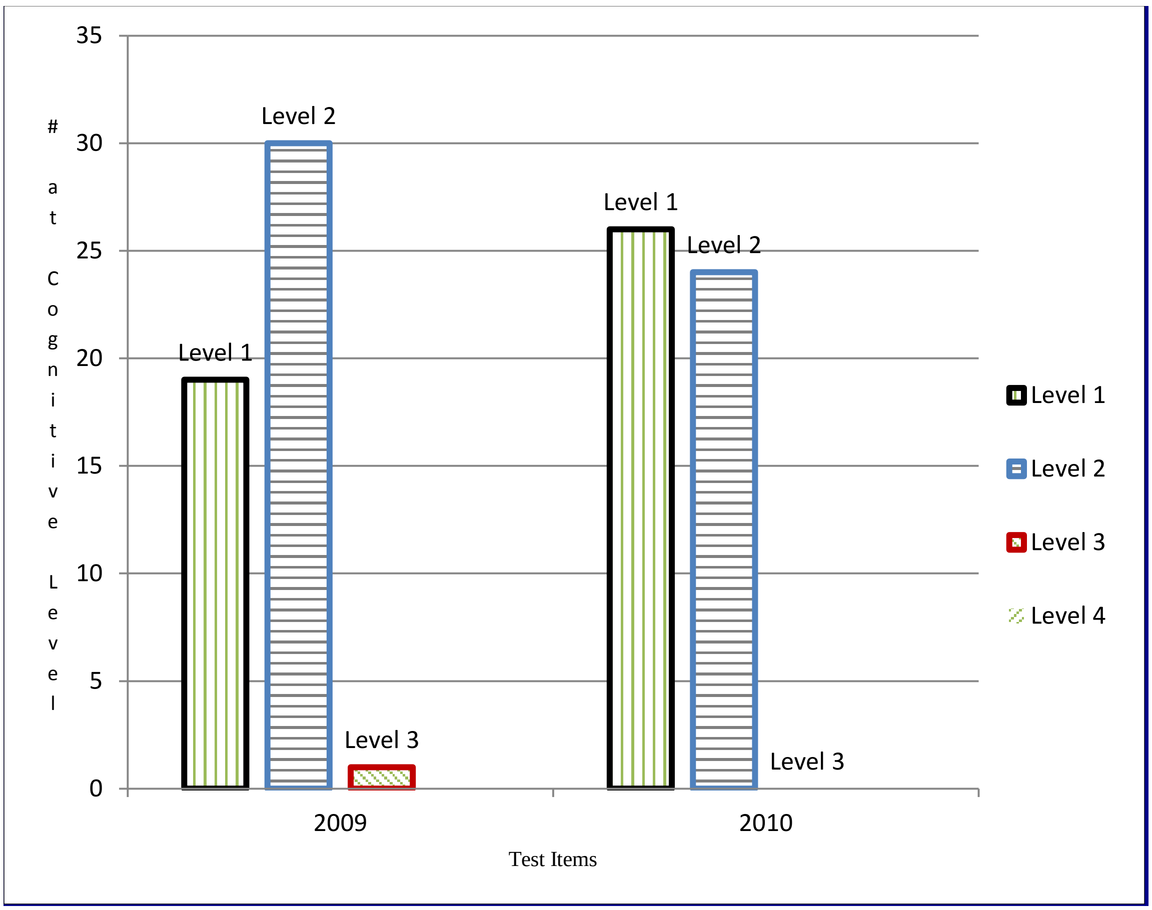


Figure 9. Cognitive Level of 2009 and 2010 Test Items

Coverage of Learning Outcomes by Test Items

Figure 10 describes the number of test items that targeted each of the learning outcomes. As noted, the number of test items reported on the figure for both tests exceeds the actual number of 50 test items, given that some items address more than one learning outcome. A total of 66 codes from the 2009 test and 54 codes from the 2010 test were matched to the learning outcomes. For example, learning outcome 1.d "apply the concept of rational numbers and irrational numbers to real life situations" was addressed by eleven test items in 2009.

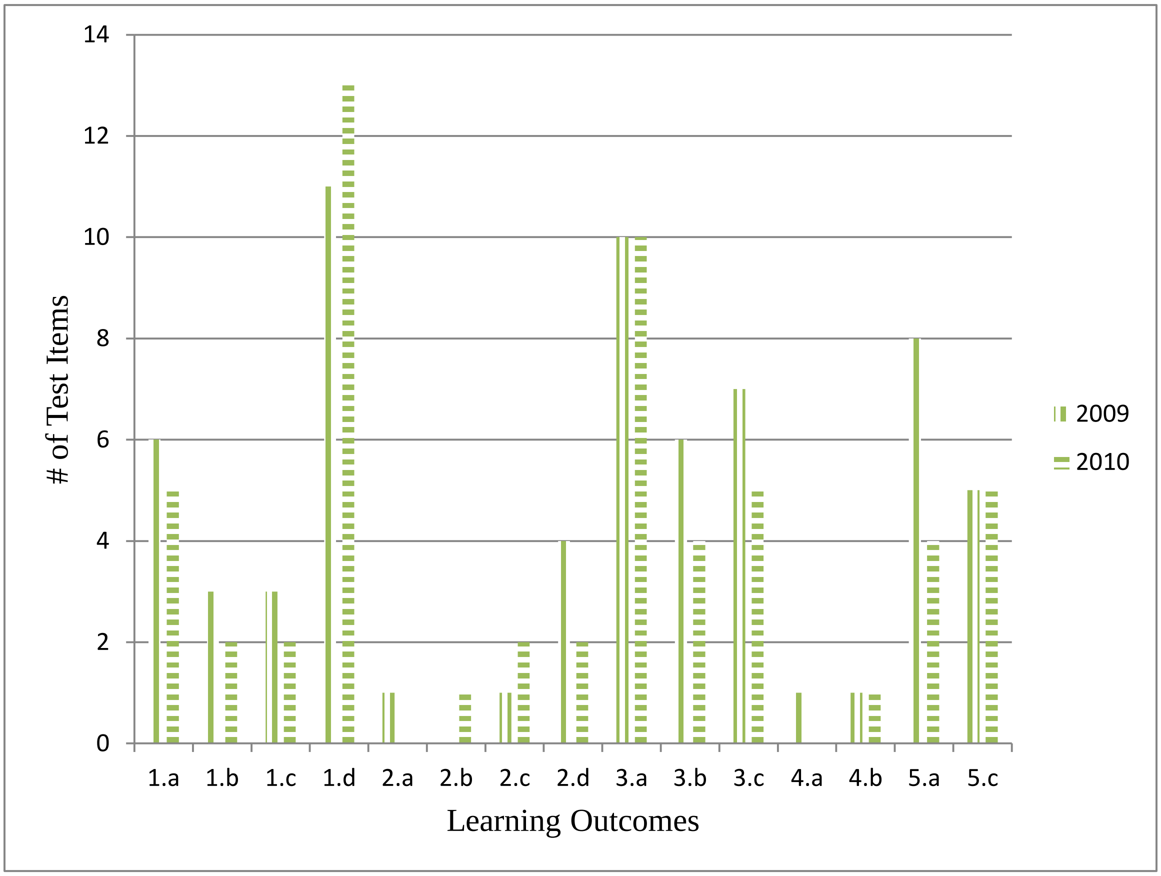


Figure 10. Coverage of Learning Outcomes by Test Items

Of the eleven items, seven also addressed other learning outcomes. Two of the eleven test items also addressed learning outcome 3.a “ measure, estimate, express and compute distance, weight, time, capacity and temperature and apply to practical solutions”; three addressed learning outcome 3.b “use and convert money based on its relative value and its use in financial transactions”; one addressed learning outcome 5.a “collect, analyze and interpret data and predict probable outcomes”; and one addressed learning outcome 5.b “ apply the concept of ‘sets’ to practical solutions”.

As illustrated, there was an uneven distribution of test items to the learning outcomes. For the 2009 test, 14 learning outcomes were addressed by at least one test item. As already discussed, 11 items (16%) addressed learning outcome 1.d “apply the concept of rational numbers and irrational numbers to real life situations” and no test item addressed learning outcome 2.b “how to plot the position and movement of two-dimensional shapes”. For the 2010 test, 13 learning outcomes were addressed by at least one test item. Although 13 items (19%) addressed learning outcome 1.d, no test items addressed learning outcomes 2.a “how to draw and construct three-dimensional objects” or 4.a “make and apply reasonable approximations by observing and/or using factual data based on meaningful references”. In terms of coverage, the 2009 national test addressed 93% of the learning outcomes while the 2010 test addressed 87%.

Alignment of Cognitive Demand of Learning Outcomes and Test Items

Alignment of Learning Outcomes and the 2009 Test Items

A test item is aligned with the learning outcome it addresses if the cognitive level of the test is at the same cognitive level of the learning outcome. Test items one level below the level of the learning outcome were considered as “under the cognitive level” and test items one level above the level of the learning outcome were considered as “above the cognitive level”. Test items two levels below or above the cognitive level of the learning outcome were considered as not aligned as well as those items that did not address any learning outcome.

For the purpose of this analysis, learning outcomes and test items are considered as either aligned or not aligned. For test items aligned at the cognitive level, below the cognitive level, or above the cognitive level of the learning outcome, the alignment criteria were described as limited, moderate, or strong alignment. When less than 40% of test items were at the depth of knowledge levels of the learning outcomes, the learning outcomes were reported as having “limited” alignment. When 40 % - 49%, inclusive, of the test items were at the depth of knowledge level of the learning outcome, it had “moderate” alignment. Only when 50 % or more of test items were at the depth of knowledge of the learning outcome was the learning outcome reported as having “strong” alignment. Figure 11 documents the cognitive levels of the learning outcomes and the 2009 test items. In Figure 11, the first column represents the Depth of Knowledge Levels of the Learning Outcomes (DOK of LO), the second column represents the Learning Outcomes (LO) and the third column represents the test items levels. For instance, in row 1, learning outcome 1.a was at level 1 depth of knowledge, and was addressed by 5 test items of which 1 was at level 1 and 3 at level 2.

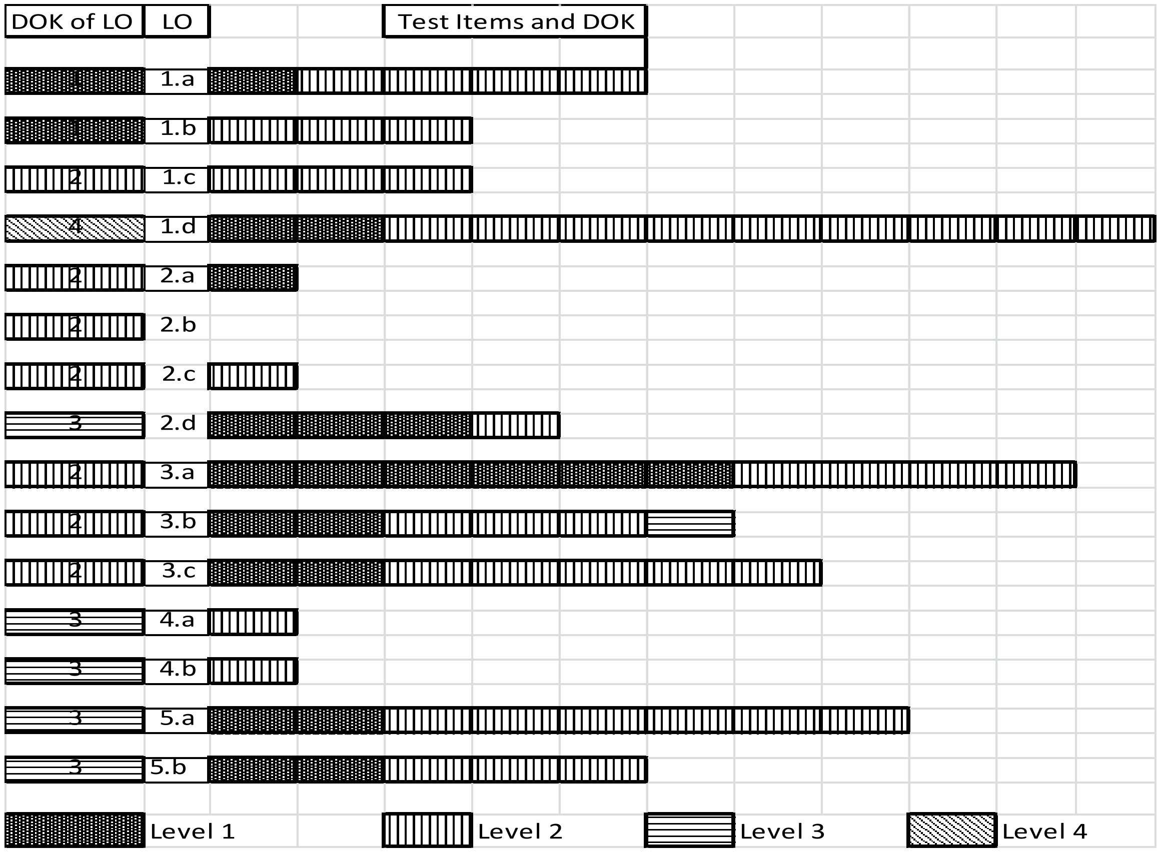


Figure 11. Learning Outcomes and the 2009 Test Items Cognitive Demand Level

Figure 11 shows that 14 of the learning outcomes were addressed by the test items. As noted, learning outcome 2.b, "how to plot the position and movement of two-dimensional shapes", was not addressed by any test item. For instance, learning outcome 1.a, "identify the consecutive sequence and position of whole numbers up to ten digits and place value", was rated at level 1; it was addressed by five test items with one item aligned at this level and four items one level above the cognitive level of the learning outcome. Similarly, learning outcome 1.c, "express equivalent base notations and other number systems", was coded at level 2; it was addressed by three test items at the cognitive level which suggests that the test items were aligned with the learning outcome.

In contrast, learning outcome 1.d rated as level 4, although it was addressed by eleven test items, the items were at level 1 and level 2 so that the test items were reported as having no alignment.

Results indicate that 17 (26%) of the test items were at the level of the associated learning outcomes, 23 (35%) were below the cognitive level, 7 (11%) were above the cognitive level, and 19 (29%) had no alignment. Using the operational definition of alignment discussed earlier, the 2009 test items had limited alignment with the learning outcomes. In principle, test items should be written to the cognitive level of the learning outcomes for maximum alignment. But if one also considers test items one level below or above the cognitive level of the learning outcome, then the 2009 test had 47 (71%) test items aligned with the learning outcomes, indicating a strong alignment.

Alignment of Learning Outcomes and the 2010 Test Items

Figure 12 describes the alignment of the learning outcomes and the 2010 test items. Figure 12 shows that 13 learning outcomes were addressed by test items that were at the cognitive level or 1 below the cognitive level of the learning outcome. Test items addressing learning outcome 1.b, "identify properties of prime and composite numbers", are in alignment with the cognitive level of the learning outcome at level 1. In contrast, learning outcome 1.a, "identify the consecutive sequence and position of whole numbers up to ten digits and place value" had four test items aligned with the cognitive level of the learning outcome and one item above the level. As noted, learning outcome 1.d, "apply the concept of rational numbers and irrational numbers to real life situations", addressed by 13 (24%) of the test items, was reported as having no alignment because all the test items were at cognitive levels 1 and 2 although the learning outcome was at cognitive level 4. Results indicate that 15 (28%) of the test items were at the level of the learning outcomes, 20 (37%) were below the cognitive level, 1 (2%) was above the related cognitive level, and 18 (33%) were reported as having no alignment to a learning outcome because they were two levels below the cognitive level of the learning outcomes.

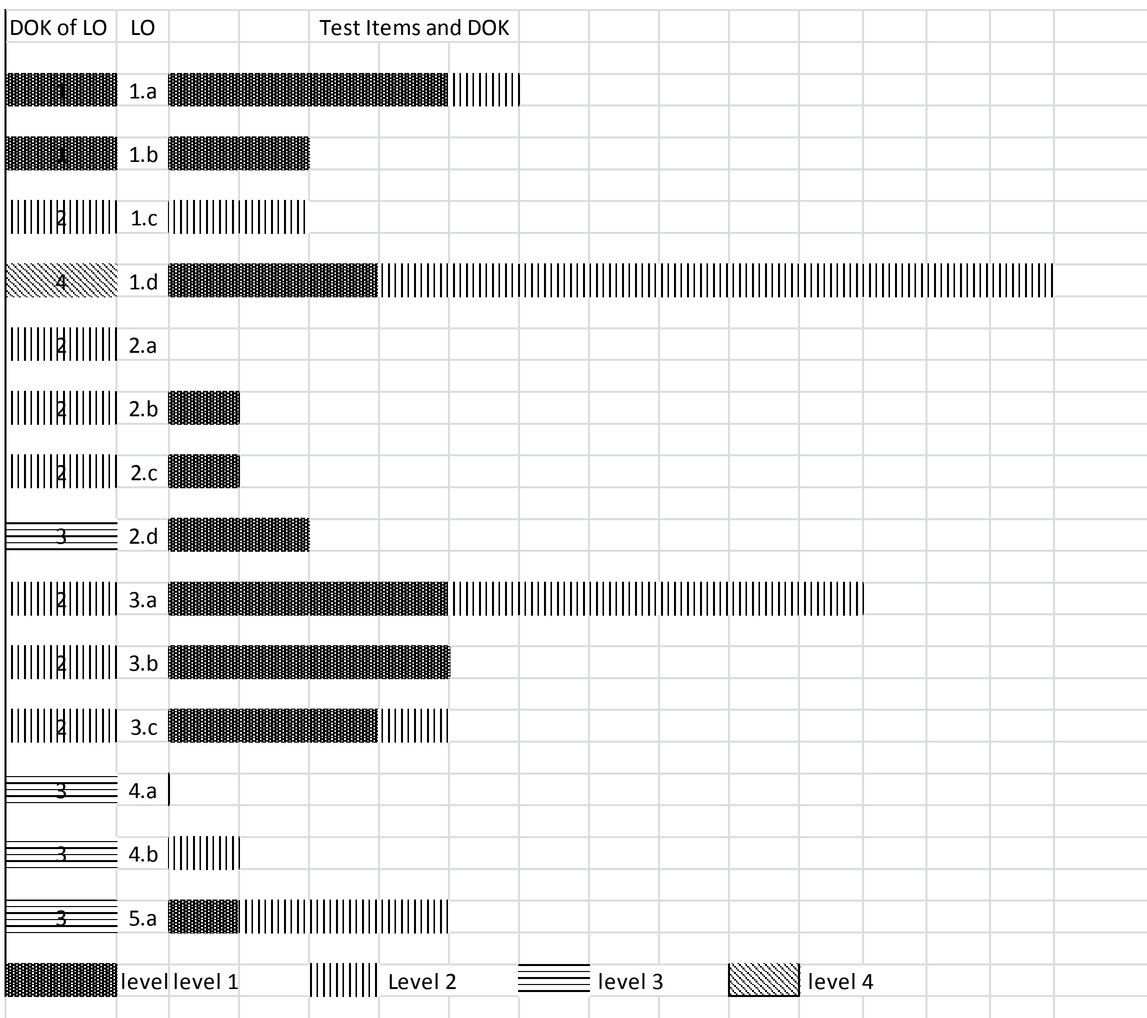


Figure 12. Learning Outcomes and 2010 Test Items Cognitive Demand Level

As noted, two learning outcomes were not addressed by any test items. Using the operational definition of alignment discussed earlier, the 2010 test items had limited alignment with the learning outcomes because less than 40% of the test items matched the cognitive level of the learning outcomes. In principle, test items should be written to the cognitive level of the learning outcomes for maximum alignment. But if one also considers test items one level below or above the cognitive level of the learning outcome, then the 2010 test had 36 (61%) test items aligned with the learning outcomes, indicating a strong alignment.

Summary of Coverage and Alignment of Learning Outcomes and Test Items

Overall, both tests met the criterion of coverage with 14 learning outcomes targeted by at least one test item for the 2009 test and 13 learning outcomes targeted by items on the 2010 test. In terms of the alignment of learning outcomes and test items, both tests have limited alignment with the learning outcomes. On both tests, learning outcome 1.d “apply the concept of rational numbers and irrational numbers to real life situations”, had a high percentage of test items that did not align with the learning outcome. It is important to note that 12 (80%) of the learning outcomes reflect a cognitive complexity of levels 2 or 3 (7 or 58% at level 2 and 5 or 42% at level 3) while the test items had only levels 1 or 2 with the exception of one item at level 3 in the 2009 test. As stated earlier, it is typical that in testing there will be items at or one level below that of the learning outcome, or possibly one level above to challenge student’s cognitive thinking. Thus considering test items one level below, at the level, or one level above as a measure of alignment, both tests would be considered as having a strong alignment with the learning outcomes.

Learning Outcomes and Instructional Segments of the Textbooks

Caribbean Primary Mathematics Textbook (Standard 5)

Table 12 describes the number of instructional segments pertaining to the content areas addressed by the learning outcomes found in the *Caribbean Primary Mathematics* (Ginn, 2003) for Standard 5 (grade 7).

Table 12

Number of Instructional Segments by Content Domain and Segment Type in the Caribbean Primary Mathematics (CPM) Textbook.

Content Domain	Learning Outcome	Pre-lessons	Lessons	End-of-lesson feature	End of chapter feature	Chapter Review	Total
NOC	1.a	12	37	1	2	0	52
NOC	1.b	8	4	3	0	0	15
NOC	1.c	4	22	0	0	0	26
NOC	1.d	17	40	1	9	0	67
SRS	2.a	4	10	0	0	3	17
SRS	2.b	2	3	0	3	0	8
SRS	2.c	0	1	0	2	0	3
SRS	2.d	7	16	0	1	1	25
MQC	3.a	8	17	0	6	0	31
MQC	3.b	1	7	0	0	0	8
MQC	3.c	0	8	0	0	0	8
EP	4.a	2	14	0	0	0	16
EP	4.b	1	6	0	0	0	7
DH	5.a	2	36	0	3	0	41
DH	5.b	6	11	0	4	0	21
	Total (%)	64 (19)	242 (70)	5 (1)	30 (7)	4 (1)	345

Note. NCO = Number Operations and Concepts; SRS = Spatial Relationship and Shapes; MQC = Measure, Quantify and Calculate; EP = Estimate and Prediction; DH = Data Handling

As illustrated in the table, 345 instructional segments were identified from the 17 chapters with 70% of the attention on lessons. Minimal attention was given to end-of-lesson extra features and chapter reviews. Learning outcomes 1.a, 1.b, 1.c, 1.d, which addressed the content domain of Number Operations and Concepts, received the highest percent of instructional lessons. Learning outcomes 4.a and 4.b that address Estimating and Making Predictions had the lowest percentage (7%) of coverage.

The opportunity to learn criterion focuses on whether or not the learning outcomes from the Upper Division (Standards 5 and 6) are also addressed in the Upper Division textbook. With regards to the instructional segments identified in *the Caribbean Primary Mathematics* (CPM) textbook, the instructional segments addressed the learning outcomes under each of the content domains. For example, under the content domain of Number that received the most attention (160 out of 345 segments), there are four learning outcomes: 1.a "identify the consecutive sequence and position of whole numbers up to ten digits and place value"; 1.b "identify properties of prime and composite numbers"; 1.c "express equivalent base notations and other number systems"; and 1.d "apply the concept of rational numbers and irrational numbers to real life situations".

It can be noted that the four learning outcomes that address the content domain of Spatial Relationship and Shapes received 53 (15%) instructional segments with learning outcome 2.c "how shapes fit together to form patterns" receiving the least attention among all the learning outcomes. As noted, the learning outcomes that addressed the content domains of Measure, Quantify, and Calculate, Estimate and Make Prediction, and Data Handling were all addressed by instructional lessons. Thus, the *Caribbean Primary*

Mathematics textbook's instructional segments address the learning outcomes for the Standard 5 level which suggests that the textbook addressed the content and provided opportunities to study the learning outcomes of the Upper Division Mathematics Curriculum.

Let's Pass Mathematics Textbook (Standard 6)

Table 13 describes the number of instructional segments pertaining to the content areas addressed by the learning outcomes in the *Let's Pass Mathematics* textbook.

Table 13

Number of Instructional Segments by Content Domain and Segment Type in the Let's Pass Mathematics (LPM) Textbook.

Content Domain	Learning Outcome	Pre-lessons	Lessons	End-of-lesson feature	End of chapter feature	Chapter Review	Total
NOC	1.a	8	14	0	0	2	24
NOC	1.b	3	2	0	0	1	6
NOC	1.c	4	4	0	0	1	9
NOC	1.d	5	5	0	0	2	12
SRS	2.a	0	0	0	0	0	0
SRS	2.b	0	0	0	0	0	0
SRS	2.c	0	0	0	0	0	0
SRS	2.d	3	7	0	0	1	11
MQC	3.a	3	9	0	0	3	15
MQC	3.b	0	0	0	0	1	1
MQC	3.c	3	3	0	0	1	7
EP	4.a	1	0	0	0	0	1
EP	4.b	0	3	0	0	2	5
DH	5.a	3	1	0	0	0	4
DH	5.b	0	0	0	0	0	0
	Total (%)	33 (34)	48 (51)	0	0	14 (15)	95

Note. NCO = Number Operations and Concepts; SRS = Spatial Relationship and Shapes; MQC = Measure, Quantify and Calculate; EP = Estimate and Prediction; DH = Data Handling

As illustrated in the table, 95 instructional segments were identified from 14 chapters with 51% of the attention on lessons followed by 34% on pre-lessons. Each chapter had a chapter review exercise, accounting for 15% of the instructional segments. No attention was given to end-of-lesson extra features or end of chapter features. Learning outcomes that addressed the content domain of Number Operations and Concepts received the attention of 51 (54%) instructional segments. Learning outcomes that addressed Data Handling 5.a "collect, analyze and interpret data and predict probable outcomes", and 5.b "apply the concept of 'sets' to practical solutions" received less attention with only 4 (4%) instructional segments. As noted, three of the learning outcomes, 2.a "how to draw and construct three-dimensional objects"; 2.b "how to plot the position and movement of two-dimensional shapes"; and 2.c "how shapes fit together to form patterns" were not addressed by any instructional segments. In this case, the instructional segments from the *Let's Pass Mathematics* (LPM) textbook used in Standard 6 fell short to provide the content, and thus the opportunities, to study the learning outcomes.

Active Mathematics – A Student's Workbook (Standard 6)

Table 14 describes the number of instructional segments pertaining to the content areas addressed by the learning outcomes found in the *Active Mathematics* textbook.

Table 14

Number of Instructional Segments by Content Domain and Segment Type in the Active Mathematics (AM) Textbook

Content Domain	Learning Outcome	Pre-lessons	Lessons	End-of-lesson feature	End of chapter feature	Chapter Review	Total
NOC	1.a	1	5	1	1	1	9
NOC	1.b	2	11	0	2	2	16
NOC	1.c	2	4	0	1	2	9
NOC	1.d	0	9	8	3	4	24
SRS	2.a	0	0	0	0	0	0
SRS	2.b	0	1	0	0	0	1
SRS	2.c	0	0	0	0	0	0
SRS	2.d	0	0	0	0	0	0
MQC	3.a	4	8	0	2	2	16
MQC	3.b	0	0	0	0	0	0
MQC	3.c	1	4	2	1	0	8
EP	4.a	1	0	0	0	0	1
EP	4.b	0	0	0	0	0	0
DH	5.a	5	3	3	1	0	12
DH	5.b	1	11	2	1	2	17
	Total (%)	17 (15)	55 (48)	16 (14)	12 (11)	13 (12)	113

Note. NCO = Number Operations and Concepts; SRS = Spatial Relationship and Shapes; MQC = Measure, Quantify and Calculate; EP = Estimate and Prediction; DH = Data Handling

As illustrated in Table 14, 113 instructional segments were identified from the 10 chapters with 48% of the attention on lessons. Learning outcomes 1.a, 1.b, 1.c, and 1.d, which addressed the content domain of Number Operations and Concepts, received the highest attention with 58 instructional segments. Learning outcomes 2.b and 4.a received less attention with only one instructional segment addressing each outcome. It can be noted that five learning outcomes, 2.a "how to draw and construct three-dimensional objects"; 2.c "how shapes fit together to form patterns"; 2.d "infer the relationship between angles in different two-dimensional shapes"; 3.b "use and convert money based on its relative value and its use in financial transactions"; and 4.b "predict the likely occurrence of an event, through logical reasoning based on trends" were not addressed by any instructional segments. As noted, the instructional segments from the *Active Mathematics – A Student's Workbook* used in Standard 6 do not address five learning outcomes associated with content areas of Spatial Relationships and Shapes; Measure, Quantify and Calculate; and Estimate and Make Prediction, thus falling short of providing opportunities for students to learn the content of those learning outcomes.

PSE Mathematics – Practice Problems & Tests with Solutions (Standard 6)

Table 15 describes the number of instructional segments pertaining to the content areas addressed by the learning outcomes found in the *Primary Selection Examination – Practice Problems & Tests with Solutions*.

Table 15

Number of Instructional Segments by Content Domain and Segment Type in the Primary Selection Examination (PSE) Textbook.

Content Domain	Learning Outcome	Pre-lessons	Lessons	End-of-lesson feature	End of chapter feature	Chapter Review	Total
NOC	1.a		24				24
NOC	1.b		11				11
NOC	1.c		7				7
NOC	1.d		25				25
SRS	2.a		0				0
SRS	2.b		0				0
SRS	2.c		7				7
SRS	2.d		12				12

Table 15 *(continued)*

Content Domain	Learning Outcome	Pre-lessons	Lessons	End-of-lesson feature	End of chapter feature	Chapter Review	Total
MQC	3.a		40				40
MQC	3.b		16				16
MQC	3.c		18				18
EP	4.a		0				0
EP	4.b		0				0
DH	5.a		21				21
DH	5.b		26				26
	Total (%)		207 (100)				207

Note. NCO = Number Operations and Concepts; SRS = Spatial Relationship and Shapes; MQC = Measure, Quantify and Calculate; EP = Estimate and Prediction; DH = Data Handling

Each of the practice problems and the items from the practice test was coded as a lesson in terms of instructional segments. The format of the practice problems and practice test are similar to those in the 2009 and 2010 tests. From the textbook, 207 instructional segments were identified with 32% of attention to the learning outcomes 1.a, 1.b, 1.c, and 1.d that addressed the content domain of Number Operations and Concepts. Learning outcomes 3.a, 3.b, and 3.c that address the content area of Measure, Quantify and Calculate received 36% attention and Data Handling received 22% attention. Spatial Relationships and Shapes received less attention, addressed by only 9% of the instructional segments. It can be noted that four learning outcomes (2.a, 2.b, 4.a, and 4.b) were not addressed by any instructional segment. Two learning outcomes (2.a and 2.b) were associated with Spatial Relationships and Shapes and learning outcomes (4.a and 4.b) were associated with the content domain related to Estimate and Make Prediction. Thus, the instructional segments from the *Primary Selection Examination – Practice*

Problems and Practice Tests (PSE) textbook used in Standard 6 fell short of addressing four learning outcomes, thus limiting the opportunity for students to study those learning outcomes.

Summary of the Learning Outcomes and Upper Division Textbooks

The multi-faceted components of opportunity to learn provide a complex look at the extent to which the four upper division textbooks used in Belize provide students with opportunities to study the learning outcomes. The data suggest that the *Caribbean Primary Mathematics* (Standard 5) is the only textbook whose instructional segments address all 15 learning outcomes. As such, the instructional segments from the three textbooks from Standard 6 (*Let's Pass Math*, *Active Mathematics*, and *Primary Selecting Examination*) fell short of addressing some of the learning outcomes. More specifically, *Let's Pass Math* did not address three learning outcomes, *Active Mathematics* did not address five, and the *Primary Selection Examination* did not address four learning outcomes. The instructional segments of *Active Mathematics and Primary Examination Selection* textbooks did not address learning outcome 4.a "make and apply reasonable approximations by observing and/or using factual data based on meaningful references", and 4.b "predict the likely occurrence of an event, through logical reasoning, based on trends" that are associated with the content domain of Estimate and Make Predictions. Figure 13 illustrates a comparison of the proportion of instructional segments from the four textbooks that addressed the content domains associated with the learning outcomes.

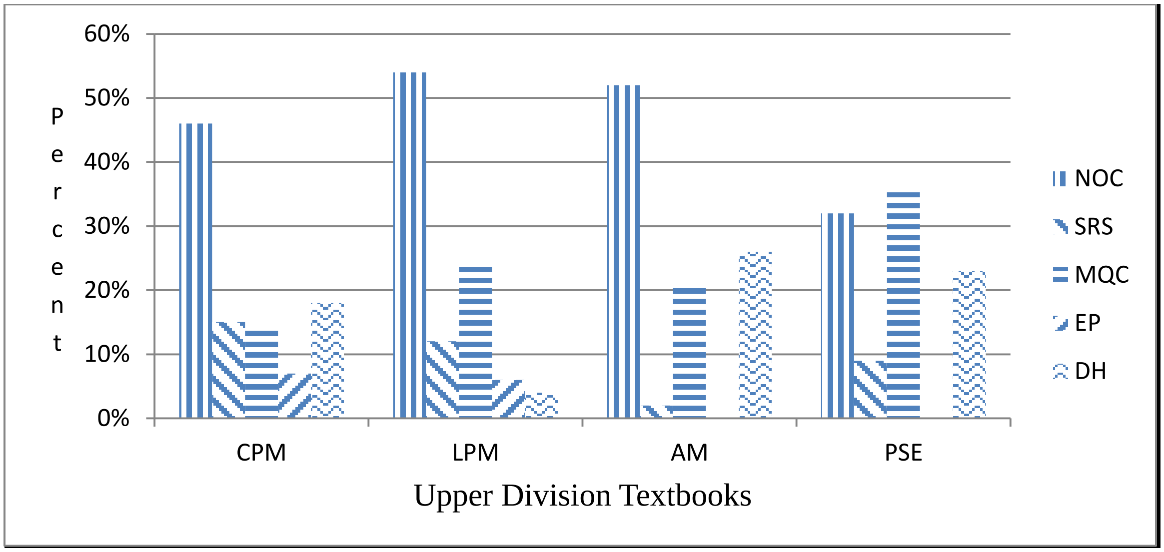


Figure 13. Proportion of instructional segments in each textbook that addressed various content domains

Note. NOC= Number Operation and Concepts; SRS= Spatial Relationships and Shapes; EP= Estimate and make Prediction; MQC= Measure, Quantify and Calculate; DH= Data Handling; CPM= *Caribbean Primary Mathematics*; LPM= *Let's Pass Math*; AM= *Active Mathematics*; PSE= *Primary Selection Examination*

Figure 13 shows that the four textbooks provide support for students to learn the content of Number Operation and Concepts (addressing the 4 learning outcomes) and Measure, Quantify and Calculate (addressing 3 learning outcomes). However, the content domain of Spatial Relationships and Shapes (with 4 learning outcomes) was only addressed in the *Caribbean Primary Mathematics*, *Let's Pass Math* and *the Primary Selection Examination* textbooks. The textbook, *Active Mathematics*, provides opportunities for students to learn four content areas (10 learning outcomes total).

Figure 14 shows a comparison of the proportion of instructional segments by grade levels, Standard 5 and Standard 6, that addressed the content domains associated with the learning outcomes (see Table 1).

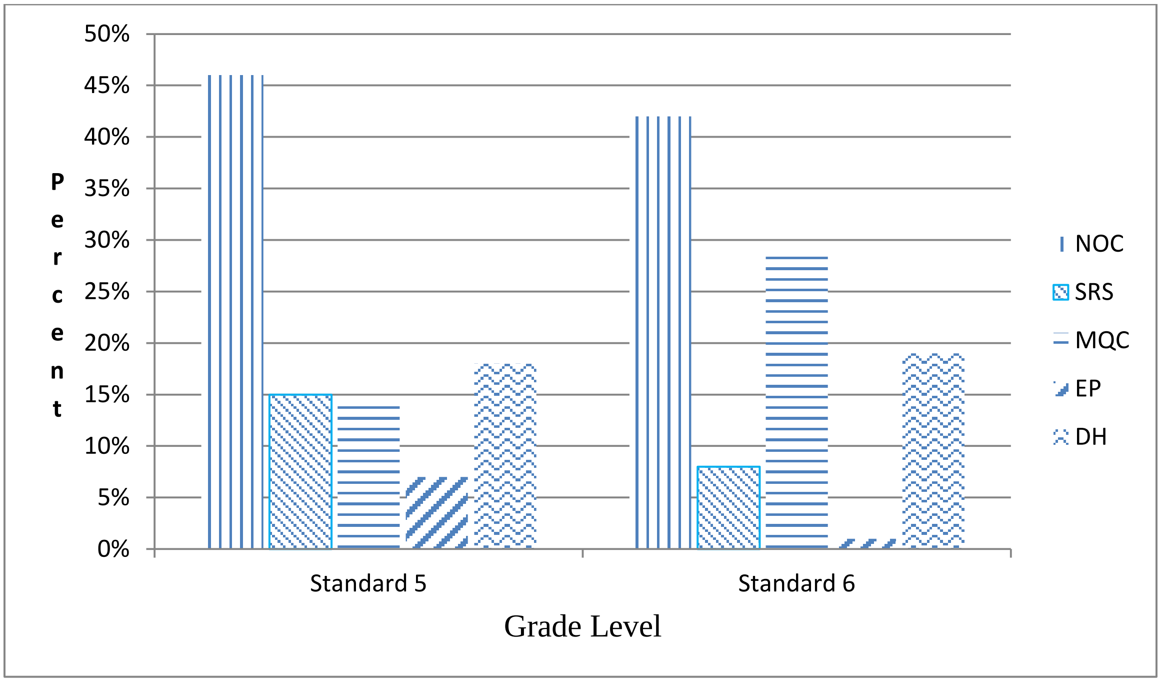


Figure 14. Proportion of instructional segments by grade level that addressed the content domains

Note. NOC= Number Operation and Concepts; SRS= Spatial Relationships and Shapes; EP= Estimate and make Prediction; MQC= Measure, Quantify and Calculate; DH= Data Handling

The instructional segments from the Standard 6 textbooks were considered as a set because they are used simultaneously across the grade level. From Figure 14, it can be noted that the instructional segments from the textbooks used at both grade levels, Standard 5 and Standard 6, address the content domains associated with the learning outcomes.

Alignment of Instructional Segments and Learning Outcomes

The alignment in this instance focuses on whether or not the cognitive demand of the learning outcomes for Upper Division in the mathematics curriculum in Belize are also addressed with the same level of cognitive demand or higher in the four textbooks.

For the purpose of this analysis, the learning outcomes and instructional segments are considered as aligned or not aligned. For those aligned, the alignment criteria that were used were described as limited, moderate, or strong alignment. When less than 40% of related instructional segments were at or above the depth-of-knowledge levels of the learning outcomes, the learning outcomes and instructional segments were reported as having "limited" alignment. When 40% - 49%, inclusive, of related instructional segments were at or above the depth of knowledge level of the learning outcome, the learning outcomes and instructional segments were reported as "moderately" aligned. Lastly, when 50% or more of related instructional segments were at or above the depth of knowledge of the learning outcome, the learning outcome and the instructional segments were reported as having "strong" alignment.

Tables 16 – 19 document the alignment of learning outcomes with the four textbooks. Table 16 summarizes the proportion of learning outcomes that are either aligned or not aligned with the instructional segments from the *Caribbean Primary Mathematics* (CPM) textbook.

Table 16

Proportion of instructional segments (%) at or above the cognitive level of the learning outcomes from the Caribbean Primary Mathematics Textbook

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
1	1.a	12/12 (100)	37/37 (100)	1/1 (100)	2/2 (100)	0	52/52 (100)[SA]
1	1.b	8/8 (100)	4/4 (100)	3/3 (100)	0	0	15/15 (100)[SA]
2	1.c	0/4 (0)	7/22 (32)	0	0	0	7/26 (27)[LA]
4	1.d	0/17 (0)	0/40 (0)	0/1 (0)	0/9 (0)	0	0/67 (0)[NA]
2	2.a	0/4 (0)	9/10 (90)	0	0	2/3 (66)	11/17 (65)[SA]
2	2.b	1/2 (50)	2/3 (66)	0	1/3 (33)	0	4/8 (50)[SA]
2	2.c	0	1/1 (100)	0	1/2 (50)	0	2/3 (66)[SA]
3	2.d	0/7 (0)	4/16 (25)	0	0/1 (0)	0/1 (0)	4/25 (16)[LA]
2	3.a	2/8 (25)	6/17 (35)	0	3/6 (50)	0	11/31 (35)[LA]
2	3.b	0/1 (0)	5/7 (71)	0	0	0	5/8 (63)[SA]
2	3.c	0	8/8 (100)	0	0	0	8/8 (100)[SA]
3	4.a	0/2 (0)	3/14 (25)	0	0	0	3/16 (19)[LA]
3	4.b	0/1 (0)	4/6 (66)	0	0	0	4/7 (57)[SA]
3	5.a	0/2 (0)	4/36 (11)	0	2/3 (66)	0	6/41 (15)[LA]
3	5.b	0/6 (0)	4/11 (36)	0	2/4 (50)	0	6/21 (29)[LA]

Note. *m/n* means m instructional segments out of n instructional segments in this type that were at or above the depth of knowledge for the learning outcome. The number beside each m/n is the percent. The superscript letters on the total column indicate the degree of alignment: SA= strong alignment; LA= Limited alignment; MA=Moderate alignment; and NA= No alignment.

For example, learning outcome 1.a was coded at level 1 (Recall) and the 52 instructional segments that addressed learning outcome 1.a were at or above cognitive level 1. Thus, the instructional segments have a strong alignment with the learning outcomes. As noted, there are eight learning outcomes that have a strong alignment with the learning outcomes. Six learning outcomes have a limited alignment and one learning outcome has no alignment.

Table 17 documents the learning outcomes and the instructional segments from the *Let's Pass Mathematics* textbook.

Table 17

Proportion of instructional segments (%) at or above the cognitive level of the learning outcomes from the Let's Pass Mathematics Textbook

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
1	1.a	8/8 (100)	14/14 (100)	0	0	2/2 (100)	24/24 (100)^SA
1	1.b	3/3 (100)	2/2 (100)	0	0	1/1 (100)	6/6 (100)^SA
2	1.c	3/4 (75)	1/4 (25)	0	0	1/1 (100)	5/9 (56)^SA
4	1.d	0/5 (0)	0/5 (0)	0	0	0/2 (0)	0/12 (0)^NA
2	2.a	0	0	0	0	0	0^NA
2	2.b	0	0	0	0	0	0^NA
2	2.c	0	0	0	0	0	0^NA
3	2.d	0/3 (0)	0/7 (0)	0	0	1/1 (100)	1/11 (9)^LA
2	3.a	1/3 (33)	4/9 (44)	0	0	3/3 (100)	8/15 (53)^SA
2	3.b	0	0	0	0	1/1 (100)	1/1 (100)^SA
2	3.c	1/3 (33)	2/3 (66)	0	0	1/1 (100)	4/7 (57) ^SA

Table 17 (*continued*)

Proportion of instructional segments (%) at or above the cognitive level of the learning outcomes from the Let's Pass Mathematics Textbook

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
3	4.a	0/1 (0)	0	0	0	0	0/1 (0)[NA]
3	4.b	0	2/3 (66)	0	0	2/2 (100)	4/5 (80)[SA]
3	5.a	0/3 (0)	0/1 (0)	0	0	0	0/4 (0)[NA]
3	5.b	0	0	0	0	0	0[NA]

Note. *m/n* means m instructional segments out of n instructional segments in this type that were at or above the depth of knowledge for the learning outcome. The number beside each m/n is the percent. The superscript letters on the total column indicate the degree of alignment: SA= strong alignment; LA= Limited alignment; MA=Moderate alignment; and NA= No alignment.

As noted in Table 17, for the textbook *Let's Pass Math* with 95 instructional segments identified, seven learning outcomes have strong alignment with the instructional segments. One learning outcome has a limited alignment and seven have no alignment.

Table 18 documents the learning outcomes and the instructional segments from the *Active Mathematics* textbook. Seven learning outcomes have strong alignment with the instructional segments, one has limited alignment and seven have no alignment.

Table 18

Proportion of instructional segments (%) at or above the cognitive level of the learning outcomes from the Active Mathematics Textbook

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
1	1.a	1/1 (100)	5/5 (100)	1/1 (100)	1/1 (100)	1/1 (100)	9/9 (100)[SA]
1	1.b	2/2 (100)	11/11 100)	0	1/1 (100)	2/2 (100)	16/16 (100)[SA]
2	1.c	2/2 (100)	4/4 (100)	0	1/1 (100)	1/2 (50)	8/9 (89)[SA]
4	1.d	0	0/9 (0)	0/8 (0)	0/3 (0)	0/4 (0)	0/24 (0)[NA]
2	2.a	0	0	0	0	0	0[NA]
2	2.b	0	1/1 (100)	0	0	0	1/1 (100)[SA]
2	2.c	0	0	0	0	0	0[NA]
3	2.d	0	0	0	0	0	0[NA]
2	3.a	1/4 (25)	3/8 (38)	0	2/2 (100)	2/2 (100)	8/16 (50)[SA]
2	3.b	0	0	0	0	0	0[NA]
2	3.c	1/1 (100)	3/4 (75)	2/2 (100)	1/1 (100)	0	7/8 (88)[SA]
3	4.a	0/1 (0)	0	0	0	0	0/1 (0)[NA]
3	4.b	0	0	0	0	0	0[NA]
3	5.a	0/5 (0)	0/3 (0)	1/3 (33)	1/1 (100)	0	2/12 (17)[LA]
3	5.b	0/1 (0)	5/11 (45)	2/2 (100)	1/1 (100)	2/2 (100)	10/17 (59)[SA]

Note. *m/n* means m instructional segments out of n instructional segments in this type that were at or above the depth of knowledge for the learning outcome. The number beside each m/n is the percent. The superscript letters on the total column indicate the degree of alignment: SA= strong alignment; LA= Limited alignment; MA=Moderate alignment; and NA= No alignment.

For the *Active Mathematics* textbook, seven learning outcomes have strong alignment with the instructional segments, one has limited alignment and seven have no alignment.

Table 19 documents the learning outcomes and the instructional segments from the *Primary Selection Examination* textbook.

Table 19

Proportion of instructional segments (%) at or above the cognitive level of the learning outcomes from the Primary Selection Examination Textbook

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
1	1.a		24/24 (100)				24/24 (100)[SA]
1	1.b		11/11 (100)				11/11 (100)[SA]
2	1.c		5/7 (71)				5/7 (71)[SA]
4	1.d		0/25 (0)				0/25 (0)[NA]
2	2.a		0				0[NA]
2	2.b		0				0[NA]
2	2.c		4/7 (57)				4/7 (57)[SA]
3	2.d		0/12 (0)				0/12 (0)[NA]
2	3.a		22/40 (55)				22/40 (55)[SA]
2	3.b		12/16 (75)				12/16 (75)[SA]
2	3.c		4/18 (22)				4/18 (22)[LA]
3	4.a		0				0[NA]
3	4.b		0				0[NA]
3	5.a		0/21 (0)				0/21 (0)[NA]
3	5.b		0/26 (0)				0/26 (0)[NA]

Note. *m/n* means m instructional segments out of n instructional segments in this type that were at or above the depth of knowledge for the learning outcome. The number below each m/n is the percent. The superscript letters on the total column indicate the degree of alignment: SA= strong alignment; LA= Limited alignment; MA=Moderate alignment; and NA= No alignment.

From the *Primary Selection Examination* textbook, six learning outcomes have strong alignment with the instructional segments, one has limited alignment and eight have no alignment.

Table 20 documents the instructional segments alignment with the set of standard 6 textbooks with the learning outcomes. As noted from Figure 20, eight learning outcomes have a strong alignment, one has a moderate alignment, three have a limited alignment, and three have no alignment with the instructional segments of the Standard 6 textbooks.

Table 20

Proportion of instructional segments (%) at or above the cognitive level of the learning outcomes for the set of Standard 6 Textbooks

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
1	1.a	9/9 (100)	43/43 (100)	1/1 (100)	1/1 (100)	3/3 (100)	57/57 (100) **SA**
1	1.b	5/5 (100)	24/24 100)	0	1/1 (100)	3/3 (100)	33/33 (100)**SA**
2	1.c	5/6 (83)	10/15 (66)	0	1/1 (100)	2/3 (66)	18/25 (72) **SA**
4	1.d	0/5	0/39 (0)	0/8 (0)	0/3 (0)	0/6 (0)	0/61 (0) **NA**
2	2.a	0	0	0	0	0	0 **NA**
2	2.b	0	1/1 (100)	0	0	0	1/1 (100) **SA**
2	2.c	0	4/7 (57)	0	0	0	4/7 (57) **SA**
3	2.d	0/3 (0)	0/19 (0)	0	0	1/1 (100)	1/23 (4) **LA**
2	3.a	2/7 (29)	29/57 (51)	0	2/2 (100)	5/5 (100)	38/71 (54) **SA**
2	3.b	0	12/16 (75)	0	0	1/1 (100)	13/17 (76) **SA**

Table 20 (*continued)*

DOK Level	LOs	Pre-lessons (%)	Lessons (%)	End of lesson feature (%)	End of chapter feature (%)	Chapter Review (%)	Total (%)
2	3.c	2/4 (50)	9/25 (36)	2/2 (100)	1/1 (100)	1/1 (100)	15/33 (45) [MA]
3	4.a	0/2 (0)	0	0	0	0	0/2 (0) [NA]
3	4.b	0	2/3 (66)	0	0	2/2 (100)	4/5 (80) [SA]
3	5.a	0/8 (0)	0/25 (0)	1/3 (33)	1/1 (100)	0	2/37 (5) [LA]
3	5.b	0/1 (0)	5/37 (14)	2/2 (100)	1/1 (100)	2/2 (100)	10/43 (23) [LA]

Note. m/n means m instructional segments out of n instructional segments in this type that were at or above the depth of knowledge for the learning outcome. The number beside each m/n is the percent. The superscript letters on the total column indicate the degree of alignment: SA= strong alignment; LA= Limited alignment; MA=Moderate alignment; and NA= No alignment.

Summary of Learning Outcomes and Instructional Segments Alignment

From the data obtained on the alignment of the learning outcomes and the instructional segments from the textbooks, Standard 5 had eight learning outcomes having a strong alignment, six having limited alignment, and one having no alignment. The Standard 6 textbooks had eight learning outcomes having a strong alignment, one having a moderate alignment, three having limited alignment, and three having no alignment. It is to be noted that learning outcomes rated at level 1, learning outcomes 1.a, “identify the consecutive sequence and position of whole numbers up to ten digits and place value”, and 1.b, “identify properties of prime and composite numbers”, had a strong alignment with the instructional segments at both grade levels. Also noted is that learning outcome 1.d, considered as level 4, did not align with any of the instructional segments at both grade levels. Overall, the instructional segments from both grade levels had eight learning outcomes having strong alignment. A noted difference can be observed between the grade levels in terms of the learning outcomes having no alignment.

Instructional Segments and Test Items Alignment

The alignment criteria focused on the number of instructional segments that were at or one level above the cognitive demand of the test items. For the purpose of this analysis, the test items and instructional segments were considered as either aligned or not aligned. For those aligned, the alignment criterion that was used was described as limited, moderate, or strong alignment. Test items that had less than 40% of related instructional segments at the depth-of-knowledge levels were reported as having "limited" alignment. Test items that had 40% - 49%, inclusive, of instructional segments at the depth of knowledge were reported as having "moderate" alignment; test items that had 50% or more of related instructional segments at the depth of knowledge were reported as "strong" alignment.

The test items were grouped by content areas pertinent to the content each test item was designed to assess. The content areas addressed were those outlined in the test table of specification, which specifies nine content domains. However, in the analysis of this study, the content domains of Number Concepts and Number Operations were combined as one content domain labeled as Number Operation and Concepts (NOC) given that in the textbooks there is no clear distinction between the two content domains in terms of their treatment in the chapters and instructional segments. Thus, the sum of the instructional segments pertaining to both content domains was reported under

Number Operations and Concepts and a similar approach was undertaken in grouping the test items by content domain.

It is interesting to note that the 2010 test had 1 test item that addressed the content area of Probability even though the content area is not listed in the table of specification (see Table 8). However, the Standard 5 textbook and one Standard 6 textbook had instructional segments which addressed the area of Probability. On that note, the test item and instructional segments were analyzed to examine the alignment.

Figures 15 – 23 document the test items associated with the eight content domains, including the content area of Probability, assessed in the national assessment and the cognitive level of the instructional segments from each textbook. Each content domain was analyzed individually to examine the extent the cognitive levels of the instructional segments align with the cognitive level of the test items within each content domain.

In Figures 15 - 23, each rectangle represents one test item which was identified by content area. Each shaded rectangle indicates the cognitive level of the test item. For the textbook instructional segments, the set of four textbooks was divided by grade level, Standard 5 and Standard 6, given that one book is used for Standard 5 and three books are used simultaneously for Standard 6. Each shaded rectangle represents the instructional segments that addressed the content domain and the cognitive level of those instructional segments. As noted, Standard 6 has three textbooks (*Let's Pass Math* (LPM), *Active Math* (AM), and *Primary Selection Examination* (PSE).

Figure 15 shows the cognitive levels of the 2009 and 2010 Test Items and instructional segments cognitive demand levels for the content domain of Number Operation and Concepts. The alignment of the Standard 6 textbooks was examined as a set rather than individually considering that the textbooks are used simultaneously in the grade level.

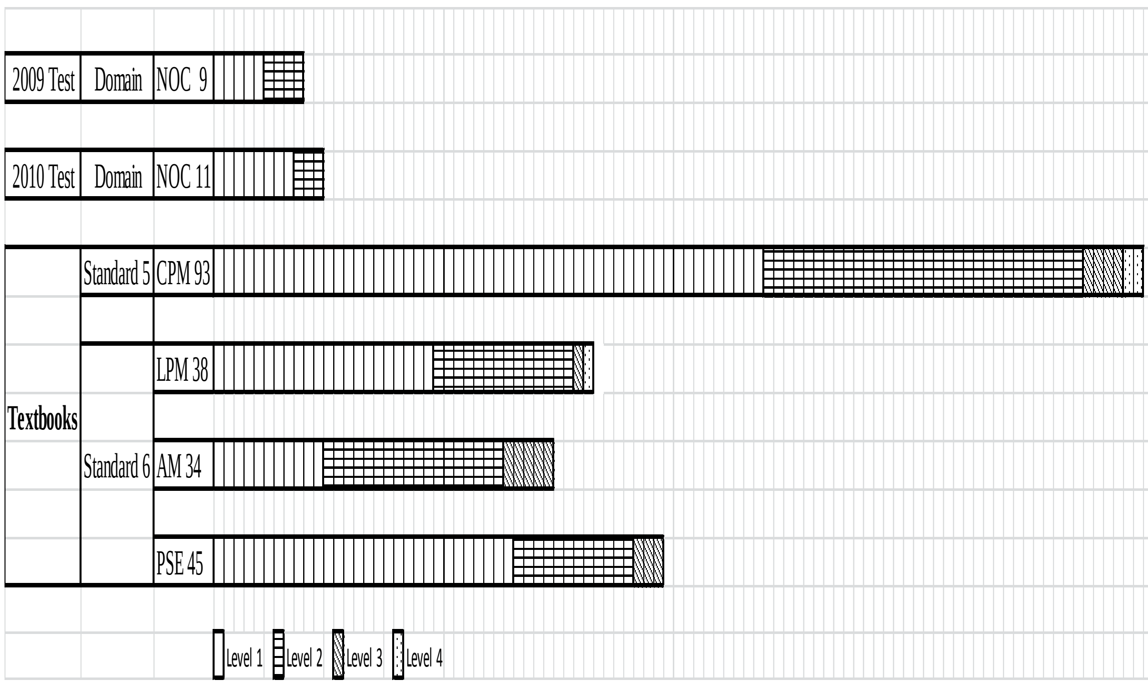


Figure 15. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Number Operation and Concepts

Note. The columns for the textbooks section indicate the grade level, the title of the textbook (e.g., *Caribbean Primary Mathematics* (CPM)), and the total number of instructional segments addressing the content domain.

Figure 15 shows that 87 instructional segments for Number Operations and Concepts from the Standard 5 textbook had a strong alignment with the test items at level one (94% at level 1 or 1 level above) and 36 instructional segments had limited alignment with the items at level 2 (39% at or 1 level above) for both tests. For the three textbooks that were used in Standard 6, 107 (91%) instructional segments aligned with the level 1 test items, thus indicating a strong alignment. With respect to the level 2 test items, 53 (45%) of the instructional segments were aligned, indicating a moderate alignment. As noted, there was a small percentage (8%) of instructional segments at level 3 and 4 for both sets of textbooks.

Figure 16 documents the test items and instructional segments for the content domain of Ratio, Rate, and Proportion (RRP). As noted, the 2009 test had one test item at level 3.

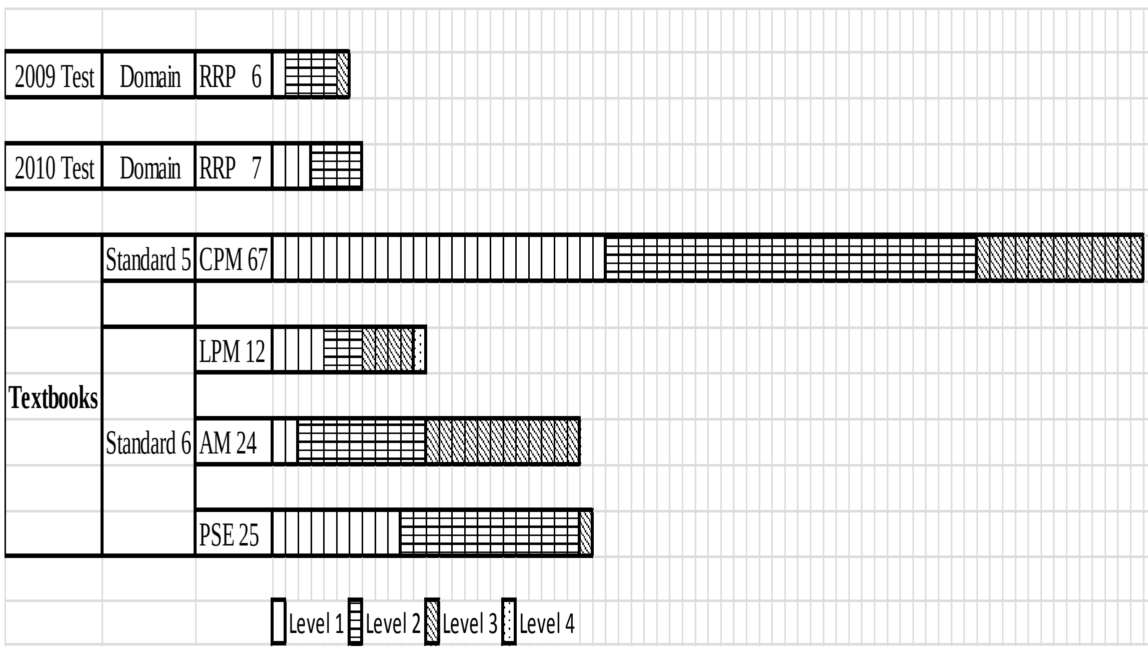


Figure 16. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Rate, Ratio and Proportion

The instructional segments from the Standard 5 textbook had a strong alignment with the test items at level one (82% at level 1or 1 level above) as well as with the items at level 2 (63% at level 2 or 1 level above) for both tests. For the 2009 level 3 test items, 12 (18%) were aligned, indicating a limited alignment. For the three textbooks that were used in Standard 6, 33 (54%) of the instructional segments aligned with the level 1 test items, indicating a strong alignment. With respect to the level 2 test items, 32 (52 %) of the instructional segments were aligned, also indicating a strong alignment. For the 2009 level 3 test items, 17 (28%) were aligned, indicating a limited alignment.

Figure 17 documents the test items and instructional segments for the content domain of Geometry (G). As noted, both sets of test items were at level 1 and the cognitive level of instructional segments ranged from level 1 to level 4.

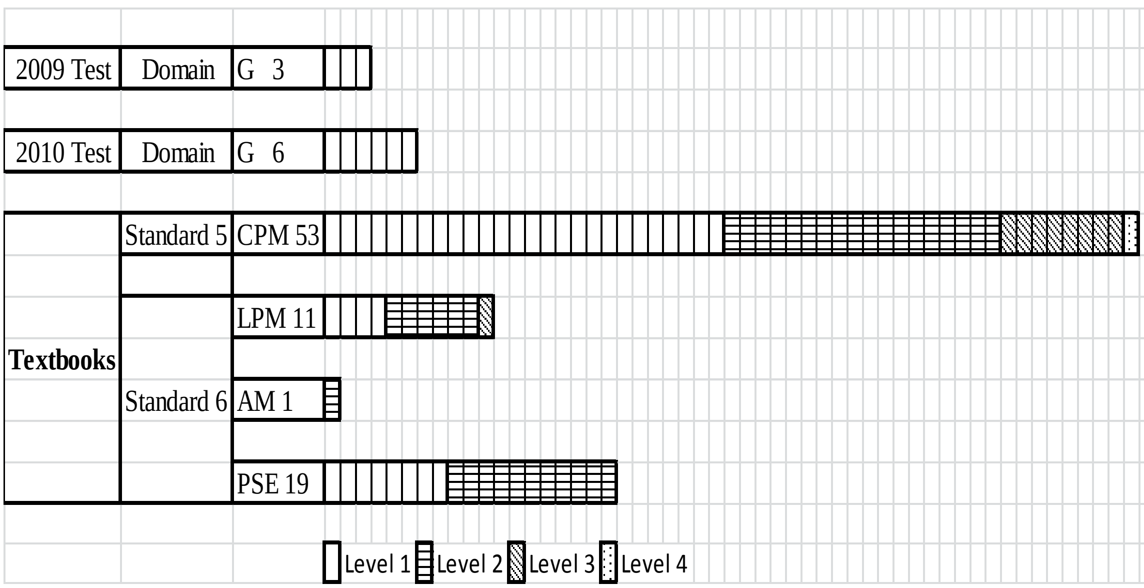


Figure 17. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Geometry

Of the instructional segments from the Standard 5 textbook, 44 (83%) were at level 1 or 1 level above, indicating a strong alignment with the test items for both tests. For the instructional segments from the Standard 6 textbook, 30 (97%) were at or 1 level above the cognitive level of the test items, indicating a strong alignment with both sets of test items.

Figure 18 describes the test items and instructional segments for the content domain of Measurement (M). The Standard *5* textbook had 30 (97%) of its instructional segments at the level or 1 level above the test items at level 1, indicating a strong alignment for both tests. However, there were 11 (35%) of the instructional segments aligned with the level 2 test items, indicating only a limited alignment. With regards to the Standard 6 textbooks, 68 (96%) of the instructional segments align with the level 1 test items and 39 (71%) with the level 2, indicating a strong alignment for both levels.

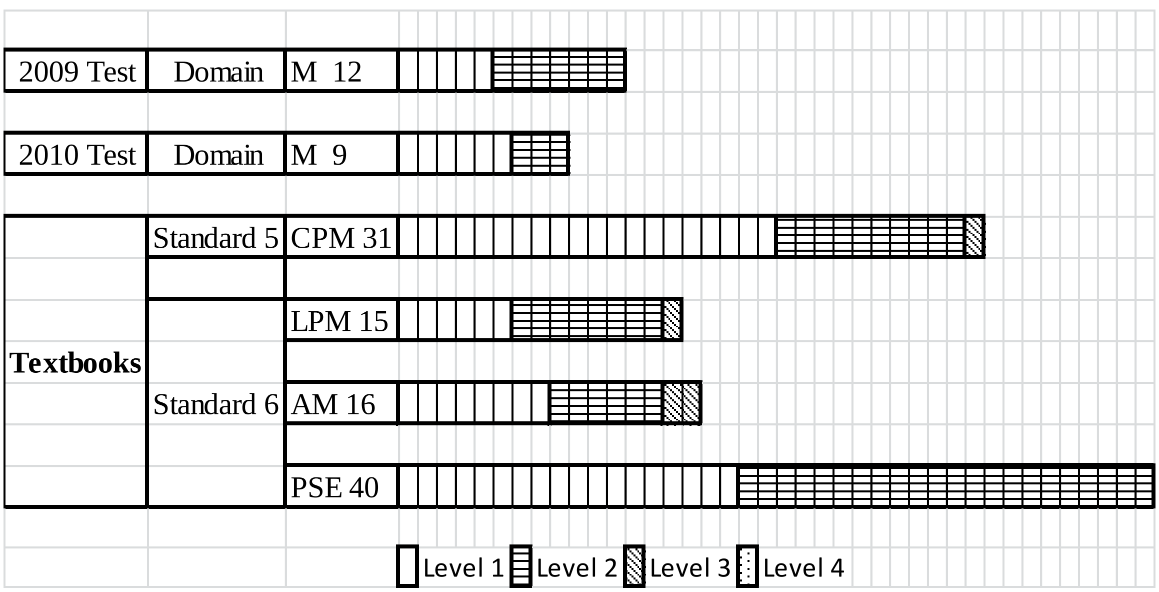


Figure 18. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Measurement

Figure 19 documents the test items and the instructional segments of the content domain of Business Math (BM). As noted, this content domain had a very small number of instructional segments from each of the textbooks, particularly the *Active Mathematics* textbook which had no instructional segment associated with Business Math. The Standard *5* textbook had 6 (75%) instructional segments at or 1 level above the test items at level 1, indicating a strong alignment. There were also 4 (50%) instructional segments at level 2 or 1 level above, indicating a strong alignment with the level 2 test items for both tests. For the Standard 6 textbooks, 17 (100%) of the instructional segments were at or 1 level above the test items at level 1, indicating a strong alignment. For the level 2 instructional segments, 11 (65%) were at the level indicating a strong alignment for both tests.

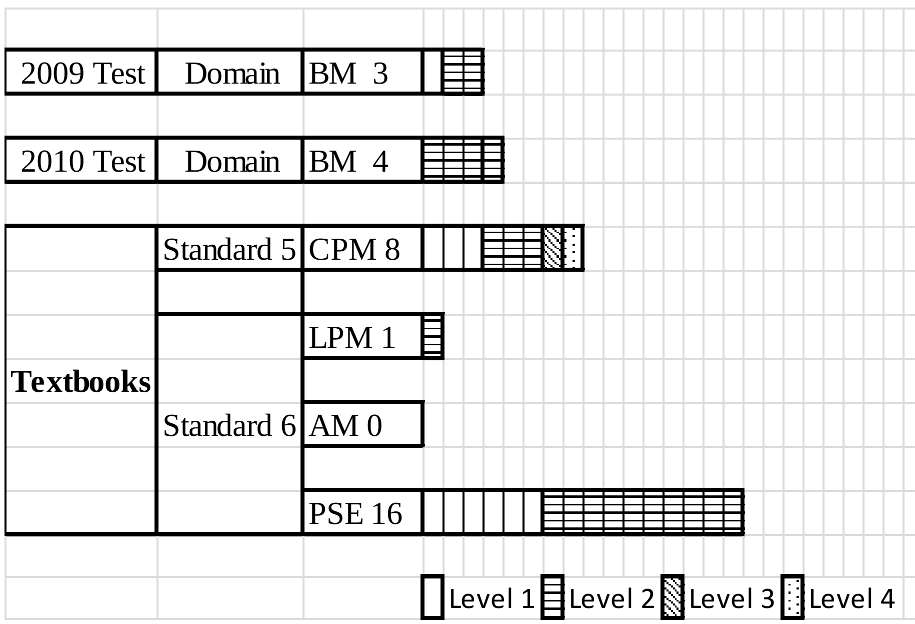


Figure 19. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Area of Business Math

Figure 20 documents the test items and instructional segments associated with the content domain of Algebra (A). The instructional segments from the Standard 5 textbook had a strong alignment 7 (88%) with the 2009 test items at level 2. With regards to the 2010 test items, 4 (50%) of the instructional segments align with the test items at level 1 indicating a strong alignment. The Standard 6 textbooks had 15 (45%) of the instructional segments at level 2 or 1 level above, indicating a moderate alignment with the 2009 level 2 test items. For the 2010 test items, 28 (85%) were at or 1 level above the level 1 test items, indicating a strong alignment.

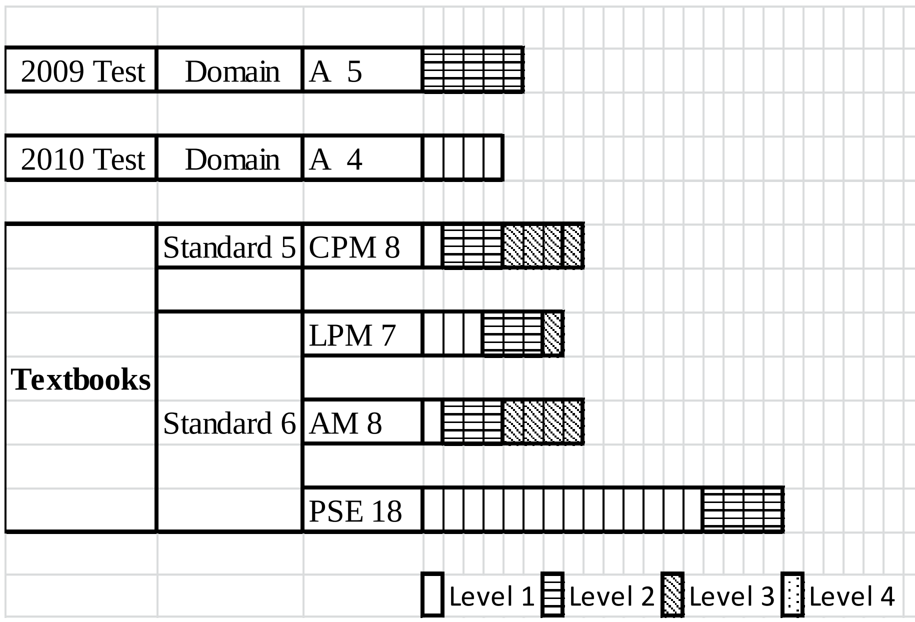


Figure 20. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Algebra

In Figure 21, of the instructional segments associated with the content domain of Graph and Statistics (GS), 35 (85%) of the instructional segments from the Standard 5 textbook had a strong alignment with the level 1 test item. For the level 2 test items, 19 (41%) of the instructional segments were at or 1 level above, which indicates a moderate alignment. For the Standard 6 textbooks, 36 (77%) of the instructional segments were at level 1 or above, suggesting a strong alignment. However, for level 2, only 14 (30%) of the instructional segments were at or 1 level above, indicating a limited alignment.

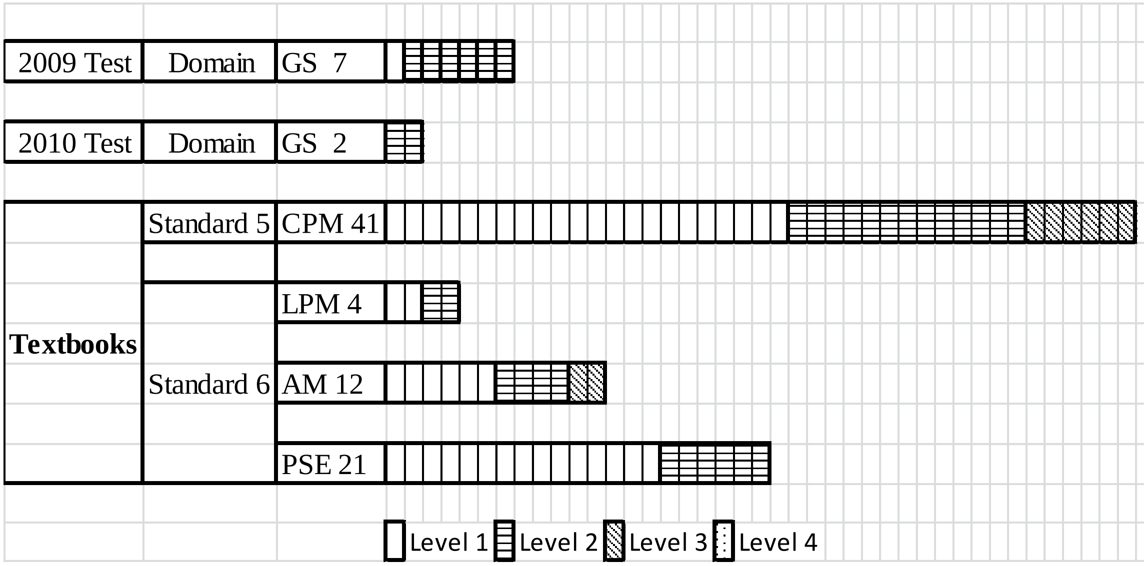


Figure 21. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Graph and Statistics

Figure 22 illustrates the cognitive level of the test items and instructional segments for the content domain of Sets (S). For the level 1 test items, 15 (71%) of the instructional segments from the Standard 5 textbook had a strong alignment for both tests. For the level 2 test items, 14 (67%) of the instructional segments were at or 1 level above, also indicating a strong alignment. For the Standard 6 textbooks, 40 (93%) of the instructional segment were at level 1 or above, suggesting a strong alignment with level 1 test items, 22 (51) were at level 2 or 1 level above also indicating a strong alignment with level 2 test items.

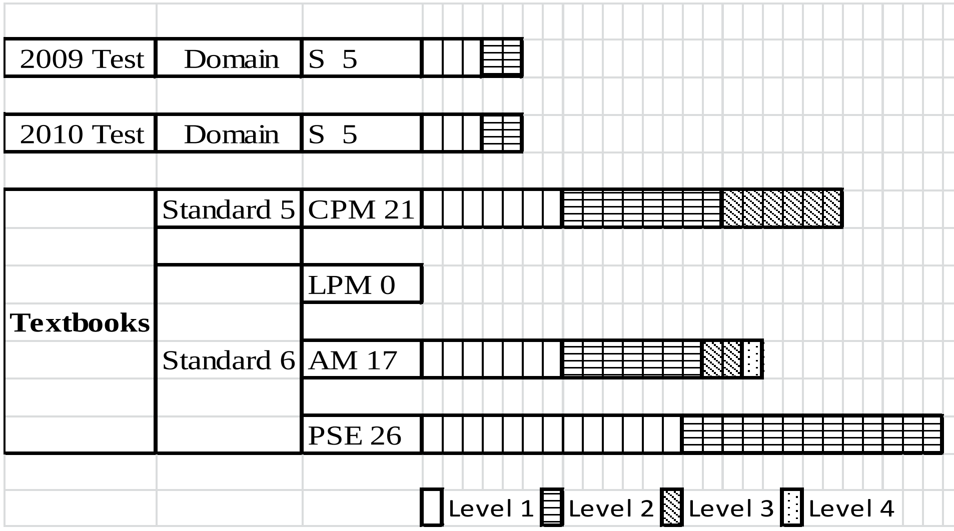


Figure 22. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Sets.

Figure 23 illustrates the cognitive level of the test item and instructional segments for the content domain of Probability (P).

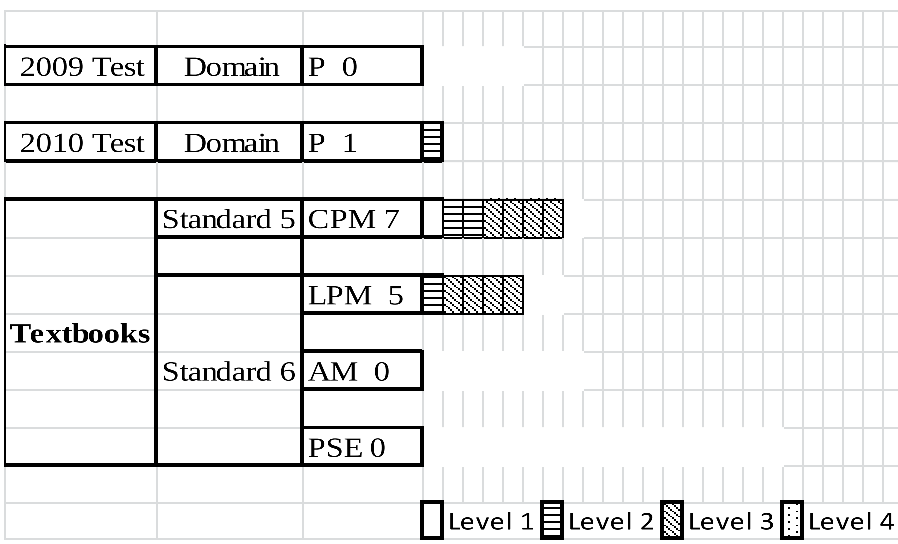


Figure 23. Cognitive Levels of 2009 and 2010 Test Items and Instructional Segments for the Content Domain of Probability.

For the level 2 test items, 6 (86%) of the instructional segments from the Standard 5 textbook had a strong alignment. For the Standard 6 textbooks, 4 (80%) of the instructional segments were at the level of the test item suggesting a strong alignment. As noted, this content domain has only one test item and very limited number of instructional segments from the Standard 5 and Standard 6 textbooks, which could be the reason it was not considered in the 2009 test.

Summary of Test Items and Instructional Segments from Textbooks

The alignment between the 2009 and 2010 test items and the instructional segments from the four mathematics textbooks varied with regards to the number of test items that had a strong, moderate, or limited alignment. Table 21 documents the extent of alignment of the instructional segments for each of the textbooks. As noted in Table 21, the Standard 5 textbook had the least number of test items with strong alignment and the most with limited alignment. Overall, the 2009 test had less test items in the three different levels of alignment compared with the 2010 test for both grade levels.

Table 21

Number of Test Items with Different Levels of Alignment with Textbooks by Grade Levels

Textbook	Aligned					
	Strong		Moderate		Limited	
	2009	2010	2009	2010	2009	2010
Standard 5	32	40	6	2	12	8
Standard 6	34	44	9	4	7	2

Nature of Alignment between Types of Curriculum

An examination of the alignment between the learning outcomes of the Upper Division Mathematics and the national assessment test items, the instructional segments alignment with the learning outcomes, and the instructional segments alignment with the test items with regards to the cognitive level of each construct was undertaken. This section describes the nature of alignment among the types of curriculum.

With respect to the learning outcomes alignment with the test items, the description of alignment focused on whether or not there was alignment. For test items that aligned, the alignment was described as limited, moderate, or strong. In terms of the alignment of learning outcomes and test items, both tests had limited alignment with the learning outcomes. A high percentage (80%) of the learning outcomes were at the cognitive demand of levels 2 and 3 while the test items were at levels 1 and 2 with the exception of one item at level 3 in the 2009 test.

With respect to the cognitive demands of the instructional segments with the learning outcomes, results suggest that at least seven of the learning outcomes had a strong alignment with the textbooks. As noted in the discussion, the *Caribbean Primary Mathematics* textbooks (*Standard* 5) had eight of the learning outcomes with a strong alignment, six with limited alignment, and one with no alignment. The Standard 6 textbooks had eight having strong alignment. These results suggest that the Standard 5 and Standard 6 textbooks addressed the learning outcomes content at a lower cognitive level than the learning outcomes.

The alignment between the 2009 and 2010 test items and the instructional segments from the four mathematics textbooks varied with regards to the number of test items that had a strong, moderate, or limited alignment. Overall, the test items from both tests align with the instructional segments in terms of the cognitive levels, with a large number of instructional segments having a strong alignment with the test items.

Summary of the Results

In this chapter, the results of the examination of the extent of alignment between the learning outcomes and the test items, learning outcomes and instructional segments, the alignment of the test items and the instructional segments, and the extent the textbooks provide students with the opportunities to study the learning outcomes of the Upper Division Mathematics Curriculum were described. Specifically, the alignment of 15 learning outcomes with each of 2009 and 2010 test items was presented, and the alignment of the instructional segments of four textbooks with the test items and the learning outcomes was outlined. In the chapter that follows (Chapter 5), I present the summary of the results, the discussion of the findings, the conclusions and the implications for curriculum development and for future research.

Chapter 5

Summary, Discussions, and Recommendations

This study investigated the extent of alignment among the learning outcomes, test items, and upper division mathematics textbooks in Belize. This study also examined the extent to which upper division textbooks provide students with the opportunity to study the concepts, skills, and processes of the nine content domains students are expected to master at the end of the upper division school years when they are assessed with the Primary Selection Examination. In this chapter, I present a brief overview of the study and discuss the findings in relation to the research questions and related literature. Limitations of this study, implications for curriculum and assessment development, as well as recommendations for future research concerning curriculum alignment are presented.

Summary of the Study

Data from the study on the extent of alignment between the learning outcomes of the Upper Division Mathematics and the national assessment test items, the instructional segments with the learning outcomes, and the instructional segments with the test items with regards to the cognitive level of each construct indicate that the three curriculum types are aligned but differ in degree of alignment and cognitive level. For each curriculum analyzed, the researcher used Webb's depth of knowledge (DOK) levels to assign a cognitive demand level to the items associated with each curriculum type. The researcher noted the cognitive levels to examine the extent of alignment among the three curriculum types (i.e., learning outcomes, test items, instructional segments).

The levels of cognitive demand of the learning outcomes ranged from level 1 to level 4 with the highest number of learning outcomes at level 2 (47%) and the least at level 4 (7%). For the test items, the level of cognitive demand varied across the two forms. The 2009 test items ranged from level 1 to level 3 with 30 (60%) of the test items at level 2. The 2010 test items ranged from level 1 to 2 with 26 (52%) at level 1.

Data from this study also indicate that the upper division mathematics textbooks analyzed fell short to address the content domains outlined in the learning outcomes as well as the test items. The number of instructional segments labeled as pre-lessons, lessons, end-of-lesson feature, end-of-chapter feature, and chapter review varied among the four textbooks in terms of the cognitive demand level of the instructional segments. Overall, the *Caribbean Primary Mathematics* textbook (Standard 5) recorded the highest percentage of instructional segments at level 3, while the *Primary Selection Examination* textbook (Standard 6) had the least percentage of instructional segments at level 3. Overall, when all three Standard 6 textbooks are considered together because they are used simultaneously in the same grade level, 369 (89%) of the instructional segments were at the cognitive demand levels of 1 or 2 and 46 (11%) were at levels 3 or 4.

Results of the Study

Learning Outcomes Alignment with Test Items. Data from this study support several findings with regard to the first research question:

- To what extent are the learning outcomes of the Upper Division Mathematics Curriculum aligned with the national assessment test items?

As discussed earlier, learning outcomes and test items are considered as either aligned or not aligned. For test items aligned at the cognitive level, below the cognitive level, or above the cognitive level of the learning outcome, the alignment criteria were described as limited, moderate, or strong alignment. When less than 40% of test items were at the depth of knowledge levels of the learning outcomes, the learning outcomes were reported as having “limited” alignment. When 40% - 49%, inclusive, of the test items were at the depth of knowledge level of the learning outcome, it had “moderate” alignment. Only when 50% or more of test items were at the depth of knowledge of the learning outcome was the learning outcome reported as having “strong” alignment.

Findings from the study indicate that the learning outcomes and the test items had limited alignment, with 6 (40%) of the 15 learning outcomes addressed by 17 (26%) of the test items with cognitive levels at the same level as the learning outcomes. One learning outcome was not addressed by any of the test items. Overall, 48 (72%) of the test items had some degree of alignment with 14 of the learning outcomes.

There were 11 (48%) test items that were one level below the cognitive level of the learning outcomes at level 1 (one level below level 2 learning outcomes) and 12 (52%) at level 2 (one level below level 3 learning outcomes). For the test items that were one level above the learning outcomes, 7 (86%) of the test items were above level 1, and 1 (14%) above level 2. With regard to the items recorded as having no alignment, 9

(50%) were level 1 test items addressing learning outcomes at level 3 and 4, and 9 (50%) were level 2 items addressing the learning outcome at level 4.

The analysis of alignment also illustrates that the cognitive level of the learning outcomes reflects a higher cognitive demand compared to the national test items. Thus, the cognitive demand levels of the learning outcomes are skewed towards the higher levels whereas the test items are skewed towards the lower levels. Although the highest percentage of the learning outcomes was recorded at level 2 and the test items also had a high percentage at level 2, the test item to learning outcome coverage placed the majority of the test items with learning outcomes that are one level below or one level above the test items, thus contributing to the limited alignment. The learning outcomes with no alignment with the test were at levels 3 or 4, associated with test items at levels 1 or 2 respectively. The highest percentage of test items with no alignment was associated with the learning outcome at level 4. This can be explained by the lack of test items at the higher levels.

Opportunity to Study the Learning Outcomes. The findings in this section address the second research question:

- To what extent do the upper division textbooks in Belize provide students with the opportunities to study the learning outcomes of the Upper Division Mathematics Curriculum?

The opportunity to learn criterion focuses on whether or not the learning outcomes from the Upper Division (Standards 5 and 6) are also addressed in the Upper Division textbook. The findings of the study indicate there were significant differences in the opportunities the four upper division textbooks provide for students to study the learning outcomes of the Mathematics Curriculum. One book, the *Caribbean Primary Mathematics* (CPM) used in Standard 5, addressed the learning outcomes but the distribution of the instructional segments among the learning outcomes varied from three to sixty-seven. The highest percentage of instructional segments (46%) addressed the learning outcome associated with the content domain of Number Operations and Concepts (NOC). Learning outcomes associated with the content domain of Estimate and Make Prediction (EP) recorded the least percentage (7%) of instructional segments.

In comparing the three textbooks used in *Standard* 6, each textbook individually fell short to address four learning outcomes. The distribution of the instructional segments across the 15 learning outcomes ranged from 0 to 24 instructional segments for the *Let's Pass Mathematics* (LPM), 0 to 24 for *Active Mathematics* (AM), and 0 to 40 for the *Primary Selection Examination* (PSE). The highest number of instructional segments for the LPM and the AM textbooks addressed the learning outcomes associated with Number Operation and Concepts. For the PSE, the highest number of instructional segments addressed the learning outcomes associated with the content domain of Spatial Relationships and Shapes (SRS).

With regards to the learning outcomes that were not addressed by any of the instructional segments, three of the four learning outcomes associated with the content domain of Spatial Relationships and Shapes were not addressed by any of the instructional segments from the LPM and AM textbooks. The PSE textbook also did not address two learning outcomes related to this content domain. The two learning outcomes associated with Estimate and Make Predictions received no attention from any of the instructional segments from the PSE textbook. Overall, the three textbooks used simultaneously in Standard 6 fell short to provide opportunities for students to study two of the learning outcomes.

Alignment of Cognitive Demand of Instructional Segments with Learning Outcomes. The findings discussed address the third research question:

- To what extent are the cognitive demands of the instructional segments in the upper division textbooks in Belize aligned with the learning outcomes?

The alignment in this instance focused on whether or not the cognitive demands of the learning outcomes for Upper Division in the mathematics curriculum in Belize are also addressed with the same level of cognitive demand or higher in the four textbooks. The learning outcomes and instructional segments are considered as aligned or not aligned. For those aligned, the alignment criteria that were used were described as limited, moderate, or strong alignment. When less than 40% of related instructional segments were at or above the depth-of-knowledge levels of the learning outcomes, the learning outcomes and instructional segments were reported as having "limited" alignment. When 40% - 49%, inclusive, of related instructional segments were at or above the depth of knowledge level of the learning outcome, the learning outcomes and instructional segments were reported as "moderately" aligned. When 50% or more of related instructional segments were at or above the depth of knowledge of the learning outcome, the learning outcome and the instructional segments were reported as having "strong" alignment.

Findings indicate that the alignment of the instructional segments among the textbooks tended to vary by grade level in terms of the number of learning outcomes with strong alignment, limited alignment, or no alignment. For the Standard 5 textbook (CPM), 8 (53%) of the learning outcomes had a strong alignment with the instructional segments, 6 (40%) had a limited alignment, and 1 (7%) had no alignment.

With respect to the Standard 6 textbooks, the three textbooks, on average, had 7 learning outcomes that were not aligned; each also had limited alignment with one learning outcome. A high percentage of instructional segments aligned with learning outcomes were at levels 1 and 2. For all four books, the learning outcome at level 4 did not align with any of the instructional segments given that the cognitive demand level of the instructional segments were at lower levels. This does not imply that there were no instructional segments at level 4 but rather that those few instructional segments identified at level 4 addressed other learning outcomes in terms of content coverage.

Alignment of Instructional Segments with Test Items. The findings discussed address the fourth research question:

- To what extent are the instructional segments in the upper division textbooks in Belize aligned with the content of the test items of the national examination?

The alignment criteria focused on the number of instructional segments that were at or one level above the cognitive demand of the test items. The test items and instructional segments were considered as either aligned or not aligned. For those aligned, the alignment criterion that was used was described as limited, moderate, or strong alignment. Test items that had less than 40% of related instructional segments at the depth-of-knowledge levels were reported as having “limited” alignment. Test items that had 40% - 49%, inclusive, of instructional segments at the depth of knowledge were reported as having “moderate” alignment; test items that had 50% or more of related instructional segments at the depth of knowledge were reported as “strong” alignment.

Findings from the study indicate that the instructional segments from the Standard 5 textbook had a strong alignment with all level 1 items assessed in the national assessment. For the level 2 test items, those items that addressed Rate/Ratio/Proportion, Business Math, Algebra, and Sets also had a strong alignment. Items that addressed the content area of Graph and Statistics had moderate alignment and items that addressed Number Operation and Concepts and Measurement had limited alignment. Test items at level 3 had limited alignment with the instructional segments that addressed the content area of Rate/Ratio/Proportion.

A similar pattern seemed to occur with the Standard 6 textbooks. Instructional segments had a strong alignment with all level 1 items. For the level 2 test items, those items that addressed Rate/Ratio/Proportion, Business Math, and Measurement also had a strong alignment. Items that addressed the content area of Number Operations and Concepts and Algebra had moderate alignment and items that addressed Graph and Statistics had limited alignment. Test items at level 3 had limited alignment with the instructional segments that addressed the content area of Rate/Ratio/Proportion. Overall, there was a high percentage (68%) of strong alignment between the test items and instructional segments at levels 1 and 2, and a low percentage (6%) of limited alignment at level 3.

Nature of Alignment among the Three Types of Curriculum. The findings discussed address the fifth research question:

- What is the nature of alignment of upper division learning outcomes, written curriculum [textbooks], and test items from the national examination in Belize?

Findings from the study indicate that the relationship among the three types of curriculum varied in the degree of alignment. A strong relationship was noted between the test items of the national assessment and the instructional segments of the textbooks. With respect to the instructional segments from the textbooks and the learning outcomes, only the Standard 5 textbook had strong alignment while the Standard 6 textbooks exhibited lower cognitive levels than the learning outcomes. A similar case was observed between the cognitive levels of the learning outcomes and the test items. The learning outcomes were at a higher level than the test items, resulting in limited alignment.

Discussion

This study documents alignment among three types of curriculum, intended (learning outcomes), the written (textbooks), and the assessed (tests) with respect to the cognitive demand levels within each curriculum. In addition to the alignment, opportunity to study the content assessed in the national test was also documented. Alignment was measured by comparing the cognitive demand levels between curriculum types, thus establishing a relationship according to the degree of alignment. Degrees of alignment were established because “perfect” alignment, namely the cognitive demand of all the learning outcomes are at the same level of the test items and the instructional segments from the textbook, is highly improbable or unlikely. Instead, the data indicate that the proportion of cognitive demand levels within curriculum and between curricula differ markedly. Marked difference was noted between the two test forms and among the four textbooks.

The various operational definitions employed for viewing the alignment among the curriculum types (e.g., extent of alignment between the learning outcomes and test items, test items and instructional segments, and learning outcomes and instructional segments) provided a multi-faceted analysis related to alignment. Such an approach was undertaken given the nature of the constructs analyzed. For example, in the alignment of the cognitive levels of the learning outcomes and the test items, the criterion for alignment considered those test items that are at the cognitive demand level of the learning outcome. This criterion is consistent with Furhman (2001) who stated that students are supposed to attain the standards; to evaluate whether students have attained those standards, assessments (test items) should be aligned with the learning outcomes.

However, it is a challenging task to determine the cognitive level of a test item. As noted by Doyle (1988), academic tasks, in the context of test items, exist at several different levels at once. Thus, further analysis of the learning outcomes and the test items considered the fact that it is reasonable to have test items 1 level below or 1 level above the learning outcome the test items are associated with. This consideration required an operational criterion of alignment that accommodated degrees of alignment, particularly given that not all test items were at the expected level of cognitive demand. So, the degree of alignment ranged from limited to moderate to strong.

As stated earlier, results of this study indicate that the extent of alignment varied among the three curriculum types. A marked difference in cognitive demand levels was found between learning outcomes and the test items of the national assessment. The test items corresponded to the levels of Recall, Skill and Concepts; the learning outcomes as stated in the mandated curriculum (BNMCC, 2000) and the instructional segments in the upper division textbooks corresponded to the levels Recall, Skill/Concepts, and Strategic Thinking, and a very small percentage at the level of Extended Thinking. Consequently, the mandated curriculum, BNMCC 2000, exhibits a higher cognitive demand as compared to the national test.

Such a difference in cognitive demand levels seems to be the main contributing factor for the lack of strong alignment. Anderson (2002) defined curricular alignment as a strong link between learning outcomes and assessment, between learning outcomes and textbooks, and between assessments and textbooks. Although it is not clear what measure of alignment is being addressed by Anderson, whether content alignment or cognitive demand alignment, the criterion of strong alignment is fundamental for content validity, content coverage, and opportunity to learn that are embedded in the term curricular alignment.

The marked difference in higher cognitive demand levels of the learning outcomes than the test items sets forth two issues to consider. First, there is a clear need to include more test items at least at level 3 so as to address the cognitive demand level of the five learning outcomes that are at that level. However, in doing so, the results of the test may reflect a lower performance than at present. Regardless of the negative effects which may be associated with the low performance, the need to align the test to the intended curriculum is paramount, especially if the results are used to determine students' access to higher education.

Another issue relates to the direction of the relationship that exists between the learning outcomes and the test items. Data indicate that the learning outcomes, which guide the development of the tests, are aimed towards high expectations for students in terms of the cognitive demand levels. For instance, the five learning outcomes at level 3 (Strategic Thinking), addressed by only one test item across the two tests, call for students to engage in complex tasks and reasoning. The situation that the cognitive demand levels of the test items are at lower levels makes inclusion of items at higher levels essential, thus potentially aligning future test items with the learning outcomes. A different situation would have occurred if the relationship had been the reverse where the cognitive demand levels of the test items were higher than the learning outcomes. There is potential in the development of the test items to strengthen the alignment, not just on content coverage but also on the cognitive demand levels.

I should note at this point that the analysis of alignment does not rate the quality of the test items. The alignment criteria do not describe an attribute of the assessment, instructional segments or learning outcomes, but rather the relationship in terms of the cognitive demand levels. In fact, these results indicate that there is a relationship between the learning outcomes and the assessment, but the strength of the relationship is not as strong as suggested by the framework.

Porter and Smithson (2001) suggest that analyzing the intended curriculum [learning outcomes] with relevant policy documents [official textbooks] is an important step to ensure opportunities to learn. Opportunity to learn considers whether the instructional segments from the mathematics textbooks address the learning outcomes. The analysis revealed that quite a number of learning outcomes were not addressed by the instructional segments from the textbooks. Some of the learning outcomes received a high percentage of attention across the four textbooks while others received limited attention. Given the importance of textbooks as a bridge between the official declaration of content standards and the actual tasks students engage (Schmidt, McKnight, & Raizen, 1997), the shortcomings of three of the textbooks, those used in Standard 6, in addressing a number of the learning outcomes suggest that students do not have the opportunity to study the content assessed in the national test.

However, an argument can be made that the design of the curriculum, modeled as a spiral curriculum, would provide access for students to study the learning outcomes from the Standard 5 textbook. The argument would seem valid, yet the premise of the spiral curriculum advocates that material revisited in the next higher grade level be more challenging and at a higher complexity appropriate for the grade level. Moreover, breadth of coverage is yet another factor to consider. For instance, in this study, learning outcome 2.c “how shapes fit together to form patterns” was covered in the *Caribbean Primary Mathematics* Textbook (Standard 5) by three instructional lessons. Two of the

Standard 6 books did not cover the learning outcome and one had seven instructional segments that addressed learning this learning outcome. Seemingly, the learning outcome is addressed by instructional lessons across the grade levels, yet the complexity level needs to be considered to determine if the lessons provide support to enhance learning.

It was interesting to note that across the four textbooks, the highest percentage of instructional segments addressed the first four learning outcomes associated with the content domain of Number Operations and Concepts. Two books had limited instructional segments related to learning outcomes associated with Spatial Relationships and Shapes; Estimate and Make Prediction; Measure, Calculate and Quantify. The limited coverage of content by the textbooks found in this study resonates with Haggarty and Pepin's (2002) conclusion that students have varying opportunities to learn depending on the textbook they use.

The lack of content coverage, which limits students' opportunity to study the learning outcomes, also affects alignment in terms of the cognitive demand level of the instructional segments at the level of the learning outcomes. Although the cognitive demand levels of the learning outcomes seem parallel to those of the instructional segments, strong alignment was evident only at cognitive demand levels 1 and 2. The Standard 6 textbooks had no alignment with 3 learning outcomes. This statement may seem contrary to what Tables 12 – 15 and the narrative suggest. In the tables, alignment was examined by individual textbooks; however, the three textbooks are used as a set, so it is important to consider alignment as a package, and there is no alignment with 3 learning outcomes.

It is interesting to note that learning outcome 1.d “apply the concept of rational numbers and irrational numbers to real life situations”, had no alignment in the Standard 6 textbooks, even when considered as a set. The proportion of instructional segments that addressed this learning outcome accounted for 104 (25%) of the total instructional segments from the three books. This can be explained by the mismatch in the cognitive demand levels that was recorded between the particular learning outcome and those of the instructional segments. Seemingly, a pattern is evident once more in that the learning outcomes have higher cognitive demand levels than the instructional segments.

The decrease in the number of learning outcomes that had no alignment with the instructional segments when the three Standard 6 textbooks are considered as a set from 7 or 8 to 3 learning outcomes may suggest an increase in the strength of the relationship. However, the distribution of the cognitive demand levels across the 3 textbooks indicates that at most 7 of the learning outcomes had a strong alignment, 3 had no alignment and 6 had limited alignment. This phenomenon of cognitive demand level mismatch whereby one curriculum has a higher cognitive level than the other seems to transcend across all the alignment analyses discussed so far.

With respect to the extent of alignment of the instructional segments, there was not a marked difference in the cognitive demand levels between the instructional segments and the test items. The textbooks had a relatively small percentage of instructional segments at levels 3 and 4 which did not seem to impact the results significantly. Such a situation was also evident where some of the textbooks, in the case of *Let's Pass Math*, had no instructional segments that addressed the content domain of Sets. Overall, the instructional segments had a strong alignment with the test items at level 1 and 2. In general the cognitive demand levels of the instructional segments were highly concentrated at level 2.

In conclusion, the results of this study concur with the findings in Alcazar's (2007) study with respect to the differences in the cognitive demand levels among the curriculum types. However, the findings in my study seem to differ slightly because of the direction of the relationship among the curriculum. In the Alcazar study, the learning outcomes, which guide the test development, were reported at the Comprehension and Application of Algorithm level and the academic tasks [tests] were reported in the categories of Problem Solving and Comprehension, indicating a misalignment of the cognitive demand levels as well as the direction of the relationship. In my study, the cognitive demand level of the learning outcomes set high expectations which fell short of a strong alignment as a result of the high proportions of low cognitive demand levels of the other curricula in the study.

Significance of the Study

It is expected that the findings from this study will inform curriculum developers in Belize, as well as in other countries, in their future efforts to address students' low performance in mathematics, as well as in other subject areas. The findings of this study suggest that the strength of the relationship among the three curriculum types fell short of strong alignment, which is fundamental for curricular alignment. As noted in the results, the fact that the alignment is not strong holds considerable implications for the other forms of curricula (e.g., the intended, the written curriculum, and the assessed) as well as personnel involved in the development of each piece of the curricular link as depicted in Figure 2 (p. 29).

One component in the curricular link that needs special attention is the textbooks which play a significant role in providing support for students to achieve the learning outcomes and in turn the opportunity to do well in the national assessment. As Reys (2004) suggests, textbooks have been identified as potential agents of change to transform curriculum, but such potential depends upon the extent to which the textbooks align to relevant syllabus documents and educational agendas. The textbook shows a relative alignment in terms of content coverage but seems to lack the alignment in the cognitive demand levels. Consequently, curriculum developers might consider adopting textbooks that address both content coverage and higher cognitive demand levels in future textbook adoption schemes for the upper division to increase students' opportunities to engage in higher level thinking that would be helpful throughout their livelihood.

The results also indicate that state policy-makers need to provide clear and consistent messages regarding important mathematics topics that students need to learn. This is not underestimating the quality of the learning outcomes but rather suggesting that the curriculum developers clearly identify what students should know or be able to do. Specific indicators within the learning outcomes on what mathematical content and skills students will be assessed on the national examination and matching the cognitive level of the learning outcomes would increase the likelihood that the learning outcomes are included in textbooks.

This study did not directly investigate textbook adoption but only examined textbooks through the lens of alignment. Nevertheless, textbook adoption committees need to consider that although a textbook series may have a high degree of alignment with the learning outcomes, the textbook may also contain a large amount of material that is not addressed in the learning outcomes. As such, alignment should not be used as a sole factor to accept or reject a textbook. There should be a comprehensive set of adoption criteria, such as the philosophy of the textbook, content coverage of the learning outcomes (e.g., several instructional lessons devoted to a topic versus a single lesson), and research informing the appropriateness of the textbook on student learning.

It is expected that the methodology used in this study will provide some guidelines for future researchers who may use content analysis to examine the alignment of curricula, particularly in the context of opportunity to learn. The use of Webb's Depth of Knowledge criteria to examine the alignment among the three types of curricula provided a consistent measure. The methodology used in this study contributes to the knowledge base on the use of content analysis in mathematics education which can serve as a model for future researchers.

Finally, the analysis of alignment among the three curriculum types provided a more complete picture of the strength of relationships and pinpointed areas that need to be addressed to increase alignment. This might promote access to the learning outcomes, providing support and opportunities for students to study what is in the national exam.

Limitations of the Study

One of the limitations of this study is related to the absence of documentation relevant to the process of development of the national examination. Information on the validity, reliability, cut score and scoring of the test items was not obtained despite numerous attempts. As mentioned earlier, the alignment analysis does not look at the quality of the test items but rather the strength of the relationship between curricula.

Another limitation is the context (Upper Division in Belize), documents used in the study, and the criterion for the alignment analysis. As a result, the findings may not be generalizable beyond the context or documents that were examined. The criterion for the alignment among the three types of curricula varied given that each curriculum presented a different situation.

A third limitation of this study is in the documentation used to describe the alignment among the three curriculum types. The description of alignment used in this study included variations among curriculum types, and did not attend to the extent of the coverage of the learning outcomes or test items by the instructional segments. Regardless if only one instructional segment addressed the learning outcome at the cognitive level or multiple instructional segments aligned to that learning outcome, these cases were considered the same with respect to the documentation of alignment in this study.

Finally, threats to reliability and validity in the coding process used to establish an acceptable level of reliability may have occurred. Coder fatigue may have occurred given the quantity of instructional segments that were coded. Although the coding exercise took into consideration short breaks, reliability was secured by the use of inter-coder agreement.

Recommendations for Future Research

The growing attention that state standards or learning outcomes, as referred in Belize, have received in articulating what mathematics is taught and assessed deserves continued research at all levels in the education system. Alignment studies should examine instructional subject content in mathematics, state standards, and assessments to identify discrepancies between curriculum being taught and the content in standards and assessments used by a state. The curriculum and instructional analysis can be linked to student achievement to help teachers identify explanations for low performance based on the curriculum. The analysis could also help educators identify areas of the standards that are not being taught, or taught with only limited time or emphasis, or for expectations for learning expressed in standards or assessments are not included in the curriculum.

Alignment studies should also examine alignment between instruction and assessments, commonly referred to in the literature as instructional alignment. In conjunction with the latter, research can also be conducted to examine teachers' use of learning outcomes and mathematics textbooks to enact the curriculum. It is evident that countries use the learning outcomes and results from the assessments to formulate policies, yet very little is documented about how teachers use the learning outcomes to guide the enactment of the curriculum or decision making.

The alignment of curriculum can also be examined from a narrow scope focusing on mathematical strands which have been historically undermined in the enactment of the curriculum, such as probability or those topics that present a high degree of difficulty for students such as algebra. Specific to the assessed curriculum, future research should also focus on the test items. Each response of a test item measure a concept or concepts students are expected to master. In addition, items on a test, as well as the entire test as a whole unit, are evaluated based on the student responses to the items. In the conduct of an item analysis, it is possible to determine which learning outcomes have been met and which ones need to be revisited using a different instructional approach. Nevertheless, to conduct such studies, the support and provision of test development materials and procedures need to be available to the researcher.

Conclusion

Although the standards-based reform curriculum is relatively young, the influence of standards [learning outcomes] in the educational system is evident and has a strong effect on policy and practice. Teachers are giving more attention to topics stressed in the learning outcomes. However, a high degree of variation has been documented with regards to the consistency or alignment of standards with other curricula. Offering clear and focused messages through aligned instructional materials and assessment systems will provide the necessary support and provide students with the opportunities to study the mathematics content assessed in the national tests.

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Appendix A

Pilot Study

This pilot study was designed to determine the extent of alignment between the national assessment and the learning outcomes. The theoretical consideration for conducting this pilot study was that alignment of standards and assessment is necessary for opportunity to learn. What follows is the literature review, conceptual framework, coding instrumentation, data collection and results from the pilot study.

Alignment of the Belize National Mathematics Assessment and the Comprehensive National Curriculum Mathematics Learning Outcomes

Introduction

A key element in understanding the impact of the national curriculum on student achievement in Belize is to examine the alignment between the curricular content to which students are exposed and the content on which they are assessed. Alignment in the context of assessment is usually taken to mean the degree to which a test (or test item) assesses the same learning goals as a given standard or set of standards (Wilson & Kenney, 2003). Thus, alignment describes the match between content expectations and assessment that can be improved by making changes either to student expectations or assessments. As more and more emphasis is placed on improving students' achievement in mathematics, alignment between assessments and expectations becomes not only critical, but also essential (Webb, 1997**).** Therefore, alignment is essential for various reasons and central to all elements of the educational system. When assessment and content standards are aligned, teacher's instruction can be directed towards the content standards, school resources are allocated to ensure the content standards have a high probability of being achieved, and more importantly the assessments are developed so their content is congruent with the standards. With all the attention on enhancing students' learning, there is a need to ensure that all content standards in mathematics are being assessed. For instance, if there are fifteen content standards, as is the case of Belize's Mathematics curriculum for the upper division at the primary level, there needs to be assessment information available for all fifteen standards so that progress towards each standard can be monitored. Literature on alignment of assessment and standards suggests that if test items are poorly aligned with standards, the high-stakes decisions made on the basis of the results of the tests may not be based on valid information (Rothman, Slattery, Vranek, & Resnick, 2002).

Need for Alignment

Alignment between content standards and assessment can strengthen an educational system in important ways: give credence to both documents; provide a consistent message and credibility, and add to the value teachers give to these documents. Moreover, as teachers understand the link between the standards and assessment, teachers are more likely to find ways to translate what is being required by these documents in their classrooms. In essence, aligning content standards with the assessment system is an important process for mapping students' learning progress and verifying students' knowledge of important mathematical ideas. Thus, a careful analysis of alignment between assessment and content standards serves as an indication that students are assessed on what is expressed as important mathematical knowledge in the content standards and assessment tools.

In light of the latter, this pilot study aimed at an analysis of the Primary Selection Examination (PSE) test and the learning outcomes (LOs) of the Belize Comprehensive National Mathematics Curriculum. Numerous studies have conducted analysis of one test with a set of standards; however, the analysis I will conduct consists of six (6) Primary Selection Examination tests from 2004 to 2009 and the set of learning outcomes in the upper division (grades 7 and 8). Specifically, the focus of the analysis will consider the alignment of a set of 6 tests with nine (9) broad areas of study and fifteen (15) learning outcomes. In the process of the analysis, this study also attempted to answer the following questions: (1) to what extent are the cognitive demands of the national assessment aligned with the cognitive demands of the learning outcomes?, and (2) to what extent is the Belize National Assessments (PSE) assessing the National Comprehensive Mathematics learning outcomes?

Background on Belize's Curriculum Framework

The country of Belize has a Comprehensive National Curriculum established in 2000. The Comprehensive National Curriculum is articulated in four documents: Philosophy, goals and policies; the national curriculum; the national syllabus; and the school curriculum which provides the division schemes and units of work. Document two (The National Curriculum) contains *Specifications* for the primary level education system; grades K-8 with age range 5-14. The *Specifications* are logical derivations of the

National Goals of Education into the knowledge, skills and attitudes that each learner should develop as a result of their education experience at the primary level. Document three (National Syllabus) translates The National Curriculum into learning outcomes for mathematics and are derived from the *Specifications.* These learning outcomes (LOs) then serve as learning-teaching targets to aim for and guide learning and teaching for the particular division. In Belize's Primary Education System, students go through three divisions: lower (infant I, II, and Standard I); middle (Standard II, III, and IV); upper (Standard V and VI). Of interest in this study is the upper division which equates to U.S. grades 7 and 8. The learning outcomes also provide general strategies for learning and teaching mathematics.

Document four (The School Curriculum) translates the National Syllabus into school level plans for learning and teaching of mathematics. As the name 'School Curriculum' suggests, these documents refer to each school's individual interpretation of the Philosophy, Goals and Policies, the National Curriculum, and the National Syllabus for the primary level of education. In essence the documents are summarized into what are commonly called Division Schemes and Units of Work and are typically organized by area of study (e.g., number, data handling, measurement, geometry). The Upper Division Schemes and Units of Work are intended to give coherence to the curriculum at the school level while taking into account the Philosophy, Goals and Policies at the national level and the local context of the school. Simultaneously, within the context of the school as an educational institution, they serve to guide teacher planning, learning and teaching at the classroom level.

The Comprehensive National Curriculum is based on the spiral approach whereby topics are revisited at the next grade level. In this approach the depth of coverage of the content is at the expense of breath and integration which is left in the hands of the teacher. Table C1 shows the fifteen mathematics learning outcomes (LOs) for the upper division (grades 7 and 8), content domain, area of study (themes), and the expected duration to be covered (in weeks) from which students leaving primary school are assessed. Use of the spiral curriculum is evidenced in the learning outcomes for the upper division where in grade 8 two additional learning outcomes are addressed and four additional ones are revisited and given more emphasis (number systems, graph and statistics, business math, rate/ratio/proportion). Thus, it is expected that teachers will cover the material from grade 7 with additional emphasis on some content areas as the principle of integration is applied, other content areas are reinforced.

Table C1.

Learning Outcomes, Content Domain, Themes, and Duration

LO #	Learning Outcomes (LOs)	Content Domain	Grade Level	Area of Study	Duration for coverage (Weeks)
1	Express equivalent base of other number systems	Number Operations	8	N	3
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	Graph & Statistics	7 , 8	EP	2,4
3	Collect, analyze and interpret data and predict probable outcomes	Graph & Statistics	7 , 8	DH	2,4
4	Use and convert money based on its relative value and its use in financial transaction.	Business Math Rate/Ratio /Proportion	7 , 8	MQC	2,4

Table C1 (*continued*)

LO #	Learning Outcomes (LOs)	Content Domain	Grade Level	Area of Study	Duration for coverage (Weeks)
5	Apply the concept of rational and irrational numbers to real life situations.	Rate/Ratio/ Proportion Number Operation	8	N	3
6	Plot the position and movement of two-dimensional shapes.	Geometry	7	SRS	2
7	Fit shapes together to form patterns	Geometry	7	SRS	2
8	Apply the concept of "Sets" to the practical situation.	Sets	7	DH	3
9	Identify properties of Prime and Composite numbers.	Number Concepts Number Operations	7	N	3
10	Perform operations in numbers up to ten digits and place value.	Number Concepts	7	N	3
11	Apply algebraic expressions to solve problems.	Algebra	7	MQC	3
12	Measure, estimate and compute distance, weight, time, capacity and temperature and apply to practical situations.	Measurement	7	MQC	3
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	Measurement	7	EP	3
14	Infer the relationship between angles in different two dimensional shapes.	Geometry Measurement	7	SRS	2
15	Draw and construct three dimensional objects	Geometry Measurement	7	SRS	2

Note. N = Number; SRS = Spatial Relationships & Shape; MQC = Measure, Quantity & Calculate; EP = Estimate and make Predictions; DH = Data Handling

From Table C1, there is an indication that most learning outcomes at grade 7 have a recommended time of three weeks with the rest having two weeks to cover the content. With regards to grade 8, the three additional outcomes that are revisited have four weeks, and the two outcomes that are added have three weeks each. On that note, given the weighted time to the learning outcomes, the proportion of items for each learning outcome should be equally distributed.

Assessment of the Belize National Comprehensive Mathematics Curriculum

Despite the provision of the Comprehensive National Curriculum at the primary level of education in mathematics in 2000, schools determined their set of textbooks and curriculum materials to help students meet those learning outcomes. In 2007, schools were provided with a set of textbooks; however, many schools used supplemental curricular materials for the teaching and learning of mathematics. The mathematics learning outcomes are assessed through a National Examination which is administered on an annual basis to all students completing primary education: The Primary School Examination (PSE). The PSE is a criterion-referenced measure comprised of multiple-choice and free response items. This study will only consider the multiple choice items for the analysis. The PSE is administered under standardized conditions and candidates are required to move to examination centers for security purposes. Secondary schools use the results of the PSE to determine selection and placement of their first year intake, as well as for system monitoring purposes.

Scoring and Reporting of the National Examination Results

Scores are interpreted according to the following grade bands indicating different levels of achievement/performance. Reports are made to the various stakeholders including the following: (1) Ministry of Education policy makers with information on trends in performance, adequacy of current performance measured against clearly established standards; (2) all managements, school principals and teachers to assist management to identify schools requiring assistance or additional resources; and (3) parents and students with information about the student's individual performance measured against clearly defined criteria for success. In addition, guidelines for the interpretation of the reports are provided.

Letter Grade	**Description**	**(Grade Range/Band)**
A	Excellent	(80-100%)
B	Competent	(70-79%)
C	Satisfactory	(60-69%)
D	Adequate	(50-59%)
E	Inadequate	(49% and below)

Performance on the PSE

An average of 6,500 candidates sit the National Mathematics Examination every year. The national mean percent correct for mathematics remained more or less constant over the six years as shown in Figure 1with spikes in 2004 and 2008. Overall performance on the PSE from 2004 to 2009 indicates that students are below the satisfactory level (60-69), remaining at the adequate and inadequate level of scores between 59% and below.

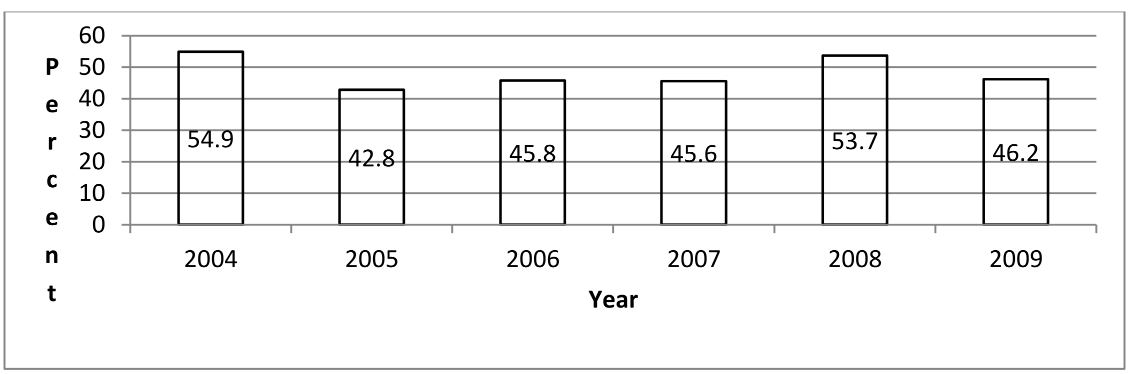

Figure C1. Mean Performance on the PSE 2004-2009

Note. Belize Ministry of Education 2009 Press Release of PSE Results

From Figure C1, there is a clear indication that mathematics continues to be an area of significant challenge for the children, teachers, schools and educational system in Belize. Notwithstanding the apparent spikes in mathematics, the mean performance in mathematics over the last ten years indicates that the majority of the students are not achieving well in mathematics; most students continue to perform in the inadequate range (a score between 0 - 49).

Methods for Alignment

In the context of school accountability and policy decision making, the efforts to make deep changes in instruction cannot be done simply by mandating new accountability measures and practices. The concept of alignment, where the assessment tools must be selected or developed so that their content is congruent with the learning outcomes, is paramount. With all the attention on improving and reporting student achievement, the need for a comprehensive analysis of two important curricular elements is vital: (1) expectations of what students should know about mathematics and what they should be able to do with that knowledge; and (2) assessments that accurately gauge student achievement and indicate whether expectations are being achieved.

Current practices and review of literature suggest at least two major approaches to ensure alignment. The first approach involves the sequential development of assessment tools where learning outcomes and assessments are aligned in the test construction process and established in the test blueprint. One disadvantage of this approach is that it frequently does not reflect reality. In many countries, the process for developing expectations and assessments is not linear or sequential, but more dynamic and recursive.

The second approach is through the analysis of documents that convey the content standards and assessments. In this approach, a systematic coding system must be developed that specifies the dimensions and processes to be made in describing each document.

Methods for determining the degree of alignment between assessments and states' content standards have become a priority. Systematic procedures for assessing alignment have been well developed (Bhola, Impara, & Buckendahl, 2003; Herman, Webb, & Zuniga, 2003; Olson, 2003; Porter, 2001; Webb, 1997, 2005) and now are being applied in states across the U.S. In essence, these approaches convene panels of experts to analyze assessment items against a matrix defined by a set of topics comprising a subject area domain and by levels of cognitive demand, reflecting a range from rote memory to procedures, applications, and complex problem solving. The matrices then become the basis for computing various indexes of alignment to convey how well a test reflects intended standards. The use of these methods range from a low complexity addressing mainly the alignment of content to the states' standards to high complexity which examines the alignment plus many other criteria such as depth of knowledge, balance of representation, and congruence between the assessment and content standard and emphasis on the skills and processes (Bhola, Impara, & Buckendahl, (2003). For the purpose of the analysis in this pilot study, the two alignment criteria considered important for judging the alignment between assessments and standards were depth of knowledge and categorical congruence.

Depth of Knowledge (DOK) evaluates the cognitive demands of the assessments against the cognitive demands of the learning outcome. This criterion was analyzed using Webb's four levels which range from recall to extended thinking (see table C2). The categorical concurrence criterion provides an indication if the assessment and learning outcomes incorporate the same content. This criterion was judged by determining whether the assessment included items measuring content from each learning outcome; at least six items must have measured content from a learning outcome in order for an acceptable level of categorical concurrence to exist between the assessment and the standard (Webb, 2005).

Table C2

Webb's Four Cognitive Levels of Depth of Knowledge (1997)

Cognitive Levels	Description of Cognitive Complexity Levels (CC)
Level 1 (Recall)	Recall of a fact, definition, term, or a simple procedure, as well as performing an algorithm or applying a formula.
Level 2 Skills/Concepts	Use information or conceptual knowledge, two or more steps in solving a task.
Level 3 Strategic Thinking	Requires reasoning, developing plan or a sequence of steps, some complexity, more than one possible answer.
Level 4 Extended Thinking	Requires an investigation, time to think and process multiple conditions of the problem.

Sample

A set of Belize's National Assessment Test (Primary Selection Examination (PSE)) from 2004 – 2009 was used, where each has 50 operational multiple-choice items. The Department of Assessment provided the test specification document that stipulates the content domain, number of items for each domain, knowledge, understanding, and process skills that the items measure across the content domains. Overall, the 2004-2009 tests addressed 9 broad mathematics domains: (1) Number Concepts, (2) Number Operations, (3) Rate/Ratio/Proportion, (4) Algebra, (5) Graphs and Statistics, (6) Sets, (7) Measurement (8) Business Math, and (9) Geometry. In addition, there are 15 learning outcomes that address the 9 content domains.

Depth of Knowledge Procedure

A critical step in validating criterion-referenced tests is to examine the alignment between test items and the learning outcomes (LOs) they were designed to measure. It is to be noted that the alignment of tests and learning outcomes begins in the test construction process where states typically develop test blueprints that specify the relative importance of each strand or facet of the learning outcomes for testing purposes. This sequential process (Webb, 1997) continues with the development of item specifications, which delineate acceptable item formats, expected cognitive demand levels of items, and if items are to be linked directly to objectives within the learning outcomes, to more general aspects of the learning outcomes, or to specific curricular components (La Marca, Redfield, Winter, Bailey, & Despriet, 2000). Webb (1997, 1999) suggests that an analysis of the degree of cognitive complexity prescribed by the learning outcomes is a critical step in the process of alignment and precedes any item/task review. What follows is the analysis of the fifteen learning outcomes followed by each of the fifty test items in terms of the cognitive complexity level using Webb's four levels (Table C2): recall, skills and concepts, strategic thinking, and extended thinking.

Learning Outcomes' Depth of Knowledge

To evaluate the match between assessment and content standards, it is important to categorize the cognitive complexity of each learning outcome. Learning Outcomes (LOs) specify what students should be able to do or know and the attitudes they should possess at the end of the upper division (grades 7-8). Thus, each learning outcome was analyzed and rated to one cognitive demand depth of knowledge level: recall, skill and concepts, strategic thinking or extended thinking.

Cognitive Complexity Level of the Mathematics Learning Outcomes

Webb's four levels of depth of knowledge as described in Table C2, were used to determine the cognitive level of each of the 15 learning outcomes. For instance, the learning outcome "*Identify properties of Prime and Composite numbers"* was considered at level 1 (recall). This learning outcome requires students to demonstrate a rote response or perform a known procedure to determine the characteristics of primes and composite numbers (e.g., factor tree). With regards to a level 2 (skill/concepts) depth of knowledge, learning outcome 1 would fall in that level because it requires conceptual understanding of the base systems. In addition students need to determine the equivalence of the bases involving two different bases. Learning outcomes requiring conceptual understanding were considered as level 2 learning outcomes.

Level 3 (Strategic Thinking) such as learning outcomes 4, 5, 8, and 11 require higher levels of thinking which require justification to real life situation problems such as the transactions involving money and formulating algebraic expressions. Finally, learning outcome 3 was considered at level 4 (extended thinking) because it requires several connections and representations.

In the rating of the cognitive complexity of the fifteen learning outcomes from Table C3, 7% were at Level 1 (Recall), 53% at Level 2 (skills and concepts), 33% at Level 3 (strategic thinking), and 7% at Level 4 (extended thinking). The learning outcomes are generally at level 2 (the skills and concepts) and level 3 (strategic thinking).

Table C3

Mathematics Learning Outcomes Cognitive Complexity for Grades 7 and 8

LO #	Learning Outcomes (LOs)	Content Domain	Grade Level	Area of Study (Themes)	Cognitive Complexity (CC)
1	Express equivalent base of other number systems	Number Operations	8	N	2
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	Graph & Statistics	7 , 8	EP	2
3	Collect, analyze and interpret data and predict probable outcomes	Graph & Statistics	7 , 8	DH	4
4	Use and convert money based on its relative value and its use in financial transaction.	Business Math Rate/Ratio/ Proportion	7 , 8	MQC	3
5	Apply the concept of rational and irrational numbers to real life situations.	Rate/Ratio/ Proportion Number Operations	8	N	3
6	Plot the position and movement of two-dimensional shapes.	Geometry	7	SRS	2
7	Fit shapes together to form patterns	Geometry	7	SRS	2
8	Apply the concept of "Sets" to the practical situation.	Sets	7	DH	3
9	Identify properties of Prime and Composite numbers.	Number Concepts Number Operations	7	N	1
10	Perform operations in numbers up to ten digits and place value.	Number Concepts	7	N	2
11	Apply algebraic expressions to solve problems.	Algebra	7	MQC	3

Table C3 (*continued*)

LO #	Learning Outcomes (LOs)	Content Domain	Grade Level	Area of Study (Themes)	Cognitive Complexity (CC)
12	Measure, estimate and compute distance, weight, time, capacity and temperature and apply to practical situations.	Measurement	7	MQC	2
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	Measurement	7	EP	3
14	Infer the relationship between angles in different two dimensional shapes.	Geometry Measurement	7	SRS	2
15	Draw and construct three dimensional objects	Geometry Measurement	7	SRS	2

Note. N = Number; SRS = Spatial Relationships & Shape; EP = Estimate and make Predictions; MQC = Measure, Quantity & Calculate; DH = Data Handling

Test Items' Depth of Knowledge

Webb's four levels of depth of knowledge were used to determine the cognitive level of each of the 50 test items for the 6 exams. Table C4 provides examples for each level.

Table C4

Sample of Test Items Cognitive Levels

Webb's Depth of Knowledge Level	Test Item	Rationale
Recall	*Which of the following is a composite number?(*Item # 2)	recall the definition
Skills/Concepts	*Twenty one thousand and ten is written as……* (Item # 7)	conceptual understanding, need to determine the equivalent in symbolic form
Strategic Thinking	*When $720 is divided in the ratio 3:5, the smaller share ……*(Item # 17)	high level thinking and reasoning.
Extended Thinking	No item was at this level.	

Table C5 presents the cognitive complexity levels of the six sets of test items.

Table C5

Cognitive Complexity Levels of Test Items

Item #	Test Items Cognitive Complexity Levels																							
	2004 Item Level				2005 Item Level				2006 Item Level				2007 Item Level				2008 Item Level				2009 Item Level			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1		2			1				1				1				1					2		
2	1					2				2			1				1				1			
3		2			1					2				2				2				2		
4	1				1					2				2			1					2		
5	1				1				1				1				1					2		
6	1					2				2				2				2				2		
7		2			1					2				2				2			1			
8	1				1					2				2				2				2		
9		2				2				2				2			1					2		
10	1					2			1					2			1					2		
11		2				2			1				1				1					2		
12	1					2				2			1					2			1			
13		2				2			1					2				2				2		
14		2			1					2			1				1					2		
15		2			1				1				1				1				1			
16		2				2				2					3			2			1			
17			3			2			1						3		1					2		
18			3				3				3		1					2				2		
19			3			2			1				1					2				2		
20			3			2				2			1					2			1			

Table C5 (*continued*)

Item #	Test Items Cognitive Complexity Levels																							
	2004 Item Level				2005 Item Level				2006 Item Level				2007 Item Level				2008 Item Level				2009 Item Level			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
21	1						3		1				1					2			1			
22		2					3		1				1				1				1			
23		2				2			1				1				1				1			
24		2			1					2				2			1					2		
25		2			1					2					3			2				2		
26	1					2					3			2				2				2		
27		2			1					2				2				2				2		
28		2			1				1					2				2			1			
29			3			2				2					3		1					2		
30		2					3		1					2			1				1			
31		2				2					3			2				2				2		
32			3			2				2			1					2			1			
33	1					2			1						3			2			1			
34		2					3			2			1				1				1			
35	1					2			1				1				1				1			
36	1				1				1				1					2			1			
37	1				1				1				1					2				2		
38		2			1				1	2			1				1				1			
39			3			2				2					3		1				1			
40	1						3				3			2				2				2		
41		2				2					3				3				3		1			
42		2				2			1					2					3			2		
43		2			1					2				2				2			1			
44		2				2				2			1					2			1			

Table C5 (*continued*)

Item #	Test Items Cognitive Complexity Levels																							
	2004 Item Level				2005 Item Level				2006 Item Level				2007 Item Level				2008 Item Level				2009 Item Level			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
45		2					3		1				1					2			1			
46			3			2				2			1				1						3	
47		2			1					2				2					3		1			
48	1				1					2			1				1				1			
49		2				2				2				2				2				2		
50		2					3			2				2				2			1			
Total	15	27	8	0	18	24	8	0	20	26	4	0	23	20	7	0	22	25	3	0	23	26	1	0
%	30	54	16	0	36	48	16	0	40	52	8	0	46	40	14	0	44	50	6	0	46	52	2	0
Levels	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

In the ratings of the cognitive complexity of the set of six tests, each consisting of 50 multiple choice items, 5 tests had 48% of items at or above Level 2 (skills and concepts). One test had 46% of items at Level 1(recall) and 40% at Level 2. It is interesting to note that none of the multiple choice items on any test were at Level 4 (extended thinking). The test items mostly addressed skills and concepts with a small percentage addressing strategic thinking. In comparison with the Mathematics Specification Grid (See appendix 1) the distribution of items addressing concepts and process skills (56%) is relatively close to the level 2 (skills and concepts) of the learning outcomes and the test items.

Categorical Concurrence

An important aspect of alignment between learning outcomes and assessment is whether both address the same content. The Webb alignment process suggests that the assessment has to have at least six items measuring content from a learning outcome in order for an acceptable level of categorical concurrence to exist between the learning outcomes and the assessment. The number of items, six, was derived using a procedure developed by Subkoviak (1988). Six items were assumed as a minimum for an assessment measuring content knowledge related to a learning outcome.

Tables C6 – C11 show the number of test items for each assessment that address each learning outcome and the content subdomains that the set of items address. For example, in Table C6, learning outcome 3 has 5 items which addressed the skills of interpreting graphs and learning outcome 4 has two subdomains which address the content area of profit and loss and estimating amount of change after a purchase. What follows is the analysis of each of the six tests to determine the categorical concurrence between the test items and the learning outcomes from 2004-2009.

Table C6

Categorical Concurrence for the 2004 PSE Mathematics Test (N= 50 Multiple Choice Items)

	Learning Outcomes (LOs)	Content Domain	# of Test Items Match	Content Areas Addressed	Categorical Concurrence
1	Express equivalent base notations, and other number systems	NO	1, 4	Scientific Roman Numeral	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	----------	------	No
3	Collect, analyze and interpret data and predict probable outcomes	GS	23, 24, 25, 26	Interpreting graphs	No
4	Use and convert money based on its relative value and its use in financial transaction.	BM	43, 44, 45, 46	Profit & Loss Estimating Change	No
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	9, 11, 12 16, 17 18, 19, 20	Fraction, rate, ratio	Yes
6	Plot the position and movement of two-dimensional shapes.	G	49, 50	Coordinate pairs	No
7	Fit shapes together to form patterns	G	----------	------------	No
8	Apply the concept of "Sets" to the practical situation.	S	27, 28, 29 30, 31	Intersections, complement	No
9	Identify properties of Prime and Composite numbers.	NC NO	2, 3, 5, 8	Composites multiples	No
10	Perform operations in numbers up to ten digits and place value.	NC	1, 6, 7, 8, 9 10, 12,13, 14 15	Place value, four operations	Yes
11	Apply algebraic expressions to solve problems.	A	20, 21, 22	Equations	No
12	Measure, estimate and compute distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	32, 39, 40, 42 47	Area, volume, perimeter, time,	No
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	35,36,37, 38 41, 4, 2, 44	estimations	Yes
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	34, 38, 39, 41 47 48	Angle classification	Yes
15	Draw and construct three dimensional objects	G M	33	cuboid	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

Table C7

Categorical Concurrence for the 2005 PSE Mathematics Test

	Learning Outcomes (LOs)	Content Domain	# of Test Items Match	Content Areas Addressed	Categorical Concurrence
1	Express equivalent base notations, and other number systems	NO	2, 11, 19	Scientific Notation Exponents	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	--------	---------	No
3	Collect, analyze and interpret data and predict probable outcomes	GS	20, 21, 23	Interpret Graphs, descriptive statistics	No
4	Use and convert money based on its relative value and its use in financial transaction.	BM RRP	40, 42, 43 44, 45, 50	Consumer arithmetic Commission, sales tax, simple interest	Yes
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	7, 2, 16 17, 18, 22 30,47, 50	Fractions , Ratio	Yes
6	Plot the position and movement of two-dimensional shapes.	G	---------	-----------	No
7	Fit shapes together to form patterns	G	---------	-----------	No
8	Apply the concept of “Sets” to the practical situation.	S	24, 25, 26 27, 33	Subsets, Intersection Finite	
9	Identify properties of Prime and Composite numbers.	NC NO	10	---------	No
10	Perform operations in numbers up to ten digits and place value.	NC	4, 5, 7, 8, 9, 13, 14, 21	Four operations Place value	Yes
11	Apply algebraic expressions to solve problems.	A	1, 3, 6, 8 19	Solve for a unknown function	No
12	Measure, estimate and compute, distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	28, 29 30, 31, 32, 34 35, 36, 37, 40	Perimeter, area, volume	Yes
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	36, 38 39,48	Weight, distance, temperature	No
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	46, 47, 48	Angle measure	No
15	Draw and construct three dimensional objects	G M	-------	----------	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

Table C8

Categorical Concurrence for the 2006 PSE Mathematics Test

	Learning Outcomes (LOs)	Content Domain	# of Test Items Match	Content Areas Addressed	Categorical Concurrence
1	Express equivalent base notations, and other number systems	NO	2, 7, 20	Exponents, base five	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	24	Probability	No
3	Collect, analyze and interpret data and predict probable outcomes	GS	10, 11, 23 25, 26	Graphs (line, circle, bar), map reading,	No
4	Use and convert money based on its relative value and its use in financial transaction.	BM RRP	13, 43, 44 46	Consumer arithmetic, currency exchange, commission	No
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	4, 12, 13, 15 16, 17, 18 42	Percent, ratio	Yes
6	Plot the position and movement of two-dimensional shapes.	G	50	reflection	No
7	Fit shapes together to form patterns	G	--------	--------	
8	Apply the concept of "Sets" to the practical situation.	S	27, 28, 29 31, 32	Intersection, union	No
9	Identify properties of Prime and Composite numbers.	NC NO	9	Prime factors	No
10	Perform operations in numbers up to ten digits and place value.	NC	1, 3, 4, 6, 22 46	Place value, order of operations	Yes
11	Apply algebraic expressions to solve problems.	A	8, 19, 20 21, 45	Inequality, solve for unknown	No
12	Measure, estimate and compute distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	14,16, 20 33, 35, 36, 37, 38, 39 40, 41	Distance/mileage area, perimeter volume, capacity	Yes
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	34, 49	angles	No
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	34, 47, 49	Hypotenuse congruency	No
15	Draw and construct three dimensional objects	G M	48	cuboid	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

Table C9

Categorical Concurrence for the 2007 PSE Mathematics Test

	Learning Outcomes (LOs)	Content Domain	# of Test Items Match	Content Areas Addressed	Categorical Concurrence
1	Express equivalent base notations, and other number systems	NO	2, 3	Exponents, scientific notation	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	---------------	-------	----------
3	Collect, analyze and interpret data and predict probable outcomes	GS	11, 20, 21 24, 49	Bar graph, circle, descriptive statistics	No
4	Use and convert money based on its relative value and its use in financial transaction.	BM RRP	16, 40, 41 42 43, 48	Consumer arithmetic, commission, discount	Yes
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	5, 9, 10, 12 13, 14,15,17 18, 24, 42	Percent, decimals, fraction, ratio, rate	Yes
6	Plot the position and movement of two-dimensional shapes.	G	22, 23	Coordinates of points	No
7	Fit shapes together to form patterns	G	--------	--------	-------
8	Apply the concept of "Sets" to the practical situation.	S	25, 26, 27 28, 29	intersection, subsets, elements	No
,9	Identify properties of Prime and Composite numbers.	NC NO	6, 8	Factorization,	No
10	Perform operations in numbers up to ten digits and place value.	NC	1, 4, 14	Place value, order of operations	No
11	Apply algebraic expressions to solve problems.	A	7, 18, 19	Inequalities, solve for unknown	No
12	Measure, estimate and compute distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	31, 32, 33 34, 35, 36 37, 38, 39	Perimeter, area, capacity, time, distance, volume	Yes
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	30, 47, 50	Circles, angles	No
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	24, 44, 45 46, 47, 50	angles	Yes
15	Draw and construct three dimensional objects	G M	39	cuboid	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

Table C10

Categorical Concurrence for the 2008 PSE Mathematics Test

	Learning Outcomes (LOs)	Content Domain	# of Test Items Match	Content Areas Addressed	Categorical Concurrence
1	Express equivalent base notations, and other number systems	NO	3, 4, 7	Standard notation	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	47	Statistics	No
3	Collect, analyze and interpret data and predict probable outcomes	GS	48, 49, 50	Descriptive statistics, pie chart	No
4	Use and convert money based on its relative value and its use in financial transaction.	BM RRP	40, 41, 42	Sales tax, profit, simple interest	No
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	12, 15, 16 18, 20, 21 22, 39	Fractions, ratio	Yes
6	Plot the position and movement of two-dimensional shapes.	G	-----------	-------------------	No
7	Fit shapes together to form patterns	G	-----------	---------------	No
8	Apply the concept of “Sets” to the practical situation.	S	23, 24, 25 26, 27	Disjoint, union, intersection, elements	No
9	Identify properties of Prime and Composite numbers.	NC NO	5	multiples	No
10	Perform operations in numbers up to ten digits and place value.	NC	1, 2, 9, 10	Rounding, place value, order of operations	No
11	Apply algebraic expressions to solve problems.	A	6, 11, 13 14, 17, 19	Inequalities, equations	Yes
12	Measure, estimate and compute distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	29, 30, 31 32, 33, 34 35, 36, 38	Volume, area, mass, distance, time	Yes
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	8	Number patterns	No
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	27, 28, 43 44, 45	Angles	No
15	Draw and construct three dimensional objects	G M	46	cuboid	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

Table C11

Categorical Concurrence for the 2009 PSE Mathematics Test

	Learning Outcomes (LOs)	Content Domain	# of Test Items Match	Content Areas Addressed	Categorical Concurrence
1	Express equivalent base notations, and other number systems	NO	3, 5, 6	Standard notation, scientific, exponents	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	-----------	-----------------	No
3	Collect, analyze and interpret data and predict probable outcomes	GS	8, 18, 25 26, 27, 28 45	data, bar graph, circle, descriptive statistics	Yes
4	Use and convert money based on its relative value and its use in financial transaction.	BM RRP	43, 44, 45 46	Consumer arithmetic, simple interest	No
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	4, 9, 10, 14 15, 17, 18 25, 39, 41	Percent, fraction, ratio, rate	Yes
6	Plot the position and movement of two-dimensional shapes.	G	48	symmetry	No
7	Fit shapes together to form patterns	G	-------------	--------------------	No
8	Apply the concept of "Sets" to the practical situation.	S	23, 24, 29 30, 31	Subsets, union, intersection	No
9	Identify properties of Prime and Composite numbers.	NC NO	1	Multiples	No
10	Perform operations in numbers up to ten digits and place value.	NC	7, 11, 12, 42	Place value, order of operations, identity	No
11	Apply algebraic expressions to solve problems.	A	2, 13, 21 12, 19, 20	Inequalities, solve for unknown	Yes
12	Measure, estimate and compute distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	32, 33, 34 35, 40, 41 42	Time/distance, area, temperature, volume	Yes
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	40	Volume	No
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	49, 50	Angles,	No
15	Draw and construct three dimensional objects	G M	47	cuboid	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

Table C12 presents a summary of the analysis using Webb's categorical concurrence.

Table C12

Summary of Categorical Concurrence for the 2004-2009 PSE Mathematics Test

	Learning Outcomes (LOs)	Content Domain	2004	2005	2006	2007	2008	2009
1	Express equivalent base notations, and other number systems	NO	No	No	No	No	No	No
2	Predict the likely occurrence of an event through logical reasoning, based on trends.	GS	No	No	No	No	No	No
3	Collect, analyze and interpret data and predict probable outcomes	GS	No	No	No	No	Yes	No
4	Use and convert money based on its relative value and its use in financial transaction.	BM RRP	No	Yes	No	Yes	No	No
5	Apply the concept of rational and irrational numbers to real life situations.	RRP NO	Yes	Yes	Yes	Yes	Yes	Yes
6	Plot the position and movement of two-dimensional shapes.	G	No	No	No	No	No	No
7	Fit shapes together to form patterns	G	No	No	No	No	No	No
8	Apply the concept of "Sets" to the practical situation.	S	No		No	No		No
9	Identify properties of Prime and Composite numbers.	NC NO	No	No	No	No	No	No
10	Perform operations in numbers up to ten digits and place value.	NC	Yes	Yes	Yes	No	No	No
11	Apply algebraic expressions to solve problems.	A	No	No	No	No	Yes	Yes
12	Measure, estimate and compute distance, weight, time, capacity, area, volume, surface area, and temperature and apply to practical situations.	M	No	Yes	Yes	Yes	Yes	Yes
13	Make and apply reasonable approximations by observing and /or using factual data based on meaningful references.	M	Yes	No	No	No	No	No
14	Infer the relationship between angles and sides in different two dimensional shapes.	G M	Yes	No	No	Yes	No	No
15	Draw and construct three dimensional objects	G M	No	No	No	No	No	No

Note. GS = Graphs & Statistics; BM = Business Math; NO = Number Operations; NC = Number Concepts; G = Geometry; S = Sets; A = Algebra; M = Measurement; RRP = Rate Ratio & Proportion

The analysis using Webb's categorical concurrence criteria suggests that the assessment has to have at least six items measuring content from a learning outcome in order for an acceptable level of categorical concurrence to exist between the learning outcomes and the assessment.

For the year 2004, only four learning outcomes met the acceptable level of categorical concurrence with six test items addressing the learning outcomes in the content area of rate/ratio/proportion, geometry, measurement, number concepts, and operations. For the 2005 assessment, four learning outcomes met the acceptable level in the content area of business math, rate/ratio/and proportion, number operations, number concepts, and measurement. In the 2006 assessment, three learning outcomes met the acceptable level in the content area of rate/ratio/proportion, number operations, number concepts, and measurement. In the 2007 assessment, there were also four learning outcomes that met the acceptable level as in 2004 and 2005. In 2008 there were also four learning outcomes met, addressing the content area of number operations, graph and statistics, rate/ratio/proportion, algebra, and measurement. Finally, in the 2009 assessment, only three learning outcomes were met in the content area of rate/ratio/proportion, number operations, algebra, and measurement.

Consistent among the set of tests for which there was categorical concurrence are the content areas of measurement, number concepts, rate/ratio/proportion, and number operations. In the last two years, 2008 and 2009, the content area of algebra was given some emphasis. Also, the area of geometry received some emphasis in 2007. From the tables, there is a clear indication that the alignment is not acceptable given the insufficient number of items (6) for eleven of the learning outcomes.

Conclusion

In this pilot study, I analyzed fifteen mathematics learning outcomes and a set of six national assessments to determine the extent of alignment between the Belize Primary Selection Examination (PSE) and the Mathematics Comprehensive National Curriculum Learning Outcomes using two criterion of the Webb Alignment Process (1997): depth of knowledge (DOK) and categorical concurrence (content match). From the analysis of the cognitive complexity demands of the learning outcomes using Webb's levels, indications are that 53% of the learning outcomes are at level 2 (skills and concepts). In the analysis of the set of 6 tests, 5 tests had 485 of the items at or above Level 2 (skills and concepts). One test had 46% of items at Level 1 (recall) and 40% at Level 2; none of the items had items at Level 4 (extended thinking). Test items mostly addressed skills and concepts, with relatively low percentages addressing strategic thinking.

The analysis of categorical concurrence indicates that the assessments did not meet the acceptable level of categorical concurrence. Four tests (2004, 2005, 2007, and 2008) had only four learning outcomes (26%) match with 6 items and two tests (2006 and 2009) had only three learning outcomes (20%) with at least 6 test items. However, at least four content domains were addressed across the six tests, which could inform teachers about the emphasis given to those content areas. Nevertheless, there was one learning outcomes, “fit shapes together to form patterns”, that was not addressed in the 2004-2009 assessments.

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Appendix B

Coding for the Learning Outcomes Depth of Knowledge

Code	**Learning Outcome**				
1	**Number**	**Maximum Depth of Knowledge Level**			
		1	**2**	**3**	**4**
1.a	identify the consecutive sequence and position of whole numbers up to ten digits and place value				
1.b	identify properties of prime and composite numbers				
1.c	express equivalent base notations and other number systems				
1.d	apply the concept of rational numbers and irrational numbers to real life situations				
2	**Spatial Relationships and Shapes**				
2.a	how to draw and construct three-dimensional objects				
2.b	how to plot the position and movement of two-dimensional shapes				
2.c	how shapes fit together to form patterns				
2.d	infer the relationship between angles in different two-dimensional shapes				
3	**Measure, Quantify and Calculate**				
3.a	measure, estimate, express and compute distance, weight, time, capacity and temperature and apply to practical situations				
3.b	use and convert money based on its relative value and its use in financial transactions				
3.c	apply algebraic expressions to solve problems				
4	**Estimate and Make Predictions**				
4.a	make and apply reasonable approximations by observing and/or using factual data based on meaningful references				
4.b	predict the likely occurrence of an event, through logical reasoning, based on trends				
5	**Data Handling**				
5.a	collect, analyze and interpret data and predict probable outcomes				
5.b	apply the concept of “sets” to practical solutions				

Appendix C

Coding Instrument for Content Coverage for the PSE Mathematics Test

Code	Learning Outcome	Test Item #		Coverage	
1	**Number**	**2009**	**2010**	**2009**	**2010**
1.a	identify the consecutive sequence and position of whole numbers up to ten digits and place value				
1.b	identify properties of prime and composite numbers				
1.c	express equivalent base notations and other number systems				
1.d	apply the concept of rational numbers and irrational numbers to real life situations				
2	**Spatial Relationships and Shapes**				
2.a	how to draw and construct three-dimensional objects				
2.b	how to plot the position and movement of two-dimensional shapes				
2.c	how shapes fit together to form patterns				
2.d	infer the relationship between angles in different two-dimensional shapes				
3	**Measure, Quantify and Calculate**				
3.a	measure, estimate, express and compute distance, weight, time, capacity and temperature and apply to practical situations				
3.b	use and convert money based on its relative value and its use in financial transactions				
3.c	apply algebraic expressions to solve problems				
4	**Estimate and Make Predictions**				
4.a	make and apply reasonable approximations by observing and/or using factual data based on meaningful references				
4.b	predict the likely occurrence of an event, through logical reasoning, based on trends				
5	**Data Handling**				
5.a	collect, analyze and interpret data and predict probable outcomes				
5.b	apply the concept of “sets” to practical solutions				

Appendix D

Coding Instrument for Cognitive Demand Level of Test Items

Test Item Number	2009 Test Cognitive Level				Test Item Cognitive Level			
	1	2	3	4	1	2	3	4
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
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22								
23								
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25								
26								
27								
28								
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31								
32								
33								
34								
35								

Appendix E

Coding Instrument for Types of Instructional Segments

Book Title: ___________________________

Grade Level: _____________________

Chapter #	Content Domain	# of Pre-lessons	# of Lessons	# of End of lesson feature	# of End of chapter features	# of Chapter Review
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Appendix F

Coding Instrument for Level of Cognitive Demand of Instructional Segments

Book Title: ___________________________

Grade Level: Grade 7

Chapter #	Content Domain	Type of Instructional Segments	Level of Cognitive Demand			
			1	2	3	4

Appendix G

Coding Instrument for the Alignment of the Learning Outcomes and Textbooks Instructional Segments

Textbook Title: ____________________
Grade Level: ________________

Instructional Segments	Learning Outcomes (LOs)														
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	4a	4b	5a	5b
Pre-lessons 1 2 3 Etc.															
Lessons 1 2 3 etc.															
End of lesson extra feature 1 2 3 Etc.															
End of chapter feature 1 2 3															
Chapter Review (Test) 1 2 3 Etc.															

Appendix H
Training Manual

1. Purpose of Training Manual
2. Criterion used in this Manual
3. Familiarization on depth-of-knowledge levels
4. Assigning depth-of-knowledge levels to learning outcomes
5. Establishing consensus on depth-of-knowledge levels for learning outcomes
6. Coding National Assessment Test Items
7. Answer Key for the depth-of-knowledge levels

Purpose of this Training Manual

This Training Manual is meant to:

(a) Familiarize coders with Webb's Four Depth of Knowledge Levels.
(b) Engage coders to assign depth of knowledge levels to learning outcomes and the assessment items

For each grade level, the primary role of a **coder** is:

1. To judge the depth-of-knowledge level of the learning outcomes.
2. To judge the depth-of-knowledge level of each assessment item.

Criterion Used in this Manual

Depth-of-Knowledge Consistency - This criterion measures the degree to which the knowledge elicited from students on the assessment is as complex within the content area as what students are expected to know and do as stated in the learning outcomes. The criterion is met if more than half of targeted objectives are hit by items of the appropriate complexity.

Depth-of-knowledge (DOK) Level Definitions.

Review the depth-of-knowledge definitions with the coders. Identify the main characteristics for each level and the characteristics that distinguish one level from adjacent levels.

Level 1 (Recall) includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. As such, a one-step and straight algorithmic procedure should be considered at this lowest level. Some verbs that can be considered as Level 1 include “identify,” “recall,” “recognize,” “use,” and “measure.”

Level 2 (Skill/Concept) requires the use of mental processes and the item requires students to make some decisions as to how to approach the problem or activity. The tasks require students to use more than one step. For example, interpreting information from a simple graph, or reading information from the graph is also at Level 2. Level 2 activities include describing non-trivial patterns, making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts.

Level 3 (Strategic Thinking) requires reasoning, planning, using evidence, and a higher level of thinking. In most instances, requiring students to explain their thinking is at Level 3. The cognitive demands at Level 3 are complex and abstract. The complexity does not result from the fact that there are multiple answers, a possibility for both Levels 1 and 2, but because the task requires more demanding reasoning. An activity, however, that has more than one possible answer and requires students to justify the response they give would most likely be at Level 3.

Level 4 (Extended Thinking) requires complex reasoning, planning, developing, and thinking, most likely over an extended period of time. For example, an investigation or application to real work requiring time to research, think, and process multiple conditions of the problem or task across disciplines, content areas or multiple sources. At Level 4 students should be required to make several connections so as to relate ideas with the content area or among content areas. In addition, students have to select one approach among many alternatives on how the situation should be solved, in order to be at this highest level. Level 4 tasks include designing and conducting experiments and projects; combining and synthesizing ideas into new concepts and critiquing results.

Assigning DOK Levels to each Learning Outcome

Use the mathematics DOK levels on the previous pages to determine the DOK levels for the following five learning outcomes in Table L1. When you are finished, look at the end of the manual to see whether you agree with the way the learning outcomes were coded!

Table L1:

Mathematics Learning Outcomes

Coder __________________

LO #	Learning Outcome	DOK Level
1	List properties of odd and composite numbers.	
2	Use logical reasoning, based on meaningful data to draw conclusions about the likely occurrence of an event.	
3	Use and convert coins and bills up to $100.00.	
4	Compute with fractions (that is, add, subtract, multiply, divide).	
5	Construct two-dimensional patterns for three-dimensional models, such as prisms and pyramids.	

Establishing Consensus on DOK Levels for Learning Outcomes

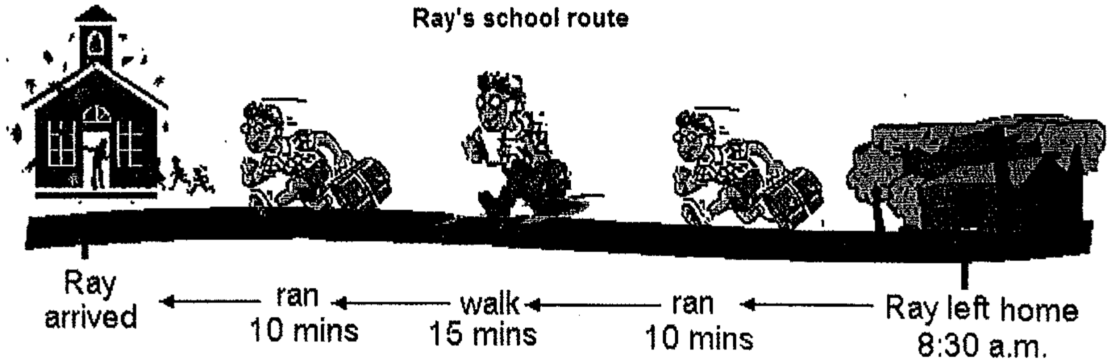
Identify any one on which there is not perfect agreement. Have coder who felt the objective was at one level state why he/she thought it was that level; then have coder who felt the objective was at another level state why he/she thought it was at that level.

Review the definitions of the DOK levels and try to move all to agreement. If getting to an agreement is taking too long, the mode will be taken, rounding the value.

Coding the Test Items

Now try coding the following 10 sample test items using the DOK Levels. After you are finished coding these, compare your answer with the answer key section at the end of this manual.

1.



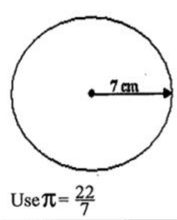
What time did Ray arrive at school?

a. 9:00 a.m.
b. 9:05 a.m.
c. 8:50 a.m.
d. 8:55 a.m.

2. Which of these is true?

(a) 0.4 > 0.04
(b) 0.4 < 0.004
(c) 0.04 < 0.004
(d) 0.004 > 0.4

3. What is the area of this figure?



What is the **area** of this figure?

a. 22 cm^2
b. 44 cm^2
c. 154 cm^2
d. 616 cm^2

4.

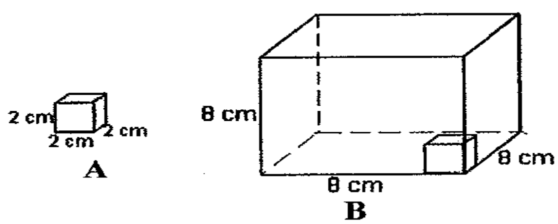
National Transportation Schedule

Leaves	Arrives
Belize City 11:35 a.m.	Corozal 2:25 p.m.

How long did the trip take?

a. 2 hrs 50 mins
b. 3 hrs 50 mins
c. 9 hrs 10 mins
d. 14 hrs 0 mins

5.



How many of container '**A**' can fit in container '**B**'?

a. 16
b. 24
c. 32
d. 64

6.

A triangle has 0 diagonals, a quadrilateral has 2 diagonals, a pentagon has 5 diagonals, and a hexagon has 9 diagonals. If the pattern continues, how many diagonals will an octagon have?

Sides	3	4	5	6
Diagonals	0	2	5	9

A 11
B 14
C 18
D 20

7.

In which set are the numbers equivalent?

A $\frac{1}{3}$, $\frac{3}{27}$, 33%

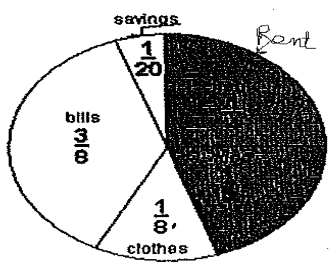
B 0.090, 90%, 0.90

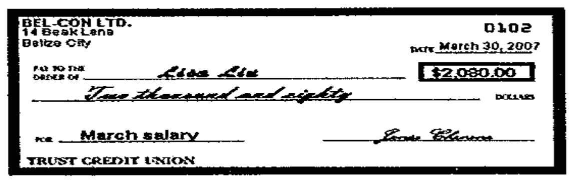
C 88%, $\frac{88}{100}$, $\frac{22}{25}$

D 0.66%, $\frac{2}{3}$, 66.7%

8.

Below is a cheque showing Lisa's salary and a pie chart showing how she shares her money.



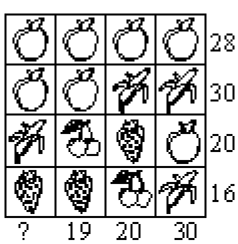


How much does Lisa spend on <u>rent</u>?

a. $416.00
b. $520.00
c. $624.00
d. $780.00

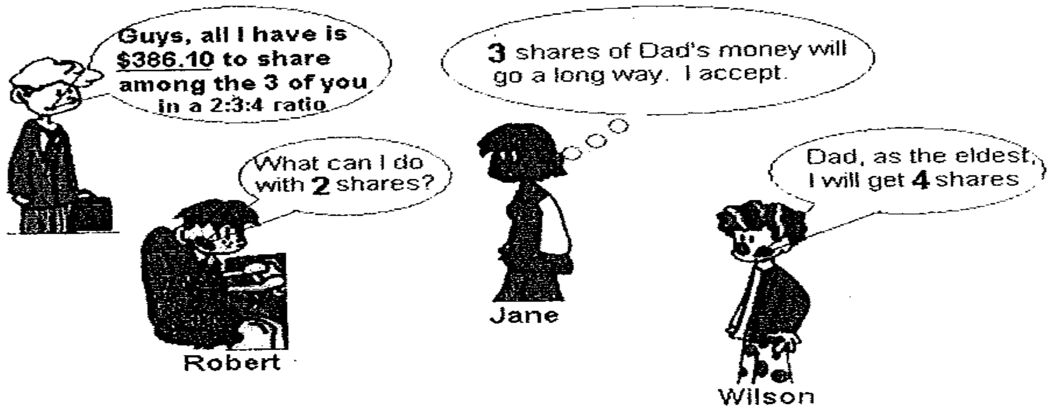
9.

Look at the drawing. The numbers alongside each column and row are the total of the values of the symbols within each column and row. What should replace the question mark?



a. 23
b. 25
c. 28
d. 30
e. 32

10.



Calculate how much Jane will receive.

a. $42.90
b. $128.70
c. $171.60
d. $257.40

Note. Test items were reprinted with permission from the Ministry of Education, Belize.

Answer Key for the DOK Levels

Learning Outcome 1. This is an example of <u>Level 1</u>. The highest demand for students requires them to recall the definition.

Learning Outcome 2. This is an example of <u>Level 3</u>. This will require students to do some reasoning in order to interpret the data and draw conclusions depending on the context.

Learning Outcome 3. This requires that the student identify the correct denominations and make reasonable estimates for amounts. This represents an example of <u>Level 2</u>.

Learning Outcome 4. This requires students to conduct basic calculations. This is <u>Level 1</u> because it involves routine processing and involves a one-step process.

Learning Outcome 5. This is an example of <u>Level 2</u>. Although recognizing and drawing a two-dimensional pattern is expected to be routine (Level 1), building a three-dimensional model would not be as routine. It would require at least two steps: first, recognizing the shape and, second, drawing a two-dimensional object to reflect the shape in three dimensions.

DOK Levels for the Test Items

1) Level 1. The choices offered indicate that this item is intended to identify students who would simply add the minutes to the initial time. Just one step is required here.

2) Level 2. Students need to interpret the decimal notation and understand that the tenths is greater than the hundredths, etc.

3) Level 1. Students only need to be able to apply the formula for area of a circle.

4) Level 2. More than one step is required here. The students must first recognize the difference between a.m. and p.m. and make some decisions about how to make this into a subtraction problem or add-on approach.

5) Level 3. There are a number of different concepts and procedures that can be used for this problem, rather than an obvious, simple one.

6) Level 2. This item is included in order to contrast it with the previous item. Pattern recognition is required, but the non-routine nature of this pattern brings the item up to a higher DOK level. Some analysis and generalization is required in order to understand and extend this pattern.

7) Level 2. There are a number of different concepts and procedures that can be used for this problem. Students must not only be able to *identify* different representations of rational numbers (Level 1), but also to *manipulate* and *compare* these representations (Level 2). This means that numerous interdependent and non-trivial steps are involved here. However, this does not require any conjecturing, planning, abstracting, or explaining, so it is not Level 3.

8) Level 4. This is a complex problem requiring students "to make several connections and apply one approach among many." It requires the students to use rational numbers and percentages and to determine the fractional part for rent, which is not obvious.

9) Level 3. This item can be approached through a number of viable strategies: pattern recognition, guess-and-check, algebra, etc. Students need to make choices and assumptions. Furthermore, no matter what strategy is employed, students need to keep track of a complex logical chain. The multiple choices provided do not make this task any less complex.

10) Level 2. This item is not routine, nor does it focus on a memorized definition or procedure. In fact, it involves numerous steps, because it requires students to identify several ratios.

Ministry of Education

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PRI/09/11(8)

September 12, 2011

Mr. Gabriel Cal
Faculty of Education & Arts
University of Belize
Belize, C.A.

Dear Mr. Cal,

We acknowledge receipt of your email dated September 7, 2011 requesting data from the PSE test items released 2004 - 2009 for use in your dissertation program.

Please be informed that approval is hereby granted for you to use the released 2004 - 2009 PSE questions.

By a copy of this letter, the Director of the Examination Unit is being informed of the approval and is requested to kindly facilitate in the process if necessary.

Sincerely,

[redacted]

(CHRISTOPHER AIRD, M.Ed.)
Chief Education Officer

c. Director, Examinations Unit
Director, QADS

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ABOUT THE AUTHOR

Gabriel Cal received a bachelor's of science degree in Secondary Mathematics from the University College of Belize in 1995 and a master's degree in Curriculum and Instruction with emphasis in Secondary Mathematics Education from the University of South Florida in 2003. He has been involved in teacher training from 1995 to the present. His passion to teaching and venture in the field of research encouraged him to enter the doctoral program in Mathematics Education at the University of South Florida in Tampa in 2007. From 2007 to 2011, he taught mathematics methods courses for undergraduate pre-service teachers.