EXPLORING AND MEASURING CURRICULUM ALIGNMENT PRACTICES IN THE CLASSROOM: A MIXED METHOD APPROACH

by

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ABSTRACT

The study examined curriculum alignment among the intended, the enacted, and the assessed curricula in Grade 9 mathematics in two domains: content/operations and cognitive processes. The Program of Studies was used to determine the content operations. The Delphi Process was used to identify the cognitive levels for the intended curriculum. Classroom observations were used to capture the enacted curriculum, and End of the Unit tests were used to determine the assessed curriculum. Results indicated that curriculum alignment among the intended, enacted and assessed curricula for the mathematics content/operations was quite high (97% alignment). In contrast, curriculum alignment among the intended, enacted and assessed curricula for the cognitive processes was quite low (7.3% alignment). This study makes a contribution towards understanding the quality of the relationship among the intended, enacted and assessed curricula in mathematics education. The methodological framework provides a model for subsequent research on curriculum alignment among the three components of the education system.

Keywords: curriculum alignment, content/operations, and cognitive processes

PREFACE

This thesis is an original work by Paolina Seitz. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board. Project Name: Exploring and Measuring Curriculum Alignment Practices in the Classroom: A Mixed Method Approach No. Pro00042583 Date: October 17, 2013.

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CHAPTER 1: THE SCOPE OF THE STUDY

Introduction

The first time I heard the word “alignment” was in reference to the wheels on my father’s automobile. In the last decade, the word “alignment” has inundated the educational debate in the context of standards-based education and educational reform. Automobiles typically have four wheels that when aligned move the automobile in the same direction. Education has three wheels – learner expectations, instruction, and assessment – that when aligned have the potential to point those responsible for the learner expectations, those responsible for providing the opportunities for students to learn what is expected to be learned, and those responsible for assessing what students have learned in the same direction (Porter & Smithson, 2002; Anderson, 2002; Martone & Sireci, 2009). But the similarities end here. Wheel alignment for a car is relatively uncomplicated and takes less than one hour to complete. Curriculum alignment in education is complex and takes much more time to complete.

The word "curriculum" signifies many different things in education. Curriculum can refer to all courses offered at a school. Curriculum may also refer to a prescribed course of studies, which students must learn in order to pass a certain level of education. For example, an elementary school might discuss how its curriculum for mathematics at the primary level (Grades 1 to 3) is designed help students learn the basic operations of addition, subtraction, multiplication, and division of whole numbers up to 10,000. Kerr (1999) describes curriculum as all the learning of students that is guided by the school. Marsh and Willis (2003) suggest that curriculum includes the totality of learning experiences provided to students in order to attain general knowledge and skills.

Another view breaks curriculum into three sequentially ordered parts. What societies envisage as important to learn constitutes the "intended" curriculum. Since it is usually presented in official documents, it may be also called the "written" and/or "official" curriculum. However, at the classroom level the intended curriculum may be altered through a range of complex classroom interactions, and what is actually delivered can be considered the "implemented" or “enacted” curriculum What students actually learn constitutes the "achieved," "learned" or “assessed” curriculum (adapted from Porter, 2002). Given the present study is to examine the alignment among the intended, enacted, and assessed curricula in Alberta, the learning expectations, which are common and mandated across schools in the province, will be taken as the intended curriculum. Perusal of the Programs of Study, which contain the learning expectations, suggest that the intended curriculum is first defined in terms of broad statements and then in terms of more specific statements describing the knowledge, skills, and attitudes to be acquired. Teachers are required to develop learning opportunities for the students to acquire the knowledge, skills, and attitudes (the enacted curriculum) set out in the intended curriculum and then to determine if their students have acquired the desired knowledge, skills, and attitudes (the assessed curriculum). Thus, for the purposes of the present study, the learner expectations set out in the Programs of Study for Alberta will be taken as the starting point for the intended curriculum. However, whereas the content and operations are explicitly identified for each learner expectation, the cognitive levels for each learner expectation are not explicit. Therefore clarification of the intended curriculum in terms of levels of thinking skills and the enacted and assessed curricula is to be determined as part of this study in order to determine the degree to which the intended, enacted and assessed curricula align both in terms of content/operations and cognitive processing.

The first studies of curriculum alignment in education dealt with the alignment between learning expectations or standards and what is assessed, that is between the intended and assessed curricula. For example, La Marcia, Redfield, Winter, and Despriet (2000) emphasized the importance of ensuring that an assessment allows students to demonstrate their knowledge and skills with respect to the content standards (learning expectations) found in the curriculum documents for the course in order to have accurate interpretations of what the students know and can do. They stated:

> Alignment is the degree to which assessments yield results that provide accurate information about student performance regarding academic content standards at the desired level of detail.…the assessment must adequately cover the content standards with the appropriate depth, reflect the emphasis of the content standards, and provide scores that cover the range of performance standards, allow all students the opportunity to demonstrate their proficiency, and be reported in a manner that clearly conveys student proficiency as it relates to the content standards. (p. 24)

Webb (2002) agreed and stated that alignment is the degree “to which learner expectations and assessments are in agreement and serve in conjunction with one another to guide the system towards student learning of what they are expected to know and do” (p. 1). Later, in 2008 and in agreement with La Marca et al., Webb, Roach, Niebling, and Kurz (2008) defined alignment “as the extent to which curricular expectations and assessments are in agreement and work together to provide guidance to educators’ efforts to facilitate students' progress toward desired academic outcomes" (p. 1).

Some researchers have studied the alignment between instruction and assessment. For example, Keokane (2008) found that alignment between instruction and an end of year unit test in a Social Studies Grade 9 classroom was only 33%. Only 33% of the questions included in the test represented what the teachers had actually taught for that unit.

Definitions that focus on learner expectations and assessments referenced to the learner expectations presume that what is taught is sound and valid. Other researchers recognized this point and argued that a more comprehensive view of curriculum alignment was necessary, with instruction providing an explanation for the presence or lack of presence of alignment between learner expectations and assessment (Anderson, 2002; Elmore & Rothman, 1999; Elliott, Braden, & White, 2001; Mitchell, 1998; Smith & O'Day, 1991; Wishnick, 1989). For example, Anderson (2002) pointed out that there is alignment only when there is a demonstrable and strong connection among content standards, instruction, and assessment. Porter (2002) agreed:

> An instructional system is to be driven by content standards, which are translated into assessments, curriculum materials, and professional development, which are all, in turn, tightly aligned to the content standards. The hypothesis is that a coherent message of desired content will influence teachers' decisions about what to teach, and teachers' decisions, in turn, will translate into their instructional practice and ultimately into student learning of the desired content. (p. 5)

Clearly, the inclusion of instruction as the middle part of curriculum provides more comprehensive explanatory evidence as to why the results of the assessment are what they are when there is or is not alignment between the standards and the assessment. For example, while the assessment results may be low because of student background factors, they may also be low due to a lack of alignment among the learner expectations, what was taught, and what was assessed. Further, it may be that the alignment among the learner expectations that call for low level cognitive thinking, what was taught and what was assessed will be higher than the alignment among learner expectations that call for higher level cognitive thinking, what was taught, and what was assessed (Kaira, 2010). Therefore, it is important that there be a strong and valid alignment among the student expectations to be learned, the instruction designed to provide students with the opportunity to acquire desired knowledge and skills, and the assessment instruments used to determine if the students have acquired the desired knowledge and skills (Ananda, 2003; Resnick, Rothman, Lattery, & Vranek, 2003).

Many of the alignment studies – whether looking at the alignment between the learner expectations or standards and what is assessed or at the alignment among learner expectations, instruction, and what is assessed – have been completed in the United States. To date, a study of the alignment among the learning expectations as set out in a program of studies for a province in Canada, instruction by teachers in the schools in the province, and the assessments teachers use to determine if the students have learned what was taught has not been done, despite the fact that there is recognition that the three components must be aligned. For example, Seitz and Rymer (2010) suggested that alignment among learner expectations, instructional strategies, and assessment of what students know and can do could be viewed in terms of the curriculum loop shown in

Figure 1. However, there has not been study to determine the degree of alignment among the components in the loop.

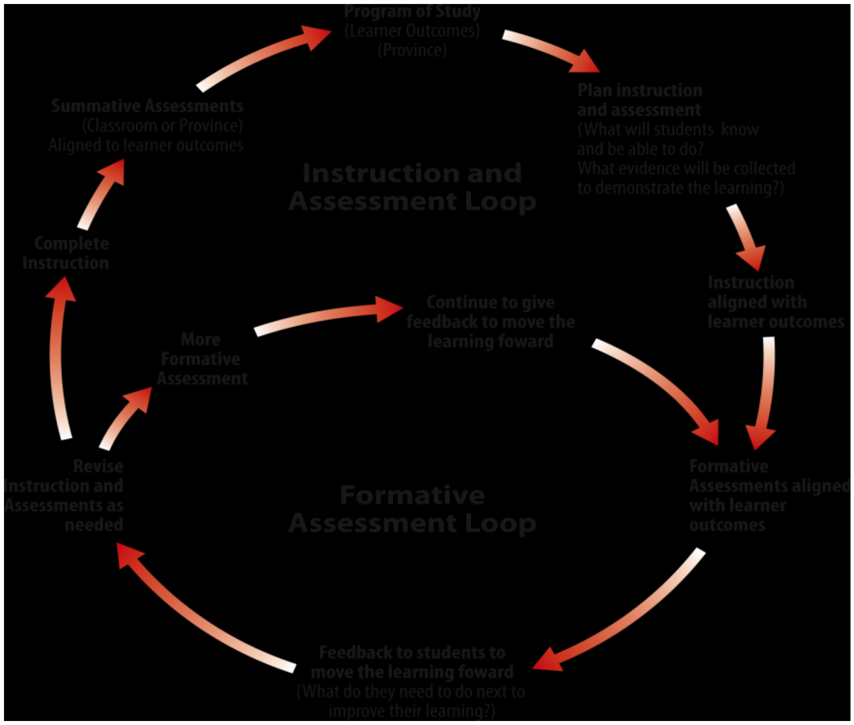

Figure 1: Alignment among learner expectations, instruction, and assessment (Seitz & Rymer, 2010)

The main goal of alignment is to ensure that the intended, the enacted, and the assessed curricula are well coordinated to ensure student achievement. When a test claims to measure achievement of some learning expectations, it is important to measure how well the test represents those learner expectations. This evaluation is important because if tests are not aligned to the learner expectations, teachers are less likely to pay attention to the learner expectations and this would affect the breadth of knowledge taught to students. Results of an alignment study therefore provide information on how well the assessment covers the learner expectations and also give insights into what is being taught in schools. Content gaps in the assessment or the learner expectations can then be determined (Ananda, 2003a) and such information is important for policy makers to make informed decisions about the intended, the enacted, and the assessed curricula.

Tindal, Cipoletti, and Almond (2005) add that results of an alignment study may be used to identify areas where learning expectations may need to be clarified so that progression of knowledge across grades is more evident. Results of an alignment study may also be used in deciding whether restructuring of an assessment is necessary or not. If restructuring is necessary, alignment results would help to identify what changes needed to be made in the intended, enacted, and assessed curricula.

Purpose and Research Questions

Consequently, the intent of this study was to determine the extent that curriculum alignment in terms of mathematics content/operations and cognitive processes is practiced in grade 9 mathematics in the province of Alberta.

The following two sequentially ordered research questions were addressed:

- Given the cognitive process levels and the emphasis given to learner expectations are not provided in the Program of Studies, what are the levels of cognitive processing as defined in the *Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Anderson, et al., 2001) corresponding to each of the learning expectations for the Patterns and Relations Strand for Grade 9 Mathematics?
- For both the mathematics content/operations and cognitive process aspects, what is the degree of alignment among
  - the intended curriculum,
  - the enacted curriculum, and
  - the assessed curriculum.

- What instructional emphasis did teachers give to each of the learner expectations? (Secondary question).

A mixed methods research design, (Creswell & Clark, 2011) in which both quantitative (numeric) and qualitative (interactions, observations) data are used together to answer the two research questions. The reason for collecting both quantitative and qualitative data was to compare and corroborate the results and findings from two different perspectives.

Rationale for Study

Over the past number of years education has been criticized for failing to uphold standards and consequently educators have been charged with improving the academic achievement of students. A review of the literature on school improvement efforts reveals a number of factors that may contribute to a decline of student achievement. One of these factors is misalignment among what should be taught, what is taught, and what is assessed (Resnick, Rothman, Slattery, & Vranek, 2003; Roach, Niebling, & Kurz, 2008). According to Cohen (1987), “the lack of excellence in schools is not caused by ineffective teaching, but mostly by misaligning what teachers teach, what they intend to teach, and what they assess as having been taught” (p. 18).

While the degree of alignment among the intended, enacted, and assessed curricula in schools seems minimal (Kurz, Elliott, Wehby, & Smithson, 2010), there has been little study of the degree of alignment among the three curricula (Squire, 2010), and no known studies have been conducted in Canada within K-12 education. Given the importance of student performance within accountability in education (Alberta Education, 2010), it is logical to investigate the extent to which curriculum alignment among the intended, enacted and assessed curricula exists. Schmoker and Marzano (1999) suggest that there are differences in what teachers teach in the same subject at the same grade level, thereby creating gaps in the content knowledge and skills which students are expected to learn. Ultimately, the premise underlying curriculum alignment research is that a justified and consistent alignment of the intended, enacted, and assessed curricula will result in systematic standard driven educational reform and increased student achievement (Smith & O'Day, 1991; Porter, 2002).

Definition of Terms

Cognitive thinking:

- *Low levels cognitive thinking*: involves knowledge and the development of intellectual skills considered to be at the lower level of thinking (Bloom, 1956). Based on the revised taxonomy of educational objectives, remembering, and understanding are low-level cognitive thinking processes (Anderson et al., 2001).
- *Higher levels of cognitive thinking*: involves knowledge and the development of intellectual skills considered to be at the higher level of thinking (Bloom, 1956). Based on the revised taxonomy of educational objectives, applying, analyzing, evaluating, and creating are higher-level cognitive thinking processes. (Anderson et al., 2001).

Curriculum: comprised of intended curriculum, the enacted curriculum, and the assessed curriculum:

- *Intended curriculum*: consists of the learning expectations provided in programs of study and that specify what mathematics content/operations and cognitive skills students are to know and acquire as a result of instruction (Porter & Smithson, 2001).

- *Enacted curriculum*: the mathematics content/operations and cognitive skills taught by teachers and studied by students so as to learn and acquire the intended curriculum (Porter & Smithson, 2001).
- *Assessed curriculum*: the assessment of what students have learned as a result of instruction and their own studies at the end of a unit or block of instruction (Porter & Smithson, 2001).

Curriculum alignment: a clear fit among the intended, enacted, and assessed curricula (Porter & Smithson, 2001).

Standards-Based Education: using the knowledge and skills students are expected to acquire through schooling in content areas to assess student performance (La Marca, Redfield, Winter, & Despriet, 2000).

Educational Accountability: measuring performance to ensure the best possible education opportunities for all of students is provided by a school authority and its schools (adapted from http://education.alberta.ca/admin/funding/accountability.aspx).

Delimitations of the Study

This study was delimited to one unit in Grade 9 Mathematics in Alberta. Additional units and subjects were not considered since it was not feasible to replicate the procedures for the present study for additional units in Grade 9 mathematics or other subject areas. However, it is hoped that the procedures followed to determine the alignment between the intended, enacted and assessed curricula for the one unit in Grade 9 mathematics will be generalizable to other subject areas and grade levels within Alberta and elsewhere. The sample of teachers and classes of students is a convenience sample located in one school district due to lack of resources to observe classrooms and interview teachers from a greater number of school districts located in other regions within the province. Therefore, it likely will not be able to generalize the findings of the study for the province as whole or to other provinces.

Organization of the Dissertation

The dissertation is organized in five chapters. Chapter 1 highlights the literature on curriculum alignment, the purpose and research questions, rationale for the study, and definition of terms. Chapter 2 presents a literature review of curriculum alignment, its connection to standards-based education and accountability, curriculum alignment between the intended and the assessed curriculum, curriculum alignment among the intended, the enacted, and the assessed curricula, and description of the Survey of Enacted Curriculum Model for measuring curriculum alignment among the intended, enacted, and assessed curricula. This model is the only model involving the intended, enacted, and assessed curricula. Different applications have used different tables of specifications to classify the learning expectations that constitute the intended curriculum. The initial table used by Porter and Smithson (2001) and the revised Taxonomy Table of Educational Objectives: Cognitive Domain (Anderson, et al., 2001) will be described. Chapter 3 describes the methodology that was used for the study. It comprises of five sections. Section one presents the creation of the intended curriculum incorporating the Delphi Method, the selection of judges, training the judges and collecting the judgments. Section two presents collecting the information about the enacted and the assessed curricula including the teacher sample, the teacher survey, the classroom observations, the instructional plans and the end of the unit test. The third section presents the data collection including the administration of the surveys, the observations, background of judges for the Delphi Procedure, the background of the classroom observers, and the teacher interviews. The fourth section describes the data preparation process including coding the observations, transcribing and coding the interviews. The fifth section presents the data analysis process. Chapter 4 presents the results of the study. First, the results of the intended curriculum are discussed including the completion of the Delphi Procedure and results of the Delphi Procedure. Second, the results of the enacted curriculum is presented incorporating a description of the participating classroom teachers, the classroom observations, background of classroom observers, the classroom observations results, the teacher surveys and the teacher interview results. Third, the assessed curriculum is presented including the alignment among intended, enacted, and assessed curricula, the Mathematics Content/Operations, and the alignment among intended, enacted, and assessed curricula: Cognitive Process. Fourth, the chapter concludes with a summary of the results. Chapter 5 contains a summary of the purpose, methods, and results, discussion of the results in terms of the present literature, limitations of the study, conclusion drawn in light of the limitations, and implications of the results for educators and policymakers and suggestions for further research in this area.

CHAPTER TWO: REVIEW OF THE LITERATURE

The purpose of this chapter is to provide a review of the literature relevant to the research on curriculum alignment in order to gain a deeper understanding of the concept and its relationship to student learning, standards-based education, and accountability. The first section considers the importance of curriculum alignment, particularly as it relates to standard-based education and accountability. The second section reviews and discusses research conducted to determine the curriculum alignment between the intended curriculum and the assessed curriculum. The third section reviews and discusses research conducted to determine the curriculum alignment between the intended and enacted curricula and the enacted and assessed curricula. The fourth section reviews and discusses research conducted to determine curriculum alignment among the intended, enacted, and assessed curricula. The fifth section describes the Survey of Enacted Curriculum Model (Porter & Smithson, 2001) that attends to the alignment of the intended curriculum, enacted curriculum, and assessed curriculum and the revised Taxonomy of Educational Objectives: Cognitive Domain (Anderson, et. al., 2001), which is now the preferred way for classifying learner expectations, what is taught, and what is assessed.

Curriculum Alignment, Standards-Based Education and Accountability

Given a standards-based education system can be used to hold school districts and schools accountable (Fuhrman, 2001), it is important that the intended, enacted, and assessed curricula align in order to achieve the intended goals (Contino, 2012). The learner expectations or standards, development of the opportunities to learn for students, and how students will be assessed to determine what the students know and can do in terms of the learning expectations must be aligned before a school or school system can be held accountable (Elliott, Braden, & White, 2001; Webb, 1997). Anderson (2002) suggested that the correct curriculum alignment among the intended, enacted, and assessed curricula will lead to successful student learning, thereby meeting the requirements of accountability in education.

Pellegrino (2006) also supported the notion that there is a need for alignment among the intended, enacted, and assessed curricula. He stated that curriculum alignment needs to become a principle of educational practice. Likewise, while different terms were used (e.g., goals and objectives instead of standards or student expectations), *The Principles for Fair Student Assessment Practices for Education in Canada* (1993) called for curriculum alignment. In particular, in Part A, Principle 1, guideline 2 in the *Principles* states that:

> Assessment methods should be clearly related to the goals and objectives of instruction, and be compatible with the instructional approaches used (p. 4),

and included the following explanation for this guideline:

> To enhance validity, assessment methods should be in harmony with the instructional objectives to which they are referenced. Planning an assessment design at the same time as planning instruction will help integrate the two in meaningful ways. Such joint planning provides an overall perspective on the knowledge, skills, attitudes, and behaviors to be learned and assessed, and the contexts in which they will be learned and assessed (p. 4).

Additionally, Fullan and Levin (2009) identified six fundamental whole-system reform strategies. Although the third strategy considers only the alignment of instruction and assessment, the strategy states that, “a two-way street between instruction and assessment should be the centerpiece of a capacity-building strategy” (p. 2). They further stated that “good instruction should drive assessment” and “good assessment informs instruction” (p.2). They advised to “keep instruction and assessment aligned and balanced” (p. 2). Unfortunately, Fullan and Levin did not include the learner expectations or curriculum standards as they are called in Ontario, perhaps because in Ontario the curriculum standards are mandated. Regardless, they should have ensured that instruction matched the curriculum standards and the assessments matched the curriculum standards and took into account the instructional process used. In their book entitled, “Fifty Ways to Close the Achievement Gap,” Downey, Steffy, Poston and English (2009) outlined six standards for high performing schools. Standards Two and Three both address the concept of curriculum alignment. Specifically, Standard Two addresses assessments aligned with curriculum and Standard Three addresses the alignment of instruction with the standards. However, they did not specifically state that there had to be simultaneous consideration of all three components. But, Squires (2012) indicated that the alignment of instruction (enacted curriculum), standards (intended curriculum), and assessments (assessed curriculum) has the potential to significantly increase student achievement.

Curriculum Alignment between the Intended and Assessed Curricula

Moss (1999) conducted a study in the state of Georgia in the United States involving over 4,000 third grade students in a large school district in order to examine the effect of alignment between the intended curriculum and the assessed curriculum on student achievement in mathematics. Participating students were measured by the Iowa Tests of Basic Skills (ITBS) administered to students in kindergarten through grade eight.

The ITBS is aligned to the learning expectations for the Iowa core curriculum and measures how well a student performs in comparison to other students. Moss (1999) found that a high degree of alignment existed between the learner expectations of the core curriculum in Georgia and the ITBS at the Grade 3 level and that this alignment increased student achievement in mathematics at Grade 3. Further, curriculum alignment canceled out traditional predictors of student achievement, including socio-economic status, gender, race and teacher effect. Based on her research, curriculum alignment not only increases student performance, but also has the potential to equalize the educational playing field for students (Moss, 1999).

In a later study, McGehee and Griffith (2001) reported that after using the process of aligning the content of the state and standardized tests and the implications for instruction, a small northeastern Arkansas district increased each of its Stanford Achievement Test 9 (SAT 9) percentile rankings for fourth and eighth grades by at least 10 points. They stated that "Schools that have embraced this alignment process [alignment between intended and assessed curricula] for the past 3 years are showing not only significant increases in SAT 9 scores but also significant movement from below basic and basic toward proficient and advanced" (p. 42).

Kaira (2010) applied item mapping to student response data for the Massachusetts Adult Proficiency Test (MAPT) for Math and Reading to assess alignment between intended and assessed curricula. Item response theory (IRT) was used to locate items on a proficiency scale and then two criterion response probability (RP) values were applied to get two sets of items. These sets of items were mapped to one of 5 proficiency categories. The two sets of item mapping results were compared to item writers' classification of the items to the proficiency categories. Chi-square tests, correlations, and logistic regression were used to assess the degree of agreement between the three sets of classifications. Seven teachers were brought together for a one-day meeting to review items that did not align in the same way to the intended proficiency categories for the three classifications in order to explain the misalignment The categories for misalignment were: cognitive complexity of the process required to respond to the item, difficulty of the item, language level of the item compared to level of students, clarity of the item, and emphasis placed on the topic during instruction. Results showed that there was higher agreement between subject matter experts (SMEs) classifications and item mapping results at RP50 than RP67. Higher agreement was also observed for items assessing lower level cognitive abilities than high cognitive abilities. The seven teachers identified item difficulty, cognitive demand, clarity of the item, level of vocabulary of item compared to reading level of examinees, and mathematical concept being assessed as the main reasons for misalignment.

Jacobs (1997), in a position paper, suggested that the value in alignment between the intended and assessed curricula comes as much in the process as it does in the results. Specifically, he contended that curriculum alignment moves teachers from covering the content in the textbook to using the standards as the base for curriculum, instruction, and assessment. He pointed out that curriculum alignment compels teachers to use the programs of study or curriculum content documents that contain learner expectations and suggested teaching materials and activities.

Curriculum Alignment Between the Intended and Enacted Curricula and Between the Enacted and Assessed Curricula

A number of researchers have examined the alignment between the intended curriculum and the enacted curriculum. For example, Cohen (1997), in a position paper, reported that when assessments are aligned with instruction, student success in learning could be increased as much as two standard deviations. Other researchers have examined the alignment between the enacted curriculum and the assessed curriculum (Walvoord & Anderson, 1998; Wiggins, 1993). They indicated that teachers who clearly understand the alignment between instruction and student assessment can both communicate their expectations to students and measure student learning in ways that foster student success.

Based on the results of their empirical study at the college level, Wagner and DiBiase (2001) suggested that aligning topics and instruction around science reform themes was related to increased student achievement. Students in an experimental group experienced a significant increase in the final test scores for the course after attending chemistry lectures that had been aligned with a chemistry laboratory course, while students in a control group exhibited no such increase. Survey data indicated that students in the experimental group believed that the alignment between the lectures and the lab experiments helped them understand the lectures.

In an experimental design study funded by the National Science Foundation in 2000, the Council of Chief State School Officers investigated the effectiveness of a new research-based model for professional development intended to improve the quality of instruction in math and science in five urban districts (Council of Chief State School Officers, 2002). Teachers from 40 middle schools were involved in this study. Application of intended and enacted parts of the Survey of Enacted Curriculum (Porter & Smithson, 2001) produced data that could be used to determine the degree of alignment between the intended curriculum and any source of variation in the enacted curriculum (Blank, 2002, 2004; Porter, 2002). Teachers in the treatment schools received extensive and sustained in-service on aligning the intended and enacted curricula (Blank, 2004). Three years of data were collected from 165 participating teachers. Results showed improved quality of instruction, as measured by increasing alignment with state standards, when comparing instruction in treatment schools to instruction in control schools.

Blank, Porter, and Smithson (2001) also conducted a study using the Survey of Enacted Curriculum model to measure the degree of alignment between instruction and assessment. Surveys were collected from 600 teachers in 20 schools across 6 states. The survey asked teachers to describe content of their instruction in grade 8 mathematics. The teacher's descriptions were compared to results of the content analyses of Grade 8 mathematics assessments from the states and the National Assessment of Educational Progress (NAEP) mathematics assessment at Grade 8. The results showed that state instruction was more aligned to the NAEP assessment (average alignment index = 0.39) compared to the assessment conducted by each state (average alignment index = 0.22). Between state alignment of instruction and assessment was slightly higher (average alignment index = 0.23) than within state alignment (alignment index = 19.2) (Blank, Porter & Smithson, 2001).

Curriculum Alignment Among the Intended, Enacted, and Assessed Curricula

The process of aligning the intended and assessed curricula or the intended and enacted curricula fails to take into account the missing curriculum (enacted in the first set of studies, assessed in the second set of studies, and intended in the third set of studies reviewed above). However, the research literature on the alignment of the intended, enacted, and assessed curricula is scant. While there are position papers written in support of curriculum alignment of the three components (Roach, Niebling, & Kurz, 2008), there are very few empirical studies (Squires, 2012).

Porter and Smithson (2000) involved 30 teachers from 11 states in the United States in a study to investigate the degree alignment among tests and with the National Assessment of Educational Assessments across the 11 states; between tests and instruction in each of the 11 states; and between instruction in one state and instruction in another state for both mathematics and science in grades 3, 4, 5, 7, 8, 9. Although the differences were not large, they found that the state tests were more aligned with each other than they were with NAEP assessments for both subject areas. For each subject and grade level, state test to state test alignment was higher than was state test to NAEP alignment. Instruction in one state was similar to instruction in another state. However, when teacher reports of their understanding of the content to be taught were compared within a state and within a school, the degree of alignment dropped significantly (Porter & Smithson, 2010).

Kurz, Elliott, Wehby, and Smithson (2010) examined the alignment between the content of the intended, enacted, and assessed curricula for eighth-grade mathematics using the Survey of Enacted Curriculum Model (Porter & Smithson, 2002). A total of 18 general and special education teachers were in their sample. The relation between alignment and student achievement was analyzed for three formative assessments and the corresponding state test within a school year. Results indicated that alignment for the intended and enacted curriculum was low. However, they found significant correlations between student achievement when the enacted and assessed curricula were aligned for the three formative assessments and the state assessment.

Burti (2011) conducted a study in order examine the alignment of the intended, enacted, and assessed Algebra I curricula in the Cherry Hill (NJ) Public School District using a mixed methods design. Burti wanted to determine the impact of course selection (Algebra I, Enriched Algebra) on achievement as measured by the Algebra I End of Course (EOC) Assessment. Using triangulation, he attempted to establish a cause-effect relationship between the intended (New Jersey Core Curriculum Content Standards), the enacted curriculum, and the assessed curriculum (Algebra I EOC assessment). The results indicated that while the district's enacted curriculum was not fully aligned with the intended or the assessed curricula, the intended and assessed curricula were more closely aligned. Inferential statistics showed that Enriched Algebra students scored significantly higher than their Algebra I counterparts.

Several early position papers indicated that there are benefits of curriculum alignment among the intended, enacted, and assessed curricula. For example, Glatthorn (1999) stated that when teachers practice curriculum alignment (intended, enacted, and assessed), it can increase student interest in their learning and thus experience greater learning success. Biggs (1999) agreed and indicated that when the intended, enacted, and assessed curricula are aligned, students cannot avoid learning.

According to Anderson (2002), another benefit of curriculum alignment is that demonstrated achievement recognizes effective teaching. She also noted that when instruction is not aligned with learner expectations, educators might misjudge the effect of teaching on achievement that is demonstrated on the assessments. Teachers may be working hard at teaching but, if what they are teaching does not align with the learner expectations or the assessments, then the teaching will not produce the desired results (Anderson, 2002). When the intended, enacted, and assessed curricula are harmonized and deliver a consistent message about what should be learned, taught, and assessed, students have greater opportunity to learn what is expected, and to truly demonstrate what they know and can do (Martone & Serici, 2009).

However, with the exception of Kaira (2010), it appears that the cognitive complexity of the learner expectations has not been explicitly considered as a factor in curriculum alignment studies. Although different levels of cognitive complexity were included in the intended curriculum, the majority of the cognitive levels were concentrated at the lower level of complexity. (Based on the *Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Anderson, et al., 2001), lower level cognitive skills are remember, understand, and apply; higher level cognitive skills are analyze, evaluate, and create). Yet, students are expected to use high order thinking skills and be able to reason and problem solve. While memorization and recall requiring a minimum level of understanding are necessary, they are not sufficient. Students must be able to apply the knowledge and skills they have learned to become critical thinkers, which requires more in-depth understanding (Zoller, 1993; Crowe, 2008). The learner expectations that call for students to perform at the higher order thinking levels require these levels to become first part of what is taught and then what is assessed (Bransford, 2000; Bailin, 2002). According to Napoleon (2006) the development of higher-level thinking requires a level of instruction that has the potential to develop a richness of knowledge and understanding not otherwise possible. Given opportunities to acquire the higher order thinking set out in the learner expectations during instruction, the assessment of what is learned needs to include questions that call for higher order of thinking. Conversely, if classroom activities are limited to the memorization of facts and details but test questions call for the higher thinking, then students will perform poorly because they have not been given the opportunity to develop these higher order-thinking concepts (Crowe, 2008).

An analysis of a curriculum-referenced test used in a large district's alignment project in the area of writing revealed that the test items focused almost exclusively on low-level thinking such as punctuation, spelling, and identifying parts of speech despite the fact that some teachers were teaching higher order writing skills (Squires, 2008). Popham (2007) argues that, "Instructionally insensitive tests render untenable the assumptions underlying a test-based strategy for educational accountability" (p. 147). He goes on to say that because of instructionally insensitive tests, student grades and scores are not a valid reflection of what they have learned.

Models of Curriculum Alignment

The most prominent models for determining the alignment between the intended curriculum and the assessed curriculum include Webb's Alignment Model (Webb, 1999) and Rothman's Achieve Model (Rothman, 2002). The most prominent model for determining the alignment among the intended curriculum, enacted curriculum, and assessed curriculum is the Survey of Enacted Curriculum Model (Porter & Smithson, 2001). Given that the intended, enacted, and assessed curricula are to be considered in the proposed study, only the Survey of Enacted Curriculum Model is described here.

The Survey of Enacted Curriculum (SEC) Model was first developed in 1998 by Porter and Smithson to offer a systematic and uniform language for making quantitative comparisons between the enacted and the assessed curricula and later revised to include the intended curriculum (Porter & Smithson, 2002). The model involves the use of a two dimensional content matrix. The content to be taught is placed in the rows and the cognitive level of thinking is placed in the columns as illustrated in Table 1. One matrix is for the enacted curriculum and the second matrix is for the assessed curriculum.

For both matrices, the content dimension is a list of topics and varies in number according to the subject area studied. There is no hierarchy in this dimension. The thinking dimension lists the level of thinking found in the learner expectations. Porter and Smithson's earlier version contained nine categories but the combination of the two dimensions resulted in a number of cells that was too large to handle. In order to make the classification easier to handle, the number of categories and, consequently, cells was reduced (Porter & Smithson, 2001).

Table 1

Content Matrix: Mathematics

	Level of Thinking				
Topic	Memorize	Perform Procedures	Communicate Understanding	Conjecture/ Generalize/ Prove	Solve Non-routine Problems
Multiple-step equations					
Inequalities					
Linear equations					
Line/slope and intercept					
Operations on polynomials					
Quadratic equations					

Adopted from the Survey of Enacted Curriculum Model (Porter, 2002)

While the number of categories in this dimension varies depending on the subject used, (the number is usually five), they are ordered by level of cognitive demand. Learner expectations, what is taught, and assessment items can be categorized by the intersection of the two dimensions and placed in the corresponding cell.

For example, consider the development of a matrix for what is taught in the classroom. Porter and Smithson (2001) used survey questionnaires to collect data on instructional practices and subject content taught from teachers. The teachers were asked to indicate for the past school year (a) the amount of time devoted to each content topic (level of coverage) and, for each topic, (b) the relative emphasis given to each student expectation (category of cognitive demand). An example of the scale for topic and an example of cognitive demand are:

- Topic: Level of coverage,
    1. none/not covered;
    2. slight coverage (less than one class or lesson);
    3. moderate coverage (one to five classes or lessons); and
    4. sustained coverage (more than five classes or lessons).
- Cognitive demand: Relative emphasis given to each category
    1. no emphasis;
    2. slight emphasis (less than 25% of time spent on this topic);
    3. moderate emphasis (accounts for 25–33% of time spent on this topic); and
    4. sustained emphasis (accounts for more than 33% of time spent on this topic).

The data is then transformed into proportions of the total instructional time spent on each cell in the two-dimensional matrix such that the proportions sum to 1 (Porter & Smithson, 2001). A matrix for assessment is constructed in the same way where the unit of analysis is item. The degree of alignment between the learner expectation matrix, content matrix, and the assessment matrix can be determined by taking the mean of the absolute value of the difference between the proportions in the pairs of cells (e.g., learner expectation matrix cells and content matrix cells) across cells:

The alignment index (AI) used is:

$$\text{AI} = [(\sum| X\text{-}Y| /2)],$$

where X represents the cell proportions in one matrix (e.g., assessment topics by cognitive demand) and Y represents the cell proportions in the other (e.g., topic by cognitive demand; Porter, 2002). The values range from .0 to 1.0. A value close to 1 indicates close agreement.

In addition, Porter and Smithson (2001) included two other surveys: an administrative survey and a student survey. The student survey, named the Survey of Classroom Activities, ask students about their instructional activities in the classroom and the assessments they took. The data garnered from these surveys are used to confirm the data in the teacher surveys. The administrative survey asks principals questions regarding the learning environment at the school and how class lists are organized. The data is used for additional information to confirm the data from the teacher surveys.

Using the surveys, data from a large sample can be collected at relatively low cost, in less time, and with less intrusiveness in the classroom. Alignment results from the SEC model provide quantitative information about the alignment, which can be helpful in informing if revisions may be needed. However, Porter (2002) acknowledged that there are weaknesses in the model: the findings are limited to what is asked in the surveys, there is potential of self-report bias, and it is questionable whether the findings actually capture the complexity of the instructional practice (Rothman, Slattery, Vranek & Resnick, 2002). In addition, the model does not provide criteria for judging alignment for some of the dimensions (Martone & Sireci, 2009). Weaknesses notwithstanding, the SEC model has been used in multiple settings; K-to 8 and high school math and science, and language arts (Roach, Niebling & Kurz, 2008), and has been endorsed by the Council of Chief State School Officers (CCSSO). Educators and policymakers also use this model to answer questions they have regarding practices in curriculum and instruction (Roach et al., 2008). It appears that the SEC model is the only model that provides comprehensive data regarding the reliability of the results (Porter, 2002).

Subsequently, the revised Taxonomy of Educational Objectives: Cognitive Domain (Anderson, et. al., 2001) replaced its initial content by thinking skills matrix used by Porter and Smithson (2001, 2002). As shown in Table 2, the two dimensions in the Taxonomy Table are the knowledge dimension and the cognitive process dimension. In the knowledge dimension the content is defined as different kinds of knowledge. These categories are factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge. The categories are partially ordered from concrete - factual knowledge to abstract - metacognitive knowledge, but with no clear-cut border between conceptual knowledge and procedural knowledge. The cognitive process dimension focuses on how the knowledge is used. The categories of the cognitive process

Table 2

The Taxonomy Table

	THE COGNITIVE PROCESS DIMENSION					
The KNOWLEDGE DIMENSION	**1. REMEMBER** ○ **Recognizing** ○ **Recalling**	**2. UNDERSTAND** ○ **Interpreting** ○ **Exemplifying** ○ **Classifying** ○ **Summarizing** ○ **Inferring** ○ **Comparing** ○ **Explaining**	**3. APPLY** ○ **Executing** ○ **Implementing**	**4. ANALYZE** ○ **Differentiating** ○ **Organizing** ○ **Attributing**	**5. EVALUATE** ○ **Checking** ○ **Critiquing**	**6. CREATE** ○ **Generating** ○ **Planning** ○ **Producing**
A. Factual Knowledge						
B. Conceptual Knowledge						
C. Procedural Knowledge						
D. Metacognitive Knowledge						

Taken from Anderson & Krathwol (2001).

dimensions are: remember, understand, apply, analyze, evaluate, and create. The underlying continuum for the second dimension is the cognitive complexity ranging from little cognitive complexity to high cognitive complexity.

Adoption of the revised Taxonomy Table provides a common language for categorizing the type of knowledge and level of thinking for all subject areas. According to Anderson (2005), the revised Taxonomy Table requires examination of curricular objectives from both the knowledge and cognitive domains, thereby providing a more accurate estimate of alignment. The framework emphasizes alignment in terms of student learning and provides an examination of curriculum alignment by examining the learning expectations, the instructional activities, and the assessments in terms of the Taxonomy Table. Further, the Taxonomy Table provides a framework that teachers can use to plan appropriate instructional activities and develop relevant assessment tasks that are aligned with the level of knowledge and cognitive complexity of the learning expectations (Anderson, 2005).

Anderson (2005) describes a three-step procedure to examine the alignment among the standards, instruction, and assessment in the Taxonomy Table model:

- First, all the learning expectations in the unit of study are placed in the appropriate cells in the Taxonomy Table.
- Second, the unit assessments are analyzed by writing in the appropriate cells the number and/or percent of items or the number and/or weighting of the evaluation criteria depending on the type of tasks being asked in the items.
- Third, the major instructional activities and related materials are analyzed based on the Taxonomy Table. This is done much like the analysis of the assessments; the number of and the emphasis given to various activities are placed in the appropriate

cells.

The cells are examined as follows. Cells that contain one or more objectives, related instructional activities and materials, and related assessments indicate a high degree of alignment. Cells that contain objectives and related instructional activities and materials, but no related assessments, or cells that contain instructional activities and materials and related assessments, but no objectives, indicate partial alignment. Cells with only one of the three components indicate lack of alignment.

Currently, there seems to be a disconnect between the cognitive rigor of the learner expectations that students are to be learning, the cognitive rigor of the actual work students are doing in the classroom, and the cognitive rigor of the tests (Weber, Aiken, Lupart, & Scott, 2009). The Revised Taxonomy Table has the ability to identify both the structure of knowledge and the cognitive processes students are expected to demonstrate. As such, teachers and administrators can be assured of an increased alignment of learner expectations, instruction, and assessment. Another benefit of the Revised Taxonomy Table is the ability to use it across different subject areas and grade levels to determine the degree of alignment among the intended, enacted, and assessed curricula.

Näsström (2008) conducted a theoretical investigation of taxonomies and frameworks used in measuring curriculum alignment. Based on the assumption that a model must be able to include content and cognitive complexity, nine different models were identified and scrutinized using defined theoretical criteria. His conclusion was that Bloom's revised taxonomy and Porter's taxonomy were the most appropriate models. Bloom's revised taxonomy and Porter's taxonomy were best able to categorize both content and cognitive complexity and supported the assumption that cognitive complexity lies on a continuous scale. Next, Näsström conducted an empirical study in order to compare the usefulness of categorizing both standards and assessment items for both Bloom's revised taxonomy and Porter's taxonomy. Two judges individually categorized one set of standards in a chemistry course and the corresponding items in one test using both taxonomies. The usefulness of the taxonomy was investigated based on Hauenstein's (1998) criteria for usefulness and on the level of inter-judge consistency. He found that Bloom's revised taxonomy was more inclusive than Porter's taxonomy. The inter-rater reliability for classification of standards was significantly better for Bloom's revised taxonomy than for Porter's taxonomy. Näsström (2008) concluded that Bloom's revised taxonomy is more useful than Porter's taxonomy as a classification tool in alignment studies.

Summary

There is little empirical research on curriculum alignment among the intended, the enacted, and the assessed curricula (Squire, 2010). In addition, there appears to be no known study of curriculum alignment among the three curricula in Alberta or the other provinces in Canada. Therefore, the purpose of this proposed study is to examine the extent of alignment among the intended, enacted, and assessed curricula in Grade 9 mathematics in Alberta, and to take into account the cognitive complexity of what students are expected to acquire.

The revised Taxonomy of Educational Objectives: Cognitive Domain (Anderson, et al. 2001) with the use of the Survey of Enacted Curriculum Model (Porter & Smithson, 2002) provides a comprehensive way to determine the degrees of alignment among intended curriculum, the enacted curriculum, and the assessed curriculum. There are two main reasons for using the revised Taxonomy. First, there is increasing evidence that measuring curriculum alignment using both knowledge and cognitive processes is superior to other methods of measuring curriculum alignment (Gamaron, Porter, Smithson, & White 1997; Anderson, 2002). Second, the revised Taxonomy can be used to measure curriculum alignment for one unit of study or for an entire course. In addition, Näsström's (2008) empirical study indicated that Bloom's revised taxonomy is the most useful taxonomy for measuring curriculum alignment.

CHAPTER THREE: METHODOLOGY

The revised Taxonomy of Educational Objectives: Cognitive Domain (Anderson, et al. 2001) was included in the Survey of Enacted Curriculum Model (Porter & Smithson, 2002) to address the two sequentially ordered research questions initially presented in Chapter 1:

- Given the cognitive process levels and the emphasis given to learner expectations are not provided in the Program of Studies, what are the levels of cognitive processing as defined in the *Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Anderson, et al., 2001) corresponding to each of the learning expectations for the Patterns and Relations Strand for Grade 9 Mathematics?
- For both the mathematics and cognitive process aspect, what is the degree of alignment among
    - the intended curriculum,
    - the enacted curriculum, and
    - the assessed curriculum.
- What instructional emphasis did teachers give to each of the learner expectations? (Secondary question).

Specifically, the cognitive process dimensions were used from the revised Taxonomy of Educational Objectives but the knowledge dimensions were replaced by the 45 learner expectations from the mathematics unit of study used in this study. Näsström's (2008) empirical study indicated that Bloom's revised taxonomy is the most useful taxonomy for measuring curriculum alignment.

A mixed methods research design was used to collect the data needed to answer the research questions. The mixed methods design was chosen because its purpose is "obtaining different but complementary data on the same topic" (Morse, 1991, p. 122) to best answer the research questions. The central premise of a mixed methods approach "is that the use of quantitative and qualitative approaches, in combination, provides a better understanding of research problems than either approach alone" (Creswell & Clark, 2011, p. 5). Creswell and Clark (2011) also indicated that whereas quantitative data are collected using a full set of predetermined responses, qualitative data are collected based on open-ended questions with no or some predetermined categories. In this mixed method study, the quantitative and qualitative data will complement each other so as to provide a valid and sound indication of the degree to which there is curriculum alignment among the intended, enacted, and assessed curriculum for one unit of study in Grade 9 Mathematics.

An important tenet of mixed methods studies is that the research questions drive the methods used (Newman & Benz, 1998; Tashakkori & Teddlie, 2010). Consideration has been given to this tenet when simultaneously planning the quantitative and qualitative methodologies for the study.

To best answer the research questions, a convergent design was used (Creswell & Clark. 2011). As illustrated in the flowchart in Figure 3, the convergent design includes four steps (Creswell & Clark, 2011).

1. Both quantitative and qualitative data are collected concurrently but separately.
2. The two data sets are analyzed separately.
3. The results of the two analyses are merged.

4. The results are interpreted to see in what ways and to what extent the results of the two data sets converge, diverge, relate to each other, and/or combine in order to answer the research questions.

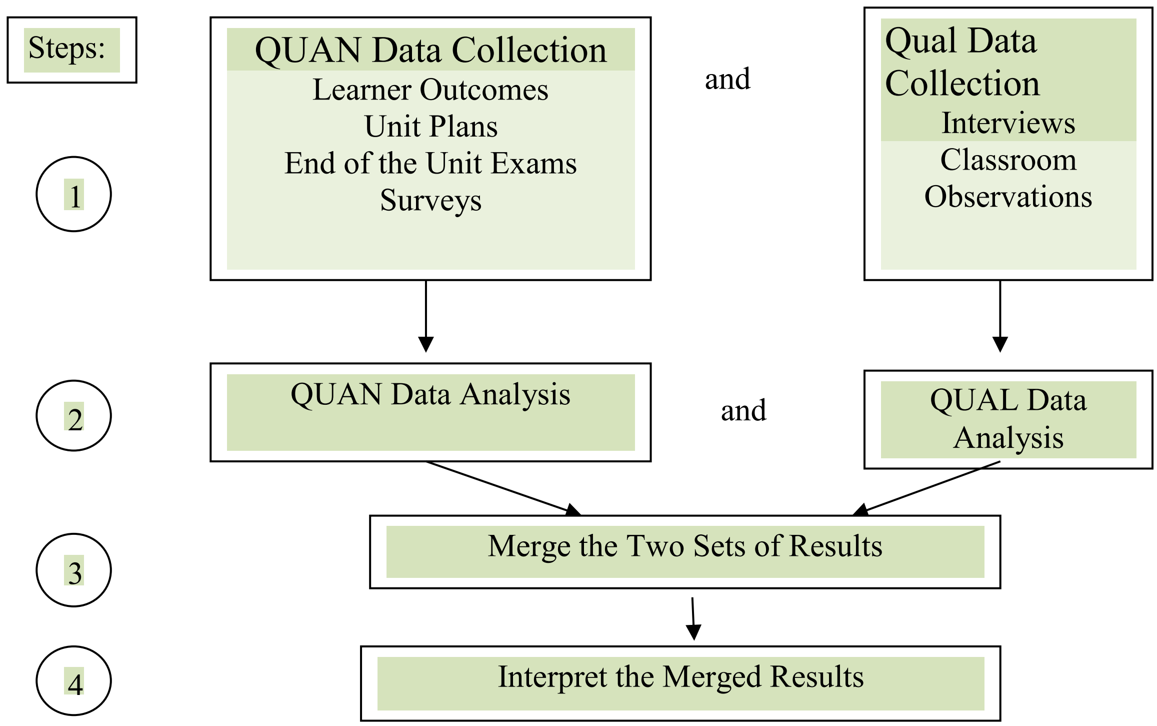

Figure 2: Flowchart of Convergent Design (adopted from Creswell & Clark (2011)

The convergent design gives equal priority to both the quantitative and qualitative data. However, for this proposed study, the data-transformation variant will be used (Creswell & Clark, 2011). Through data-transformation, the researcher will numerically code the data thereby allowing quantitative data analyses. Results from the qualitative data are combined with the quantitative data using direct comparison (Creswell & Clark, 2011). The quantitative data will be given priority while the qualitative data will be used to complement or confirm the quantitative data.

The balance of this chapter is organized in eight sections. Creation of the Taxonomy Table for a sample unit in Grade 9 Mathematics is presented first. The second section gives the process for selecting the judges who will determine the intended curriculum. The third section presents the process of training the judges, followed by the fourth section, which describes the process for collecting the judgments. Collecting information about the enacted and assessed curricula is presented in section five. The data collection and the data preparation are described in the sixth and seventh sections. Lastly, the data analyses procedures are provided in Section 8.

Permission for conducting this study was obtained from all necessary sources. Ethics approval was obtained from the University of Alberta Ethics Board. Written consent was also obtained from the school board, the school principal, and the classroom teachers. Participants were asked to sign an informed consent form before they participated in the study.

Creation of the Intended Curriculum

The revised Taxonomy Table matrix presented in Chapter 2 on page 30 was created for the Grade 9 Mathematics unit of study examined. The cell entries were initially completed by a panel of Grade 9 mathematics teachers and then validated by the same panel using the Delphi procedure (Linstone & Turoff (1975). This table, which reflects the intended curriculum, was then used to organize the

a. information collected from the surveys, classroom observations, teacher interviews, and assessments for the unit of study, and
b. analyses of the data and information collected

to determine the degree of alignment between the intended curriculum, the enacted curriculum, and the assessed curriculum.

Delphi Method

The Delphi method (Helmer, Dalkey, & Rescher, 1959) is used for structuring a group communication process where the members of the group may be in one place together or in different geographical locations and who will work independently from one another. The process allows for a group of individuals, as a whole, to deal with a complex problem. To achieve this structured communication, a set of procedures is used. Several rounds of questionnaires are sent out to a panel of experts commonly referred to as judges. After each round, the anonymous responses are aggregated and then shared along with a judge's response from the previous round with each panel member. Each panel member can then see how he/she did relative to all the panel members. Armed with this information, each judge may adjust his/her previous judgment, after which he/she returns his/her form. Often multiple rounds are needed to reach the desired level of consensus (e.g., at least 80% agreement among judges).

For this study, a panel of Grade 9 mathematics teachers initially and independently placed the learner expectations in the cells of the Taxonomy Table. They then sent the completed table to the researcher, who summarized the panel members' responses for each cell. The summary consisted of the proportion of judges who placed a learning expectation in the same cell in the Taxonomy Table. The summary, together with each judge's initial response, was sent to each judge separately. Second and third rounds were conducted and, 88% agreement was reached. The final table became the operational definition of the intended curriculum for the unit of study.

Selection of Judges

As indicted above, a panel of at least 10 Grade 9 mathematics teachers completed the placement of the learner expectations in the Taxonomy Table. To allow for the possibility of refusal to participate and to address the situation where one or more judges' were invited to participate on the panel. The selection criteria used was:

1. subject area experts in Grade 9 mathematics,
2. knowledge of students in Grade 9 mathematics,
3. experience with the interpretation of learner expectations in Grade 9 mathematics, and
4. were not participating in the survey, observations, and interviews conducted as part of the study.

In order to identify the pool of judges, the researcher notified superintendents from districts in Southern Alberta that were not involved in the study to obtain approval to contact grade 9 mathematics teachers from their districts. Following approval, 15 grade 9 mathematics teachers were invited via email to participate on the panel of judges. Ten teachers agreed to participate.

Training the Judges

To avoid possible deletions due to systematic differences among the judges, the judges who agreed to participate were trained in order to increase the possibility that all the judges completed the task in the same way. The training manual provided in Appendix A was used for the training. Assembling the judges for training in one or two locations was not possible because the judges lived in a variety of places and commuting to one location was not possible, the researcher sent the training manual as part of the judges' package and made telephone contact with each judge to help ensure that all judges completed the task in the same way.

Collecting the Judgments

As stated earlier, the Delphi procedure usually requires two or three rounds. In the present case, the judges independently placed the learner expectations first in the cells with no knowledge of what the other judges did in the first round. Then they received a copy of the Taxonomy with a summary of what the placement of the learner expectations and the judge's own placement in the second and third subsequent rounds. The judge then reviewed this version of the Taxonomy and was invited to make changes in the judge's placement of some learner expectations in light of information about the placements of the full set of judges in the previous round.

Round 1.

Each judge:

1. placed each learner expectation in the Alberta Programs of Study from the chosen unit in mathematics in the cell of the subject area Taxonomy Table that the judge believed the learner expectation belonged,
2. noted comments he/she has at all points of the process, and
3. returned the completed Taxonomy Table to the researcher.

Following receipt of the completed Taxonomy Table, the comments were examined to see if any changes in placement were in order. Then the percentage of times an item is placed in a cell was determined for the full set of judges. Copies of this summary were prepared for each judge. The cell in which the judge placed each learner expectation was marked on the judge's copy.

Round 2.

Each judge:

1. received the summary with the judge's cells marked to each judge,

2. reviewed the summary and his/her placements,
3. made any changes he/she wishes to, and
4. returned his/her possibly revised Taxonomy Table.

The percentage of times an item was placed in a cell was determined for the full set of returned Taxonomy Tables. The researcher looked at the percentage measures to determine if a third round was needed. For this study, consensus reached when 80% of the judges on the panel placed each learner expectation in the same cell of the Taxonomy Table, which was not the case after Round 2.

For the third round, copies of the second round summary was prepared for each judge and cell in which the judge placed each learner expectation was marked and the same as process as Round 2 was followed.

Collecting Information about the Enacted and Assessed Curricula

Teacher Sample

The sample of teachers for the enacted and assessed curricula parts of the Survey of Enacted Curriculum model was a convenience sample. Although eight teachers were invited to be part of the study, five teachers who were teachers in a geographically large school district in southern Alberta consented to participate. These teachers completed a teacher survey and were observed each day they taught the mathematics unit of study on Patterns and Relations. They also provided unit plans, formative and summative assessments for the unit, and participated in a closing interview. The full set of data collection instruments are listed in Table 3 in terms of the curriculum for which information was collected or provided.

Table 3

Data Collection Instruments

Intended Curriculum	**Enacted Curriculum**	**Assessed Curriculum**
Taxonomy Table	Teacher Survey	Teacher Survey
	Classroom Observations	Teacher End of the Unit test
	Teacher Interviews	Assessments administered during the instructional period
	Teacher Unit Plans	
	Assessments administered during the instructional period	

Teacher Survey

The researcher developed the teacher survey used for this study with the influence of the Survey of Enacted Curriculum (SEC) model (Porter & Smithson, 2001). The teacher survey, which was administered at the end of the unit of instruction, consisted of three parts.

In Part I, teachers indicated, for each learner expectation,

1. whether or not they provided an opportunity for the students to learn the material outlined in the learning expectation,
2. the highest level of cognitive thinking the students might engage in, and
3. the emphasis they gave to the teaching of each learner expectation.

The six levels of cognitive complexity were

a. Remembering,

b. Understanding,

c. Applying,

d. Analyzing,

e. Evaluating, and

f. Creating.

The emphasis the teacher gave to each learner expectation were:

1– Some Emphasis

2 - Moderate Emphasis

3 - Strong Emphasis.

For example, for the learner expectation, *demonstrate the differences between the exponent and the base by building models of a given power, such as* 2^3 *and* 3^2, the teachers were asked to indicate if they taught it and, if so, the level of cognitive complexity the students were engage in (Remember), and the emphasis the teacher gave to it (Moderate).

Part II asked about teachers' practices for planning, teaching, and assessing. Part III asked about teacher characteristics to allow a description of the sample of teachers. A copy of a sample Taxonomy Table for the Patterns and Relations unit in Mathematics is provided in Appendix B to illustrate the Teacher Survey that was used in the study. The unit used was the Patterns and Relations Strand, which was part of the Grade 9 mathematics program.

Classroom Observations

Researchers use classroom observations because it is proven to be an objective and reliable measurement procedure to capture what goes on during a class (Waxman & Huang, 1999). There are several strengths of using classroom observations. Classroom observations: (1) permit researchers to study the processes of education in naturalistic settings; (2) provide more detailed and precise evidence; (3) can stimulate change and verify that the change occurred; and (4) the findings from these observational studies can provide a coherent, well-substantiated knowledge base about instruction (Walberg, 1995).

A structured observation schedule was developed that used the learner expectations as stated in the unit of study on Patterns and Relations and the cognitive process for each learning expectation identified using the Delphi procedure as describe above. The observation schedule, in checklist format, allowed the observers to check off the learner expectations that were being observed and the cognitive processes used. In addition, a space was provided for additional comments or clarification. Each class was observed daily for the duration of the unit of study. The first observation was a warm-up observation during which the teacher and the students had a chance to get used to a visitor in the classroom. The rest of the visits involved making observations. Three observers assisted the researcher with the classroom observations. These observers were retired junior high mathematics teachers. A copy of the sample observation schedule is provided in Appendix C.

Instructional Plans and End of Unit Test

Unit plans and the assessment instruments the teacher in each class used during the time he/she taught the unit as well as the assessment instrument they administered at the end of the unit were collected. Each instructional activity and each item on the End of the Unit assessment instrument was placed in the appropriate cell of the Taxonomy Table. The data was used to ensure that what was stated in the unit plans were consistent with what was observed.

Interviews

A semi-structured interview format that contains predetermined open-ended questions was used as a follow-up to the teacher survey and classroom observations. This provided more in-depth information where needed (McNamara, 1999). Semi-structured interviews give those interviewed an opportunity to express their own perspectives as additional data (Patton, 2002). The questions were constructed to complement the responses to the survey questions, clarify any issues that arose during the classroom observations. They also provided an opportunity to discuss the teachers' instructional plans and assessment procedures.

An example of a predetermined question is:

1. When do you use the Alberta Programs of Study for the unit on numbers?
   a. When I planned what I would do in the numbers unit?
   ___ Yes ___ No (Go to question 3)
   b. When I planned what I am going to do in the following class on numbers?
   ___ Yes ___ No
   c. When I developed the tests/quizzes I give during the numbers unit?
   ___ Yes ___ No

A copy of the interview format is provided in Appendix D for the Patterns and Relations Strand in Grade 9 Mathematics.

Data Collection

One unit of study in Mathematics at the grade 9 level was selected for the study. At the end of unit, participating teachers were asked to share their unit plans, and the assessment instruments they used during instruction. In addition, they were asked to participate in classroom observations, a teacher survey and individual interviews.

Administration of Surveys

Teachers were asked to complete the teacher survey on their own time.

Observations

Classroom observations were conducted on a daily basis for the duration of the unit of study. It was anticipated that the unit of study would require 3 weeks or 15 classes per teacher. The first visit was a warm-up observation during which the teacher and the students had a chance to get used to a visitor in the classroom. The remainder of the visits involved making observations using the observation checklist. A brief, discussion of what was observed for each visit was shared with the corresponding teacher in order to make sure that the teacher agreed with what was recorded by the observer. At the end of the classroom observation period, the observer and the teacher met to go over the observations and addressed questions that arose.

Background of Judges

A total of 15 present (n = 9) and retired (n = 6) mathematics teachers were invited to participate on the panel of judges. Seven present and three retired teachers agreed to be involved in the process. Six were female and four were male. One judge was from Northern Alberta, three judges were from the greater Edmonton area, one judge was from rural Central Alberta, two judges were from the greater Calgary area, and three judges were from Southern Alberta. Collectively, the ten judges taught mathematics at the grades 7 to 12 levels from 7 years to 38 years, with a mean of 21.4 years. Of the ten judges, eight had experience teaching junior high (Grades 7 to 9) mathematics and the other two judges had experience teaching senior high (Grades 10 to 12) mathematics in Alberta. One judge, who taught mathematics for 17 years, had recently completed her PhD in secondary mathematics education. Another judge who had been teaching for eleven years had previously authored teaching resources in mathematics education and had been involved with the development of the assessment framework for the Student Learning Assessments (SLA) in Numeracy with

Alberta Education. All judges had B. Ed degree with a major in mathematics education. In addition, four judges had their M. Ed degrees and one judge had a Ph. D in secondary mathematics.

Background of Classroom Observers

Two well-respected retired mathematics teachers, who taught grades 7 to 9 mathematics for most of their teaching careers, agreed to do the classroom observations. In addition, one other retired teacher consented to being involved as an observer on an as needed basis and the researcher was also involved when needed. The two main observers had their B. Ed degree with a major in Mathematics education. The third observer had a B Ed and an M. Ed. with a minor in Mathematics education.

The classroom observers were trained prior to beginning their observations. The training involved the researcher providing a training session with each classroom observer to ensure that they had a common understanding of the process to be used when conducting the classroom observations. Particular attention was paid to gaining a common and clear understanding of the six cognitive levels that the observers would be looking for and which they were to record on the observation checklist. The manual used to train the observers and the observation checklists is provided in Appendix E.

Teacher Interviews

After completion of the observations, an interview was scheduled with each observed teacher to discuss the observation data, what was written in the teachers' unit plans, and the assessment instruments used. The length of the interview varied from 30 minutes to about one hour.

The researcher conducted all interviews and informed consent from the teacher was obtained prior to the interview. The researcher took notes during the interviews.

Data Preparation

All completed surveys, observation schedules, and interview forms are stored on a password protected secure site, which can only be accessed by the researcher.

Coding Observations

The coding of the completed observation schedules included all observed data as marked by the observer for each day of observations. The code of Y was given if the behavior had been observed and a code of N was given for non-observed behaviors.

Transcribing and Coding Interviews

The responses to the open-response items included in the interviews were transcribed with each line numbered to facilitate retrieving and making quotes and references. The researcher coded the transcriptions with the assistance of the written notation of the conversation taken during the interview and guided by the two dimensions in the Taxonomy Table. Two transcribed interviews were randomly selected and independently coded to obtain a measure (0.80) on inter-coder agreement. For those measures that did not have 0.80 consensuses, the remaining interviews were double-coded and then consensus reached between the two coders for each interview. The two coders were the researcher and one of the classroom observers.

Data Analysis

The data analysis was conducted in sequential order with five distinct stages for the set of learning expectations.

Stage 1: The researcher looked for agreement between the data collected for the enacted and the assessed curricula from each of the sources as illustrated in Table 3 on page 41.

Stage 2: Concurrent procedures were used to merge the quantitative data from the surveys and qualitative data collected during the classroom observations, interviews, and unit tests to obtain a complete view of the enacted and the assessed curricula for mathematics. First, the teacher survey data was matched with the unit plans and lesson plans. Second, data and information from the lesson plans were matched with classroom observations, and the interviews. The results of the final quantitative and qualitative databases were compared using a side-by-side summary table (Creswell & Plano Clark, 2011).

Stage 3: The merged data for the enacted curriculum was entered independently into the Taxonomy Table by the researcher and by one of the classroom observers. Criterion for reaching consensus was 80%.

Stage 4: The merged data from the assessed data was entered independently into the Taxonomy Table by the researcher and the classroom observer. Criterion for reaching consensus was 80%.

Stage 5: At this point, there were three Taxonomy Tables, one for the intended curriculum, one for the enacted curriculum, and one for the assessed curriculum. The original intent was to use Porter's alignment index statistic for each distinct pair of tables in order to obtain an overall index of agreement. However, this index was not used because not all of the learning expectations were measured. Consequently, it was not possible to assess the fit between the three curricula for these learner expectations.

The base for the index that reflected the overall alignment among the intended, enacted, and assessed curriculum was the total number of items administered. Two indices were computed, one of mathematics content and operations and the second for the cognitive processes.

The *mathematics content and operations index* was the ratio of the total number of teachers who taught the learner expectation given they assessed the learner expectation to the total number of items. If a teacher taught and assessed the learner expectation, then there was automatic alignment among the intended, the enacted, and the assessed curricula. If the mathematics content and operations index was close to or equaled 1.00, then there was full curriculum alignment among the intended, enacted, and assessed curricula across the five teachers.

The *cognitive process index* was the ratio of the total number of teachers who taught the intended cognitive process for learner expectation given they assessed the learner expectation at the intended cognitive level to the total number of items. If the cognitive process index was close to or equaled 1.00, then there was full curriculum alignment among the intended, enacted, and assessed curricula across the five teachers.

CHAPTER 4: RESULTS

Introduction

Chapter 4 consists of four parts. The results of the Delphi Method (the intended curriculum) are presented in Part 1. The results of the classroom observations, teacher surveys, and teacher interviews (the enacted curriculum) are provided in Part 2. The End of the Unit tests (the assessed curriculum) results are provided in Part 3. Part 4 consolidates the results of the first three parts and includes tables measuring the curriculum alignment among the intended, the enacted, and the assessed curricula.

The alignment among the intended, enacted, and assessed curricula was investigated for the Patterns and Relations Strand at the Grade 9 level. This strand has seven learner outcomes. Each outcome has from five to 10 achievement indicators or learner expectations. The alignment among the intended, enacted, and assessed curricula was examined in terms of the fit among the

a. mathematics content/operations in the learner expectations listed in the program of studies (the intended curriculum), the mathematics content/operations taught in the classroom (enacted curriculum) and mathematics content/operations assessed (assessed curriculum) and
b. cognitive processes to be used to do what is called for in the learner expectations (the intended curriculum), the cognitive processes taught in the classroom (enacted curriculum), and the cognitive processes assessed (assessed curriculum).

The Intended Curriculum

The intended curriculum in terms of mathematics content/operations was defined as the mathematics element and operation contained in a learning expectation (e.g., pictorial, oral, or written pattern, linear equation, polynomial expression). The intended curriculum in term of cognitive processes was the cognitive process the student was expected to engage while the student was "operating" with the mathematics element (e.g. write an expression, solve an equation, identify terms in a polynomial expression). For example, the first learning expectation is "Write an expression representing a given pictorial, oral, or written pattern". The mathematics element is the "pictorial, oral, or written pattern." The operation is "write an expression that represents …". The cognitive process is the process a student needs to engage to be able to complete correctly the operation. What cognitive process – remember, understand, apply, analyze, evaluate, or create – must a student use to meet the first learning expectation?

Whereas the mathematics element and operation explicitly appear in the learner expectations, cognitive processes do not. Therefore, the intended curriculum described in terms of the cognitive processes was determined by a panel of experienced mathematics teachers who used the Delphi procedure for reaching consensus (see Chapter 3).

Completion of Delphi Procedure

In most Delphi applications, three rounds of Delphi data collection are sufficient to reach consensus among the judges (Kalaian & Shah, 2006; Yang, 2003). This was also true in this study. The judges completed the placement of the learner expectations in the Taxonomy Table with at least 80% consensus in the third round for all but six of the 45 learning expectations for the Grade 9 Mathematics Patterns and Relations Strand.

Results of the Delphi Procedure

The final Round 3 percentages for each learner expectation are reported in Table 4. As shown, the judges reached 100% consensus on 10 learner expectations, 90% consensus on 23 learner expectations, 80% consensus on six learner expectations, and less than 80% consensus on six learner expectations. Table 3 in Appendix F contains the full set of results for Round 3.

Table 4

Delphi Procedure: Round 3 Results

Grade 9 Mathematics Patterns and Relations Strand

LE	1	2	3	4	5	6	7	8	9	10	11	12
DR	*Ap*	*Ap*	*U*	*Ap*	*Ap*	*U*	*Ap*	*Ap*	*U*	*U*	*U*	*U*
%	100	90	100	90	80	100	80	90	90	90	90	90
LE	13	14	15	16	17	18	19	20	21	22	23	24
DR	Ap	U	Ap	U	Ap	Ap	Ap	E	C	C	Ap	U
%	90	80	90	60	90	100	100	90	90	90	100	80
LE	25	26	27	28	29	30	31	32	33	34	35	36
DR	Ap	U	E	Ap	C	Ap	R	U	U	U	U	R
%	90	90	90	90	60	90	70	90	90	80	80	90
LE	37	38	39	40	41	42	43	44	45			
DR	Ap	E	U	U	U	Ap	E	U	U			
%	100	100	90	70	80	90	100	90	70			

Notes: LE – Learner Expectations
Cognitive Process: R – Remember, U – Understand, Ap – Apply, An – Analyze, E – Evaluate, and C – Create
DR - Delphi Results
% - Percentage of agreement by the panel of judges

The judges' comments were examined to try to gain an understanding of reasons the judges used to place the six learner expectations that did not reach 80% consensus. The comments revealed a difference on how the judges interpreted the verbs used in the learner expectation statements. For example, learner expectation 16 asks students to "identify and correct…" Four judges felt that "correct" is at a higher cognitive level than Understand; one judge placed it at Apply, one at Analyze, and two at Evaluate. Learner expectation 29 asks students to "Create a concrete model or a pictorial representation …" Four of the judges believed that the verb create may lead teachers to think that this learner expectation should be placed at a higher cognitive level. However, they felt that it asks students to model which they believe fits under the Understand dimension. One of the judges stated, "Just because the indicator has the word 'create' in it, I don't feel that justifies moving it up to the highest level". The remaining six judges felt that students are asked to create, which indicates a higher order cognitive level. Learner expectations 40 and 45, which required students to "identify errors in a given explanation of the simplification of a polynomial expression" led to different placements. While three judges indicated the two learner expectations required evaluation and placed them at the fifth cognitive level, Evaluate, seven judges indicated that "identification of errors…" required interpreting and explaining and placed the two expectations at the second cognitive level, Understanding.

A question arises, how much of the confusion is due to the judges' interpretation and how much is due to the language utilized in the learner expectations? The answer to this question was beyond the scope of this study. However, Alberta Education should clarify the learner expectations to the point that what is stated is interpreted by all Grade 9 mathematics teachers in essentially the same way.

The Enacted Curriculum

The enacted curriculum was determined by having qualified observers observe all classes in which a sample of teachers taught the learner expectations for the Patterns and

Relations Strand, administering a survey questionnaire to the teachers observed and conducting a follow-up interview of the teachers observed.

Classroom Teachers

Eight teachers in a school district in Southern Alberta were invited to participate in the study. Five teachers from three schools in the district accepted the invitation and gave consent to participate. Of the five teachers, three taught at the same school and two teachers taught at different schools. Two teachers were male and three teachers were female. The teachers tended not to move from one school to another; at the time of this study, four teachers had taught at the same school for 27 years, 21 years, 14 years, 8 year, and the fifth teacher was in in her first year of teaching (replaced a maternity leave teacher). Three teachers had been teaching Mathematics for 20 years, one teacher had been teaching Mathematics for 14 years and fifth teacher was in the first year of teaching Mathematics. Three teachers held a B. Ed. Degree, one held a B. A. degree and a B. Ed degree, and the fifth teacher held a B. Ed. Degree and a M. Ed degree. Their major areas of study were: Music, Drama, Languages, French, and Native Education/Social Studies. None of the teachers had majored in Mathematics but one teacher had minored in Mathematics.

While conducting the teacher interviews, it became clear that the five mathematics teachers were members of the district mathematics team. The team members re-wrote the learner expectations in the Program of Studies for mathematics into “I can…” statements. The team members also created three formative booklets organized in terms of the Learner Outcomes for the Pattern and Relations Strand and taking into account the learner expectations within each learner outcome. For example, the curriculum content covered in

Booklet 1 was Patterns and Equations and Graphing Linear Relations. The learner expectations and the corresponding “I can” statements were stated as follows:

Patterns and Equations - Generalize a pattern arising from a problem-Solving context, using a linear equation and verify by substitution.

Learner Expectation from the Program of Study	Rewritten into “I can…” Statements
1. Write an expression representing a given pictorial, oral or written pattern.	☐I can define what a linear relation is.
2. Write a linear equation to represent a given context.	☐I can write a linear relation to describe a pattern.
3. Describe a context for a given linear equation.	☐I can create a table of values from an equation.
4. Solve, using a linear equation, a given problem that involves pictorial, oral and written linear patterns.	☐I can write a linear equation from a table of values.
5. Write a linear equation representing the pattern in a given table of values, and verify the equation by substituting values from the table.	☐I can write a linear equation from a given context.

Graphing Linear Relations - Graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems.

Learner Expectation from the Program of Study	Rewritten into “I can…” Statements
6. Describe the pattern found in a given graph.	☐I can graph a linear equation
7. Solve a given problem by graphing a linear relation and analyzing the graph.	☐I can graph a table of values.
8. Graph a given linear relation, including horizontal and vertical lines.	☐I can create a table of values from a graph.
9. Match given equations of linear relations with their corresponding graphs.	☐I can describe a pattern found in a graph.
10. Extend a given graph (extrapolate) to determine the value of an unknown element.	☐I can extend a pattern found in a graph.
11. Interpolate the approximate value of one variable on a given graph, given the value of the other variable.	☐I can solve problems involving linear equations and graphs

Booklet 2 covered Solving Equation and Inequalities, and Booklet 3 covered Polynomials.

Each of the booklets also contained a series of questions for students that reinforced the concepts covered in the booklet. After instruction of each concept taught, it was expected that students work through these questions in the booklets individually or with a partner and ask clarifying questions of their partner or the teacher. At the completion of each booklet, it was expected that students would work through the formative test for the booklet. After the formative test was discussed and corrected, and the teacher in his/her professional judgment felt that the students had learned the material covered in each booklet, the students were given a summative test. This planning and teaching process was followed for all three booklets. The booklets did not provide any information regarding the cognitive levels of the concepts to be taught. Despite this latter observation, it might be expected that essentially the same mathematics content, operations, and cognitive processes called for by the learning expectation (the intended curriculum) would be observed in the classroom observations and reported by the teachers in the teacher survey and interviews.

Classroom Observations

The classroom observations started mid-January and concluded mid-May. Participating teachers started teaching the Patterns and Relations strand at different times within the four-month period. One teacher started teaching the strand January 20th, while the last teacher started the strand on April 28th. The number of weeks the teachers took to cover the strand was seven weeks, eight weeks, two at 10 weeks, and 12 weeks. Mathematics 9 was taught 5 periods per week in two of the schools and seven periods per week in the third school. The length of the periods was 40 minute in two schools and 44 minutes in one school. The classroom observations were conducted in each class during the time that the Patterns and Relations strand was taught. Altogether, a total of 238 classroom observations were made.

Classroom Observer Results

The learner expectations and the cognitive processes taught by the teachers as observed by the classroom observers are reported for each teacher in Table 5, respectively.

Table 5

Teacher Survey and Classroom Observations of Learner Expectations and Cognitive Process

LE	1	2	3	4	5	6	7	8	9	10	11	12
Teacher A												
ClOb	*Ap*	*U*	*Ap*	*An*	*An*	*E*	*An*	*Ap*	*Ap*	*Ap*	*Ap*	*Ap*
YSur	U	U	U	E	Ap	U	Ap	Ap	U	An	E	E
LE	13	14	15	16	17	18	19	20	21	22	23	24
ClOb	Ap	AP	Ap	An	An	E	Ap	Ap	Ap	An	Ap	Ap
TSur	Ap	An	Ap	An	Ap	Ap	Ap	E	C	E	Ap	An
LE	25	26	27	28	29	30	31	32	33	34	35	36
ClOb	Ap	Ap	E	E	Ap	Ap	Ap	An	Ap	Ap	An	An
TSur	An	E	An	Ap	An	Ap	Ap	Ap	Ap	Ap	Ap	An
LE	37	38	39	40	41	42	43	44	45			
ClOb	Ap	An	An	Ap	Ap	Ap	An	NO	An			
TSur	Ap	An	An	E	Ap	Ap	Ap	E	E			
LE	1	2	3	4	5	6	7	8	9	10	11	12
Teacher B												
ClOb	***Ap***	***Ap***	*C*	*Ap*	*Ap*	*E*	*An*	*Ap*	***E***	*Ap*	*E*	*Ap*
TSur	**Ap**	**Ap**	An	An	An	An	Ap	An	**E**	An	An	An
LE	13	14	15	16	17	18	19	20	21	22	23	24
ClOb	Ap	Ap	Ap	Ap	Ap	Ap	Ap	**Ap**	Ap	Ap	Ap	Ap
TSur	An	An	E	An	An	An	An	**Ap**	An	An	An	An
LE	25	26	27	28	29	30	31	32	33	34	35	36
ClOb	Ap	Ap	**Ap**	Ap	**Ap**	Ap	Ap	**Ap**	NO	**Ap**	**Ap**	Ap
TSur	An	E	**Ap**	An	**Ap**	An	An	**Ap**	An	**Ap**	**Ap**	An
LE	37	38	39	40	41	42	43	44	45			
ClOb	Ap	Ap	Ap	NO	**Ap**	Ap	U	NO	An			
TSur	An	An	An	An	**Ap**	An	An	E	E			
LE	1	2	3	4	5	6	7	8	9	10	11	12
Teacher C												
ClOb	*Ap*	***U***	*Ap*	*An*	*An*	*E*	*An*	***Ap***	*Ap*	*Ap*	*Ap*	*Ap*
TSur	U	**U**	U	E	Ap	U	Ap	**Ap**	U	An	E	E

Table 5 Cont.

LE	13	14	15	16	17	18	19	20	21	22	23	24
ClOb	**Ap**	Ap	**Ap**	**An**	An	E	**Ap**	Ap	Ap	An	**Ap**	Ap
TSur	**Ap**	An	**Ap**	**An**	Ap	Ap	**Ap**	E	C	E	**Ap**	An
LE	25	26	27	28	29	30	31	32	33	34	35	36
ClOb	Ap	Ap	E	E	Ap	**Ap**	**Ap**	An	**Ap**	**Ap**	An	An
TSur	An	E	An	Ap	An	**Ap**	**Ap**	Ap	**Ap**	**Ap**	Ap	An
LE	37	38	39	40	41	42	43	44	45	LE	37	38
ClOb	**Ap**	**An**	**An**	Ap	**Ap**	**Ap**	Ap	NO	An	ClOb	**Ap**	**An**
TSur	**Ap**	**An**	**An**	E	**Ap**	**Ap**	An	E	E	TSur	**Ap**	**An**
LE	1	2	3	4	5	6	7	8	9	10	11	12
Teacher D												
ClOb	*Ap*	***U***	*Ap*	*An*	*An*	*E*	*An*	***Ap***	*Ap*	*Ap*	*Ap*	*Ap*
TSur	U	**U**	U	E	Ap	U	Ap	**Ap**	U	An	E	E
LE	13	14	15	16	17	18	19	20	21	22	23	24
ClOb	**Ap**	Ap	**Ap**	**An**	An	E	**Ap**	Ap	Ap	An	**Ap**	Ap
TSur	**Ap**	An	**Ap**	**An**	Ap	Ap	**Ap**	E	C	E	**Ap**	An
LE	25	26	27	28	29	30	31	32	33	34	35	36
ClOb	Ap	Ap	E	E	Ap	**Ap**	**Ap**	Ap	**Ap**	**Ap**	An	An
TSur	An	E	An	Ap	An	**Ap**	**Ap**	An	**Ap**	**Ap**	Ap	An
LE	37	38	39	40	41	42	43	44	45			
ClOb	**Ap**	**An**	**An**	Ap	**Ap**	**Ap**	An	NO	An			
TSur	**Ap**	**An**	**An**	E	**Ap**	**Ap**	Ap	E	E			
LE	1	2	3	4	5	6	7	8	9	10	11	12
Teacher E												
ClOb	*Ap*	***U***	*Ap*	*An*	*An*	*E*	*An*	***Ap***	*Ap*	*Ap*	*Ap*	*Ap*
TSur	U	**U**	U	E	Ap	U	Ap	**Ap**	U	An	E	E
LE	13	14	15	16	17	18	19	20	21	22	23	24
ClOb	**Ap**	Ap	**Ap**	**An**	An	E	**Ap**	Ap	Ap	An	**Ap**	Ap
TSur	**Ap**	An	**Ap**	**An**	Ap	Ap	**Ap**	E	C	E	**Ap**	An
LE	25	26	27	28	29	30	31	32	33	34	35	36
ClOb	Ap	Ap	E	E	Ap	**Ap**	**Ap**	An	**Ap**	**Ap**	An	An
TSur	An	E	An	Ap	An	**Ap**	**Ap**	Ap	**Ap**	**Ap**	Ap	An
LE	37	38	39	40	41	42	43	44	45			
ClOb	**Ap**	**An**	**An**	Ap	**Ap**	**Ap**	An	NO	NO			
TSur	**Ap**	**An**	**An**	E	**Ap**	**Ap**	Ap	E	E			

Notes: LE – Learner Expectations
Cognitive Process: R – Remember, U – Understand, Ap – Apply, An – Analyze, E – Evaluate, and C – Create
ClOb - Classroom Observations
TSur - Teacher Survey
NO - not observed

Two sets of results are provided for each teacher. The letters in the first row indicate the cognitive process the observers saw being taught for each learner expectation. The letters in the second row indicate the cognitive process the teachers indicated they taught for each learner outcome. For example, for the first learning outcome, “Write an expression representing a given pictorial, oral or written pattern”, teachers *A* (First Panel, Table 5) and *B* (Second Panel, Table 5) were observed teaching at the Apply cognitive level and teachers *C* (Third Panel, Table 5), *D* (Fourth Panel, Table 5), and *E* (Fifth Panel, Table 5) were observed teaching the at the Create cognitive level. The teachers indicated on the survey form that the cognitive process they taught was Understanding, Apply, Understanding, Understanding, and Understanding, respectively. As can be seen, there is agreement between what the observer saw and what the teacher indicated for only Teacher B for the first learner expectation.

*Content/Operations***.** The classroom observations indicated that the five teachers taught all but a few of the 45 Patterns and Relations learner expectations. Teacher *A* (First Panel, Table 5) taught all but learning expectation 44, Teacher *B* (Second Panel) taught all the learner expectations but 33, 40 and 44; Teacher *C* (Third Panel) taught all learner expectations but 23, 29, 30, 32, 33, 37, 38, 40, and 44; Teacher *D* (Fourth Panel) taught all the learner expectations but 15 and 44; and Teacher *E* (Fifth Panel) taught all of the learner outcomes. That is, of the 45 learner expectations, learner expectation 44 was taught by one teacher, learner expectations 33 and 40 were taught by three teachers, and learner expectations 15, 23, 29, 30, 32, 37, and 38 were taught by four teachers. Taken together, the results suggest the enacted curriculum defined in terms of mathematics content (elements and operations) set out in the learner expectations was essentially aligned with the intended curriculum defined in terms of the mathematics content identified in the learning expectations.

*Cognitive Process***.** In contrast and as foreshadowed above, there was variability among the cognitive process levels at which the teachers taught the learner expectations as observed by the classroom observers for most learner expectation. There were only three learner expectations – 12, 13, and 20 – that all five teachers taught the same cognitive level to their students and only nine learner expectations that four of the five teachers taught the same cognitive level to their students. The same cognitive levels for the remaining 33 learner expectations were taught by no more than three teachers. Clearly, despite being members of the District's mathematics team, there is unwanted variation in the cognitive processes observed being taught to students. All students did not receive the same instruction with respect to cognitive processing.

Teacher Surveys and Teacher Interviews

The five participating teachers completed separately the teacher survey after each had completed teaching the Patterns and Relations strand. Part I of the survey asked the teachers to indicate whether or not they provided an opportunity for the students to learn the material outlined in the learning expectations, the highest level of cognitive thinking the students were engaged in, and the emphasis they gave to each learner expectation. Part II asked about teachers' practices for planning, teaching, and assessing student learning for the Patterns and Relations strand. Part III asked about teacher characteristics to allow for a description of the sample of teachers. Teacher interviews were also conducted after the teachers completed teaching the Patterns and Relations strand and the Teacher Survey. The researcher met with each teacher individually at the school site. The results of components of Parts I and II of the teacher surveys and the results of the teacher interviews are presented and discussed in the next four subsections. The teacher characteristics were provided earlier in the description of the group of five teachers.

Teacher Surveys and Teacher Interviews Results

Content/Operations. With one exception, the teachers indicated that they had provided their students with an opportunity to learn the mathematics contents and operations identified in the learner expectations for the Patterns and Relations strand. Teacher D indicated that she did not provide an opportunity to learn learner expectation 32. These results confirm the earlier suggestion that the enacted curriculum defined in terms of mathematics content (elements and operations) set out in the learner expectations was essentially aligned with the intended curriculum defined in terms of the mathematics content identified in the learning expectations.

Emphasis. The Alberta Program of Studies for mathematics does not specify emphasis to be given to any strand or learning expectation. Given this lack of assigned emphasis by the Program of Studies, a conclusion can be made that learner expectations should be given equal emphasis. This was not the case in this study. Despite the mathematics content coverage, the five teachers varied in the emphasis they gave to each learning expectation as shown in Table 6. For example, Teacher A gave 23 learner expectations an emphasis of 1, Teacher B gave zero learner expectations an emphasis of 1, Teacher C gave 19 learner expectations an emphasis of 1, Teacher D gave 13 learner expectations and emphasis of 1, and teacher E gave 11 learner expectations an emphasis of 1. More specifically, for learner expectation 9, teacher A gave it a two, teacher B gave it a three, teacher C gave it a one, teacher D gave it a three, and teacher E gave it a two. There were only two learner expectations that were given the same emphasis by all five teachers.

Cognitive Process. There was significant variability in the cognitive process levels at which each learner expectation was taught as reported by the teachers. For example, for the

Table 6

Emphasis of Learner Expectations as Indicated by the Teachers

LE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
T A	*1*	*2*	*1*	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*1*	*1*
T B	*2*	*2*	*2*	*3*	*3*	*3*	*2*	*3*	*3*	*2*	*NA*	*2*
T C	*3*	*2*	*1*	*1*	*3*	*1*	*2*	*3*	*1*	*1*	*1*	*1*
T D	*2*	*2*	*1*	*3*	*2*	*2*	*2*	*3*	*3*	*3*	*3*	*3*
TE	*1*	*3*	*2*	*2*	*3*	*2*	*1*	*3*	*2*	*3*	*3*	*2*
L E	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***
T A	*1*	*2*	*2*	*1*	*2*	*1*	*NA*	*1*	*NA*	*NA*	*2*	*1*
T B	*2*	*2*	*3*	*2*	*3*	*2*	*3*	*2*	*3*	*3*	*3*	*3*
T C	*1*	*3*	*2*	*1*	*3*	*3*	*2*	*1*	*2*	*2*	*2*	*1*
T D	*1*	*1*	*2*	*2*	*2*	*3*	*3*	*1*	*2*	*3*	*1*	*1*
TE	*1*	*1*	*3*	*2*	*2*	*3*	*2*	*1*	*3*	*2*	*3*	*3*
L E	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
T A	*2*	*1*	*2*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*2*	*2*
T B	*3*	*3*	*2*	*3*	*3*	*3*	*3*	*2*	*2*	*3*	*3*	*2*
T C	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*2*	*3*	*2*	*2*	*3*
T D	*3*	*1*	*1*	*3*	*3*	*3*	*3*	*0*	*3*	*2*	*2*	*3*
T E	*2*	*2*	*1*	*3*	*3*	*3*	*3*	*1*	*2*	*3*	*1*	*1*
LE	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**			
T A	*1*	*1*	*2*	*2*	*1*	*1*	*1*	*2*	*2*			
T B	*3*	*2*	*2*	*2*	*3*	*3*	*2*	*2*	*2*			
T C	*1*	*1*	*1*	*1*	*3*	*1*	*1*	*2*	*2*			
T D	*1*	*1*	*2*	*2*	*1*	*1*	*1*	*3*	*2*			
T E	*3*	*0*	*1*	*2*	*3*	*3*	*0*	*1*	*2*			

Note: 0 – Not Emphasized 1 – Some Emphasis 2 – Moderate Emphasis 3 – Strongly Emphasized
NA - Not Assigned

first expectation, Teacher A (First Panel, Table 5) taught at the cognitive level Understand, Teachers B (Second Panel) and D (Fourth Panel) taught at the cognitive level Apply, and Teachers C (Third Panel) and E (Fifth Panel) taught at the cognitive level Create. There was no learning expectation that five teachers reported they taught at the same cognitive level. There were only seven expectations – 2, 7, 8, 13, 20, 28, and 31 – that four of the five teachers taught at the same cognitive process level. For the remaining 37 learning expectations, no more than three teachers indicated they taught at the same cognitive process level.

During the interviews that were held with each teacher after they had completed their survey, the teachers were asked what they did to get students to see and understand higher order cognitive processes for the learning outcomes that called for higher order thinking. Their answers varied. Teacher D had the students explain their thought processes, or had them solve problems on the board and then lead a discussion on why the answer was correct or incorrect. Teacher E stated "my favorite way was to have students create their own patterns and give these patterns to their peers to solve on the board, and then discuss them as a whole class." Teachers B felt that teaching higher order thinking skills and problem solving presented the greatest challenge. They needed to make a conscious effort to teach these higher order thinking skills because students tended to want the answer given to them and it was sometimes easier to cater to the students rather than have them develop their own solutions. Teacher B expressed her belief that they had covered all the learning outcomes but noticed that they tended to stay more at the lower three cognitive levels. The teacher went on to say that it was "a reminder that work needs to be done at the higher levels".

Teachers' view of alignment. As indicated earlier, all five teachers were members of the district mathematics team that developed a series of common instructional activities and assessments. To ensure alignment among what they developed, the committee developed the schematic shown in Figure 3.

learner outcomes → "I can…" statements → booklets → worksheets → common tests for each booklet → end of the unit test.

Figure 3: Schematic of Teachers View of Alignment

Despite this planning and preparation and the schematic, the teachers did not firmly follow what was developed. Teacher B indicated she used, "a variety of resources and strategies" and indicated he/she used suggested activities from LearnAlberta's Planning Guides and textbook activities and practice questions. Teacher E stated that he tried to design instructional activities directed toward the achievement of specific skills within each outcome. Teacher B added, " I do my best to incorporate differentiation in the form of activities to suit various learning styles and ability levels. I design assessments, especially formative assessments, in a way that I hope is a logical follow-up from the learning activities I have used during teaching". In contrast, Teacher E stated that the booklets were used as the dipstick and that everything that was taught or assessed was based on the booklets. Two teachers indicated that it was their first year using the booklets and that students liked the booklets and how they were aligned. One of the two teachers stated, "Personally, I think that learning has improved but not because of the booklets but because the booklets provided opportunities for dialogue and individual attention". The other teacher stated, "using the booklets was a learning process for me as well as the kids this year". However, Teachers A and B expressed a need for further professional development on the alignment process. Teacher B added that the alignment "is a skill that I am still trying to perfect".

At the end of the interview the teachers were asked what training in curriculum alignment they had in their pre-service teacher education program or since they have been teaching. Teacher C indicated taking courses in which the alignment between classroom instruction and the Program of Studies was covered during her pre-service teacher education program. The remaining four teachers emphatically said that they had not received any training in curriculum alignment in their pre-service teacher education program. However, these same teachers indicated that they had taken part in the district's Mathematics committee meetings to rewrite the learner expectations as "I can…" statements, met with a cohort of teachers in their district to plan and share resources, and/or attended a Professional Development session which addressed curriculum alignment or teaching strategies.

The Assessed Curriculum

The assessed curriculum was defined by the end-of-unit test or sequentially ordered tests administered during the unit. Although the teachers indicated that the district team created an end of the unit summative test, only one teacher used the district test. Teachers A, C, and D used an end of the unit test that they created together. Teacher B did not use an end of the unit test, *per se*. Rather, Teacher B used a series of progressive tests, each test covering a segment of the learner expectations. Teacher E used the district test. The researcher and one of the classroom observers independently determined the classification of the learner expectations that were assessed and the cognitive processing levels called for by each item included in each of the three tests. There was 96% agreement with the learner expectations and 85.5% agreement with the cognitive levels. Following discussion, 100% agreement was reached for both the classification of the learner expectations and the cognitive levels.

The test created by Teachers A, C, and D consisted of 22 multiple-choice items and four numeric response items assessing 18 of the 45 learner outcomes. As shown in Table 7, the learner expectations that were assessed were: 4, 5, 6, 7, 9, 13, 15, 19, 20, 23, 25, 29, 31, 34, 35, 37, 41, and 42. As shown in Table 7 two learner expectations were assessed at the cognitive level Remember, 11 learner expectations were assessed at the cognitive level Understand, eight learner expectations were assessed at the cognitive level Apply, three

Table 7

Unit Test Items, Learner Expectations, and Cognitive Processes: Teachers A, C, and D

Item	**1**	**NR**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**NR**	**10**
LE	*31*	*4*	*5*	*41*	*6*	*23*	*4*	*4*	*7*	*42*	*4*	*20*
CP(AC)	R	An	U	Ap	Ap	Ap	U	U	An	U	Ap	U
Item	**11**	**12**	**13**	**14**	**15**	**NR**	**16**	**17**	**18**	**19**	**20**	**21**
LE	*23*	*37*	*4*	*19*	*13*	*42*	*25*	*35*	*25*	*34*	*29*	*9*
CP(AC)	Ap	U	An	U	Ap	E	U	U	U	Ap	Ap	An
Item	**NR**	**22**										
LE	15	31										
CP(AC)	U	R										

Notes:- LE – Learner Expectations
CP(AC) – Cognitive Process: R – Remember, U – Understand, Ap – Apply, An – Analyze, E - Evaluate, and C – Create: (Assessed Curriculum)

learner expectations were assessed at the cognitive level Analyze, and one learner expectation was assessed at the cognitive level Evaluate. There were three learner expectations that were assessed more than once. Four questions assessed learner expectation 4; two questions were at the cognitive level Understand one question was at cognitive level Apply and one question was at the cognitive level Analyze. Two questions assessed learner expectations 25; both questions were at the cognitive level Understand. Two questions assessed learner expectations 31; both questions were at the cognitive level Remember. In addition, there was one question that appeared twice in two different parts of the test.

The series of progressive summative tests used by Teacher B contained 68 questions that assessed 19 of the 45 learner expectations. As reported in Table 8, the 19 learner expectations that were assessed included: 1, 5, 6, 8, 12, 13, 15, 19, 23, 25, 28, 31, 34, 35, 37, 39, 41, 42, and 44. Thirty-five items assessed at the cognitive level "Understand", 32 items assessed at the cognitive level Apply, and one item assessed at the cognitive level Analyze.

Table 8

Unit Test Items, Learner Expectations and Cognitive Processes: Teacher B

Item	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**B1**	**B2**	**B3**	**C1**
LE	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*5*
CP(AC)	U	U	U	U	U	U	U	U	Ap	Ap	Ap	Ap

Item	**C2**	**C3a**	**C3b**	**C3c**	**C3d**	**C4a**	**C4b**	**C4c**	**C5**	**D1**	**D2**	**D3**
LE	*5*	*6*	*6*	*12*	*6*	*6*	*6*	*12*	*8*	*15*	*15*	*15*
CP(AC)	U	U	U	Ap	U	U	U	U	Ap	Ap	Ap	Ap

Item	**D4**	**D5**	**D6**	**D7**	**D8**	**E1a**	**E1b**	**E2a**	**E2b**	**E3a**	**E3b**	**E4a**
LE	*15*	*15*	*15*	*15*	*15*	*19*	*19*	*19*	*19*	*25*	*25*	*23*
CP(AC)	Ap	Ap	Ap	Ap	Ap	U	U	U	U	U	U	U

Item	**E4b**	**F1a**	**F1b**	**F2a**	**F2b**	**F2c**	**G1a**	**G1b**	**G1c**	**H1**	**H2**	**I1**
LE	*23*	*23*	*23*	*23*	*23*	*23*	*23*	*23*	*23*	*28*	*28*	*31*
CP(AC)	U	U	U	Ap	Ap	Ap	Ap	Ap	Ap	Ap	Ap	U

Item	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**I10**	**I11**	**J1**	**J2**
LE	*41*	*31*	*42*	*34*	*31*	*44*	*31*	*1*	*1*	*42*	*31*	*31*
CP(AC)	U	U	Ap	Ap	Ap	Ap	U	Ap	Ap	U	U	Ap

Item	**J3a**	**J3b**	**J3c**	**J3d**	**J4**	**J5a**	**J5b**	**J6**
LE	*42*	*41*	*34*	*35*	*37*	*39*	*39*	*41*
CP(AC)	U	U	U	U	An	Ap	Ap	Ap

Notes:- LE – Learner Expectations
CP(AC) – Cognitive Process: R – Remember, U – Understand, Ap – Apply, An – Analyze, E – Evaluate, and C – Create: (Assessed Curriculum)

There were 14 learner expectations that were assessed more than once. Two questions assessed learner expectation 1; both questions were at the cognitive level Apply. Two questions assessed learner expectation 5; one question was at the cognitive level Understand, and one question was at the cognitive level Apply. Five questions assessed learner expectation 6; all five questions were at the cognitive level Understand. Two questions assessed learner expectation 12; one question assessed at the cognitive level Understand, and one question assessed at the cognitive level Apply. Eleven questions assessed learner expectation 13, eight questions were at the cognitive level Understand, and three questions were at the cognitive level Apply. Eight questions assessed learner expectation 15; all eight questions were at the cognitive level Apply. Four questions assessed learner expectation 19; all four questions were at the cognitive level Understand. Ten questions assessed learner expectation 23, four questions were at the cognitive level Understand, and six questions were at the cognitive level Apply. Two questions assessed learner expectation 25; both questions were at the cognitive level Understand. Two questions assessed learner expectation 28; both questions were at the cognitive level Apply. Five questions assessed learner expectation 31, four questions were at the cognitive level Understand, and one question was at the cognitive level Apply. Two questions assessed learner expectation 39, both questions were at the cognitive level Apply. Two questions assessed learner expectation 41, one question was at the cognitive level "Understand", and one question was at the cognitive level Apply. Two questions assessed learner expectation 42; both questions were at the cognitive level Understand.

The district created test used by Teacher E contained 20 questions with nine questions having multiple parts for a total of 45 items. As illustrated in Table 9, the district's team assessed 20 of the 45 learner expectations – 2, 5, 6, 7, 8, 11, 12, 13, 14, 17, 18, 19, 28, 30, 31, 32, 34, 35, 42, and 45 and the parts of questions with parts are separated. Of the full set of assessed learner expectations, one learner expectation was assessed at the cognitive level Remember, eight learner expectations were assessed at the cognitive level Understand, 32 learner expectations were assessed at the cognitive level Apply, one learner expectation was assessed at the cognitive level Analyze, two learner expectations were assessed at the cognitive level Evaluate, and one learner expectations was assessed at the cognitive level Create.

Table 9

Unit Test Items, Learner Expectations and Cognitive Processes: Teacher E

Item	**1**	**2**	**4**	**4a**	**4b**	**4c**	**5**	**6**	**7a**	**7b**	**7c**	**7d**
LE	*2*	*2*	*5*	*2*	*2*	*2*	*5*	*6*	*6*	*11*	*6*	*12*
CP	Ap	Ap	E	Ap	Ap	Ap	Ap	U	Ap	Ap	Ap	Ap
Item	**7e**	**8a**	**8b**	**8c**	**8d**	**8e**	**8f**	**9a**	**9b**	**9c**	**9d**	**9e**
LE	32	5	8	18	7	12	12	13	13	13	13	13
CP	C	Ap	Ap	An	Ap	Ap	Ap	U	U	U	U	U
Item	**10**	**11**	**12a**	**12b**	**13**	**14a**	**14b**	**15a**	**15b**	**16**	**17**	**18a**
LE	14	30	17	18	19	28	28	28	28	29	31	34
CP	Ap	U	Ap	Ap	Ap	Ap	Ap	Ap	Ap	E	R	Ap
Item	**18b**	**18c**	**18d**	**18e**	**19a**	**19b**	**19c**	**19d**	**20**			
LE	35	34	35	34	42	42	42	42	45			
CP	Ap	Ap	Ap	Ap	Ap	Ap	Ap	Ap	U			

Notes:- LE – Learner Expectations
CP – Cognitive Process: R – Remember, U – Understand, Ap – Apply, An – Analyze, E – Evaluate, and C – Create

There were five questions that assessed learner expectation 2; all five questions were at the cognitive level Apply. Three questions assessed learner expectation 5; two questions were at the cognitive level Apply and the other question was at the cognitive level Evaluate. Three questions assessed learner expectation 12; all three questions were at the cognitive level Apply. Five questions assessed learner expectation 13; all five questions were at the cognitive level Understand. Four questions assessed learner expectations 28; all four questions were at the cognitive level Apply. Three questions assessed learner expectation 34; all three questions were at the cognitive level Apply. Two questions assessed learner expectation 35; both questions were at the cognitive level Apply. Four questions assessed learner expectation 42; all four questions were at the cognitive level Apply.

Alignment among the Intended, Enacted, and Assessed Curricula

The analyses of results will be discussed in two parts. Part 1 will examine the alignment in the content/operations domain. Part 2 will look at the alignment in the cognitive process domain. Within both domains, the alignment of the intended, enacted, and assessed curricula will be discussed. Two methods were used to gather data for the enacted curriculum. The first method was classroom observations made by retired grade 9 Mathematics teachers. Both observers had taught mathematics for a good more than 30 years and both had majored in mathematics. The second method was teachers' self report via the Teacher Survey. While all but one teacher had a good number of years teaching mathematics, only one had a minor in mathematics. As reported above, there was not strong agreement between the placements of the learner expectations in the six cognitive process levels. Given the stronger university mathematics of the observers and their greater teaching experience, it was assumed that their classifications were more accurate than the teachers' classifications. Therefore, the results from the classroom observations were used for the enacted curriculum.

As mentioned in Chapter 3, the assessment among the intended, enacted, and assessed curricula was based on the learning expectations that were assessed. Indeed, as shown in the matching of what cognitive process was assessed by each item not all learner expectations were assessed by each teacher (see Tables 10, 11, and 12). Further, 12 learner expectations did not have an assessment item. Consequently, it was not possible to assess the fit between the three curricula for these 12 learner expectations.

Altogether 191 items or item parts were administered. This was the base for the index that reflected the overall alignment among the intended, enacted, and assessed curriculum. Two indices were computed, one of mathematics content and operations and the second for the cognitive processes.

The *mathematics content and operations index* was the ratio of the total number of teachers who taught the learner expectation given they assessed the learner expectation to the total number of items, 191. If a teacher taught and assessed the learner expectation, then there was automatic alignment among the intended, the enacted, and the assessed curricula. If the mathematics content and operations index was close to or equaled 1.00, then there was full curriculum alignment among the intended, enacted, and assessed curricula across the five teachers.

The *cognitive process index* was the ratio of the total number of teachers who taught the intended cognitive process for learner expectation given they assessed the learner expectation at the intended cognitive level to the total number of items, 191. If the cognitive process index was close to or equaled 1.00, then there was full curriculum alignment among the intended, enacted, and assessed curricula across the five teachers.

Mathematics Content/Operations

The results for the alignment among the intended, enacted, and assessed curricula for content and operations are presented in Table 10. The number of teachers who both taught and assessed Learner Expectation was 1. Three teachers both taught and assessed Learner Expectation 4. The value of the mathematics content and operations index for the mathematics content and operations was 0.97. The results of this study indicate that there is high alignment (Index: $AI_{123} = 0.97$) among the intended, enacted, and assessed

Table 10

Full Curriculum Alignment: *Mathematics Content/Operations*

LE	Number of Teachers						NA
	0	1	2	3	4	5	
1		X					
2		X					
3		X					
4				X			
5						X	
6						X	
7						X	
8		X					
9					X		
10							X
11					X		
12			X				
13						X	
14		X					
15				X			
16							X
17		X					
18			X				
19						X	
20				X			
21							X
22							X
23				X			
24							X
25					X		
26							X
27							X
28			X				
29			X				
30		X					
31						X	
32		X					
33							X
34						X	
35						X	
36							X
37				X			
38							X
39		X					
40							X

Table 10 (Cont.)

LE	Number of Teachers						NA
	0	1	2	3	4	5	
41					X		
42						X	
43							X
44							X
45		X					

Note: RS - Rating Scale

0 - No match among the intended, the enacted and the assessed curricula

1 - One teacher Full Curriculum match

2 - Two teachers full Curriculum match

3 - Three teachers full curriculum match

4 - Four teachers full curriculum match

5 - Five teachers full curriculum match

NA - Learner Expectations were not assessed

curricula in the content/operations of learner expectations. In other words, the study found that teachers taught the learner expectations as prescribed in the Program of Studies and they assessed what they taught. The majority of the items on the End of the Unit tests were connected to a learner expectation that the teachers said they taught and that the classroom observer indicated they had taught by virtue of placing the cognitive process taught in one of the six cognitive process levels. Teachers based their instruction and their assessment on the content and operation associated with the each learner expectation. One teacher but not necessarily the same teacher had full alignment for learner expectations 1, 2, 3, 8, 14, 17, 30, 32, 39, and 45. Two teachers had full alignment for learner expectations 12, 18, 28, and 29. Three teachers had full alignment for learner expectations 4, 15, 20, 23, and 37. Four teachers had full alignment for learner expectations 9, 11, 25, and 41. Five teachers had full alignment for learner expectations 5, 6, 7, 13, 19, 31, 34, 35, and 42. Only for learner expectation 44 was there no alignment by any of the five teachers.

Cognitive Processes

The results for the alignment among the intended, enacted, and assessed curricula for cognitive process is presented in Table 11. The value of the cognitive process index was

0.073, indicates that there was low alignment among the intended, enacted, and assessed curricula across the five teachers. As shown, one teacher, but not necessarily the same teacher, had full alignment for learner expectations 1, 5, 15, 18, 25, 34, and 35; two teachers had full alignment of learner expectation 23; and all five teachers had full alignment for learner expectation 13. There was no alignment found for learner expectations 2, 3, 4, 6, 7, 8, 9, 11, 12, 14, 17, 19, 20, 28, 29, 30, 31, 32, 37, 39, 40, 41, 42, 44, and 45.

Since full cognitive process curriculum alignment was low, consideration was given to partial curriculum alignment. Partial curriculum alignment refers to aligning common cognitive processes between two of the three curriculum components. A match between the intended cognitive process and the cognitive process the teacher taught or between the intended cognitive process and the cognitive process assessed or between the cognitive process taught and the assessed cognitive process for a learner expectation are considered to be partially aligned. The results for partial alignment are provided in Table 12. For example, for learner expectation 12, there are two teachers with no alignment, one teacher with partial alignment between the intended and the enacted curricula and one teacher with partial alignment between the enacted and the assessed curricula.

Not including the nine learner expectations that had full curriculum alignment, the degree of partial alignment for the 36 learner expectations between the intended and the enacted curricula was low (0.21). Not including the 12 learner expectations that were not assessed and the nine learner expectations that had full curriculum alignment, the degree of partial between the intended and the assessed curricula was low (0.18). Excluding the 21 learner expectations as mentioned above, the degree of partial alignment between the enacted

Table 11

Full Curriculum Alignment: Cognitive Process

LE	Number of Teachers						NA
	0	1	2	3	4	5	
1		X					
2	X						
3	X						
4	X						
5		X					
6	X						
7	X						
8	X						
9	X						
10							X
11	X						
12	X						
13						X	
14	X						
15		X					
16							X
17	X						
18		X					
19	X						
20	X						
21							X
22							X
23			X				
24							X
25		X					
26							X
27							X
28	X						
29	X						
30	X						
31	X						
32	X						
33							X
34		X					
35		X					
36							X
37	X						
38							X
39	X						
40							X

Table 11 (Cont.)

LE	Number of Teachers						NA
	0	1	2	3	4	5	
41	X						
42	X						
43							X
44	X						
45	X						

Note: RS - Rating Scale
0 – No match among the intended, the enacted and the assessed curricula
1 – One teacher Full Curriculum match
2 - Two teachers full Curriculum match
3 - Three teachers full curriculum match
4 - Four teachers full curriculum match
5 - Five teachers full curriculum match
NA - Learner Expectations were not assessed

and the assessed curricula was low (0.15). As reported in Table 12, there was partial alignment between the intended and the enacted curriculum for learner expectations 1, 2, 4, 7, 8, 15, 17, 19, 21, 22, 25, 27, 30, 34, 37, 38, 42, and 45. There was partial alignment between the intended and the assessed curricula for learner expectations 2, 4, 5, 6, 7, 8, 12, 17, 18, 19, 28, 31, 35, 41, 42, and 45. There was partial alignment between the enacted and the assessed curricula for learner expectations 9, 12, 29, 31, 32, 34, 39, 41. There was full alignment for learner expectations 1, 5, 13, 18, 23, 25, 28, and 35.

Table 12

Partial and Full Curriculum Alignment: Cognitive Process

LE	**0**	**1**	**2**	**3**	**4**	**NA**
1	3	1			1	
2	3	2				
3	5					
4	3	1	1			
5	3		1		1	
6	3		2			
7	3	1	1			
8	1	3	1			
9	2			3		
10	5					X
11	5					
12	2		1	2		
13	0				5	
14	5					

Table 12 (Cont.)

LE	0	1	2	3	4	NA
15	1	3			1	
16	5					X
17	3	1	1			
18	3		1		1	
19	0	4	1			
20	5					
21	4	1				X
22	4	1				X
23	1	1	1		2	
24	5					X
25	2	2			1	
26	5					X
27	1	4				X
28	3		1		1	
29	3			2		
30	3	2				
31	0		4	1		
32	4			1		
33	5					
34	5	1		4		
35	1		3		1	
36	5					X
37	3	2				
38	3	2				X
39	4			1		
40	5					X
41	0		1	4		
42	1	3	1			
43	3	2				X
44	5					
45	3	1	1			

Note: 0 – No match among the intended, the enacted and the assessed curricula
1. Intended and enacted match
2. Intended and assessed match
3. Enacted and assessed match
4. Full curriculum alignment
5. NA. Not Assessed

Summary

Overall, the study's findings indicate high curriculum alignment for the content/operations and low curriculum alignment for the cognitive processes. As indicated before, the Program of Studies does not identify the cognitive process necessary to obtain a correct answer for the operation listed in each learner expectation. Further, the materials provided by the district committee, which the five teachers served on, did not attend to what cognitive process was needed to obtain a correct answer for the operation listed in each learner expectation. Thus, it is not surprising that the index for full alignment and the indices for partial alignment for cognitive processing are low.

The full set of placements from which the tables presented above were calculated is provided in Appendix G.

CHAPTER 5

FINDINGS, CONCLUSIONS, AND IMPLICATIONS

Introduction

Chapter 5 is divided into seven parts. First, a review of the research problem and methodology is presented followed by a summary of results. The results are then discussed in terms of the literature. The limitations of the study and the conclusion drawn in light of the limitations are then provided. Implications for practice and recommendations for future studies are provided in the last two parts.

Research Problem and Method

The study was designed to explore and measure the concept of curriculum alignment in the Patterns and Relations Strand in the Grade 9 Mathematics Program of Studies. Two aspects were examined. The first aspect was mathematics content and operations as identified in each learner expectation for the Patterns and Relations strand. The second aspect was the cognitive processes students were to engage in when operating on the mathematics content. For both aspects, the alignment among the

a. learner expectations and in terms of the cognitive processes along the cognitive process dimension in the *Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Anderson, et al., 2001),
b. enacted curriculum defined as the instruction of elements and operations, and
c. cognitive processes provided to the students, and the assessed curriculum defined in terms of the end-of-unit tests in terms of the elements and operations assessed

and in terms of the cognitive processes measured. The study sought to answer the following questions:

- Given the cognitive process levels and the emphasis given to learner expectations are not provided in the Program of Studies, what are the levels of cognitive processing as defined in the *Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Anderson, et al., 2001) corresponding to each of the learning expectations for the Patterns and Relations Stand for Grade 9 Mathematics?
- For both the mathematics and cognitive process aspect, what is the degree of alignment among
    - the intended curriculum,
    - the enacted curriculum, and
    - the assessed curriculum.
- What instructional emphasis did teachers give to each of the learner expectations? (secondary question)

The methodology used in this study was to first identify the cognitive processes corresponding to each of the 45 learner expectation in the Patterns and Relations strand. A panel of 10 subject experts from throughout Alberta identified the cognitive levels by matching the verbs used in the learner expectations and the keywords in each cognitive level of the revised Taxonomy. Three rounds were required. Following the third round, consensus of at least 80% was achieved for 39 of the 45 learner expectations.

The enacted and assessed curricula were determined for five different classes and teachers. The enacted curriculum was determined in two ways. First, two retired qualified mathematics teachers conducted classroom observations on a daily basis for the duration of the Patterns and Relations strand. Second, the five teachers independently completed the Teacher Survey, which included placing the learner expectations in the six cognitive process levels and the emphasis the teachers gave to each learner expectation. After they completed their surveys, the teachers were individually interviewed. However, given the expertise of the classroom observers and the variability of the placements of the learning expectations in the six cognitive process levels among the teachers, only data from the classroom observations were used to determine which cognitive processes were taught to the students. During the interview, the end-of-unit tests were collected from the five participating teachers to determine the assessed curriculum.

The alignment among the three curricula was based on the items included in the end-of-unit tests. Understandably, the teachers did not measure each of the 45 learning expectation. The mathematics content and operations index was the ratio of the total number of teachers who taught the learner expectation given they assessed the learner expectation. The cognitive process index was the ratio of the total number of teachers who taught the intended cognitive process for learner expectation given they assessed the learner expectation at the intended cognitive level to the total number of items. An index value close to 1.00 indicated alignment. In contrast, an index value close to zero indicated no alignment.

Summary of Results

The results revealed

- high alignment (0.97) among the intended, enacted, and assessed curricula for the mathematics content and operations;
- low curriculum alignment (0.073) among the intended, enacted, and assessed

curriculum for cognitive processing; and

- significant variability in emphasis given to the learner expectations.

Whereas that participating teachers were teaching and assessing the content and operations for the Patterns and Relations strand they fell short at teaching the cognitive processes called for by learner expectations, and providing inconsistency of emphasis for each of the learning expectations.

Given the low alignment for the full curriculum alignment for cognitive process, partial alignment between the three pairs of curricula was determined. The values of the indices were again low (0.21, intended and enacted; 0.18, intended and assessed; and 0.15 enacted and assessed curricula).

Discussion of Results

High alignment was found among the intended, the enacted, and the assessed curricula for the content/operations of learner expectations. This is an important finding for three reasons. First, this is contradictory to the findings in the research literature indicating low curriculum alignment (Kurz, Elliott, Wehby, and Smithson (2010). Second, given that in the province of Alberta, teachers are expected to teach the content found in the Program of Studies (the intended curriculum), this study indicates that participating teachers were indeed following the content found in the Patterns and Relations strand in the Grade 9 Program of Studies for Mathematics. Third, the findings are important because when there is alignment among the intended, enacted, and assessed curricula, student learning and achievement improve (Gamoran, Porter, Smithson, & White, 1997; Rowan, 1998). The difference noted in the first reason is attributable to the common curriculum mentioned in the second reason, which is not the case in the studies conducted in the United States.

In contrast, low alignment was found among the cognitive processes of the intended curriculum, the cognitive processes taught to the students, and the cognitive processes assessed. These results closely match the results obtained by Kaira (2010) in which he used item mapping to assess the alignment among the intended, enacted, and assessed curricula for the Mathematics and Numeracy subtest and the Reading subtest of the Massachusetts Adult Proficiency Test (MAPT). . The Program of Studies for the present study does not include identification of cognitive processes expected for the learner expectations, nor is there any direction on emphasis to be given to each of the learner expectations. Similarly, although teachers indicated that the cognitive processes were discussed at their district team meetings, there was no identification or discussion of cognitive processes on any of the documents created by the district team nor the teachers themselves.

The results of this study indicate that teachers concentrated instruction at the lower cognitive levels. Resnick (2004) and Fuhrman (2001) found similar results, stating that assessment items assess processes with lower cognitive complexity and not higher cognitive levels called for in the standards-based educational reform in the United States. This is not to say that the lower cognitive levels are not important. Indeed, although Mathematics concepts may be mastered at different cognitive levels, the lower level cognitive skills are the foundation for the higher order cognitive skills (Kaira, 2010). For example, the cognitive level Remember is an essential skill for problem solving since it taps into long-term memory. The higher-order cognitive levels promote transfer of knowledge as opposed to formulaic methods where learners become proficient at substituting numbers into a formula. Perhaps what is needed is a balance in the teaching of the cognitive processes where both lower and higher levels cognitive skills are taught and assessed appropriately.

Popham (2000) indicated that the standards (the intended curriculum) are too vague and general to be able to teach and assess the standards appropriately. The findings of this study support Popham's concern. The lack of clearly identified cognitive processes and a lack of emphasis provided in the standards in the United States and in the Program of Studies in Alberta is a likely reason why teachers tend not to teach the higher cognitive processes.

A growing number of educators and educational stakeholders are supporting the notion that students need "21st-century skills" to be successful in today's society. It's exciting to think that our 21st century society needs new and different skills. However, the skills students need in the 21st century are not new (Rotherham & Willingham, 2009). For example, calls for teaching critical thinking and problem solving skills have been continually made (Rotherham & Willingham, 2009).

.Why is that so? There may be several answers to the question. Cognitive processes have not been identified in programs of study. Participating teachers indicated that they taught all the learner expectations. However, little or no attention was given to teaching cognitive processes. The end of the unit tests did not assess the higher cognitive processes, and they are not assessed by external examinations where students are only given two hours to write. The assessment of these cognitive skills would require more time.

Limitations of the Study

A limitation of the study was the small sample size. The sample of teachers and classes of students was a convenience sample located in one school district due to lack of resources to observe classrooms and interview teachers from a greater number of school districts within the province.

A second limitation of the study is the lack of generalizability given that there were only three schools from the same district participating in the study. The cost of conducting the research and time commitment of the classroom observations prevented the involvement of other districts.

A third limitation of the study was using only one strand of the grade 9 mathematics program. Therefore, the findings of the preset study may not be generalizable to other subject areas and grade levels within Alberta and elsewhere.

A fourth limitation is that only one subject area was considered. Again, the cost and time commitment prevented the extension of the study to other subject areas.

Conclusion

The results of the study indicate high curriculum alignment for the mathematics content/operations of the learning expectations (0.97) and very low curriculum alignment for the cognitive complexity of the learning expectations (0.73). The principle of curriculum alignment is that successful student learning and achievement can be more reliably attained when there is an alignment of (1) learner expectations, (2) instruction in the classroom, and (3) reliable assessment information. But to be most successful, the learner expectations need to clearly identify the level of cognitive processing needed to operate on the mathematics elements for the learner expectations.

Curriculum alignment can provide a framework for examining the extents to which the revised learner expectations, revised instruction, and revised assessments are aligned. The findings of this study make a contribution toward improving the learning of students with its call to explicitly identify cognitive processes at all levels to be learned and to determine if the enacted curriculum and the assessed curriculum, both revised to take account of the cognitive processes, are properly aligned.

Implications for Practice

The study found significant variance in the interpretations, instruction, and assessment of the cognitive levels in the mathematics Patterns and Relations strand. After three Delphi rounds there were still six learning expectations that the panel of judges could not reach 80% consensus. Their comments pointed to a lack of clarity of the verbs used in the learner expectations. There was also significant variance in the interpretations of the learner expectations with regards to the cognitive processes by the five teachers who were observed. It is evident that there is a problem with the language used in the learner expectation, particularly with respect to the verbs used in the Program of Studies for mathematics. Curriculum Branch at Alberta Education is presently involved in redesigning curriculum. In this redesigning process it would be judicious to clearly identify and define the cognitive processes that will be required of teachers to teach and students to acquire much like the Mathematics Program of Studies of the early to mid-1990s where the mathematics processes for each of the specific learning expectations were explicitly stated. For example, the Program of Studies for K-9 Mathematics stated that the "program of studies incorporates seven interrelated mathematical processes that are intended to permeate teaching and learning" (p. 2). The seven mathematical processes were: Communication (C), Connections (CN), Estimation and Mental Mathematics (E), Problem Solving (PS), Reasoning (R), Technology (T), and Visualization (V) (Program of Studies for K-9 Mathematics, 1995) This was accomplished by including the appropriate processes to be taught and learned in parenthesis at the end of each learning expectation. An example of a specific outcome including the mathematical processes is,

" Illustrate the solution process for a first-degree, single variable equation, using

concrete materials or diagrams, (PS, R, V) (p. 41).

Identifying the mathematical processes for each learning expectation was a good model but it fell short of addressing some important higher order thinking skills for students. A recommendation is made that the *Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Anderson, et al., 2001) is used to identify the cognitive complexity levels for each learning expectation. (These cognitive domains are: Remember (R), Understand (U), Apply (Ap.), Analyze (A), Evaluate (E), and Create (C)). Two examples for two learning expectations from the Grade 9 Patterns and Relations Strand and the identification of the cognitive complexity to be taught would be,

> *Model the solution of a given linear equation using concrete or pictorial representations, and record the process (Ap.).*
>
> *Generalize and apply a rule for adding or subtracting a positive or negative number to determine the solution of a given inequality (C).*

Furthermore, it would be prudent to provide direction for the emphasis that should be given by teachers when teaching each of the learner expectation.

In an earlier study conducted by the researcher, 57 district assessment policies were reviewed. The researcher observed that cognitive levels were not included in any of the reviewed policies. Out of the 57 policies reviewed seven were deemed to be reflective of current assessment practices that positively impacted student learning. Developing or revising district policies to reflect curriculum alignment strategies is an activity that would support teachers and administrators to carry out curriculum alignment work in their schools. An education system that is supportive of educational reform could include curriculum alignment in its plan. And just as educators need to remain attentive to assure that learning expectations, instructional practices and assessments are aligned and current, educational policy makers have a responsibility to ensure that the policies they put in place support practices that are based on empirical evidence and that have a positive impact on student achievement.

Alignment of learner expectations, instruction, and assessments is an essential principle of systemic and standards-based educational reform. As such, curriculum alignment could be used as a tool for the professional development of teachers. This would provide teachers the opportunity to analyze their own teaching and assessment practices based on the coherent understanding of the learner expectations. Engaging in professional development in curriculum alignment would assist teachers to clearly know what it is that they are responsible for teaching (content and cognitive processes), make decisions about the use of appropriate teaching strategies for helping students learn the content and acquire the cognitive skills that are specified in the learning expectation; develop relevant assessment items that represent both the content and cognitive processes stated in the learner expectations; and use the students' assessment data to identify strengths and weaknesses and adjust instruction accordingly. This practice has the potential to clarify the teaching for teachers and the learning for students.

Recommendations for Research

As mentioned before, the findings of the study in the area of curriculum alignment was restricted to one strand, in one subject area, and in one grade level. Namely, it was restricted in the Patterns and Relations strand of the Mathematics program of studies in grade 9. In particular, the study indicated high alignment with the mathematics content/operations but low alignment with the cognitive levels. Given this, the following recommendations are made:

1. The curriculum alignment in the other strands in the Grade 9 Program of Studies for mathematics and the strands in the mathematics programs at other grade levels should be examined.
2. The curriculum alignment in other subject areas should be examined.
3. The issue of why teachers are not teaching higher cognitive processes needs to be examined.
4. Allowance should be made to allow a larger sample size classes to better determine the enacted and assessed curricula.
5. More research is needed to develop the processes that allow educational stakeholders and researchers to measure the degree of curriculum alignment in a consistent and coherent manner.
6. There is a need to investigate how the results from the implementation of curriculum alignment are used. Some of the questions that could be examined are: How will the results impact changes in praxis - both in classroom instruction and in setting policies? How does curriculum alignment results inform the writing of future curriculum documents by the Curriculum Branch at Alberta Education?

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APPENDIX A

Delphi Procedures Manual

DELPHI PROCEDURES MANUAL

Adopted from PARTICIPATORY METHODS TOOLKIT Practitioner's Manual Delphi: Nikki Slocum (2005) (United Nations University – Comparative Regional Integration Studies)

GUIDE FOR THE DELPHI PROCESS

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Thanks you for your willingness to participate in this study.

A. BACKGROUND

Purpose of the Study:

The intent of this study is to determine the extent that curriculum alignment is practiced in grade 9 mathematics classrooms in Alberta. More specifically, what is the degree of alignment among:

- the intended curriculum (the learner outcomes, which are given and written in programs of study but ordered in terms of content and levels of thinking for the mathematics unit to be considered),
- the enacted curriculum (the instructional content and activities that teachers use to provide their students with an opportunity to learn to content and acquire the thinking skills identified in the intended curriculum for the mathematics unit to be considered), and
- the assessed curriculum (the assessment instruments teachers use to assess their students to determine what the content they have learned and the thinking skills they have acquired for the mathematics unit to be considered)?

Research has shown that when there is alignment, student learning improves.

Creation of the Intended Curriculum

One of the initial steps in the analysis of curriculum alignment is the placement of the learner expectations from the program of studies into Bloom's Revised Taxonomy Table. As a member of a panel of Grade 9 mathematics teachers, you are being asked to complete these placements. A copy of the Taxonomy Table you will use is presented on the next page. As you can see, there are two dimensions. The Knowledge Dimension has four levels and the Cognitive Process Dimension has six levels.

Your basic task is to consider each learning expectation for a unit in Grade 9 mathematics and place it in the cell it best represents. For example, the learner expectation *demonstrate the differences between the exponent and the base by building models of a given power, such as* 2^3 *and* 3^2 in the number strand might be placed in the cell defined by the level of knowledge – Factual Knowledge and the level of cognitive process – Remembering. You will find a copy of the learning expectations in the packet of materials provided to you.

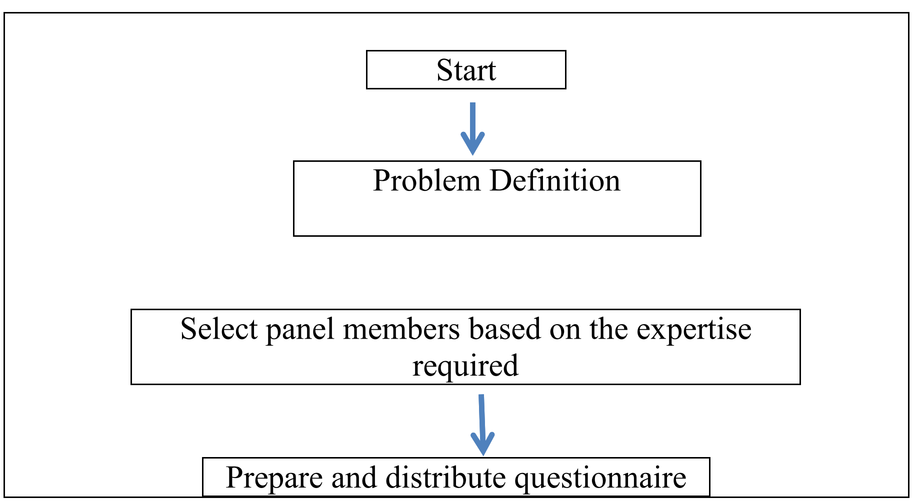
Taxonomy Table

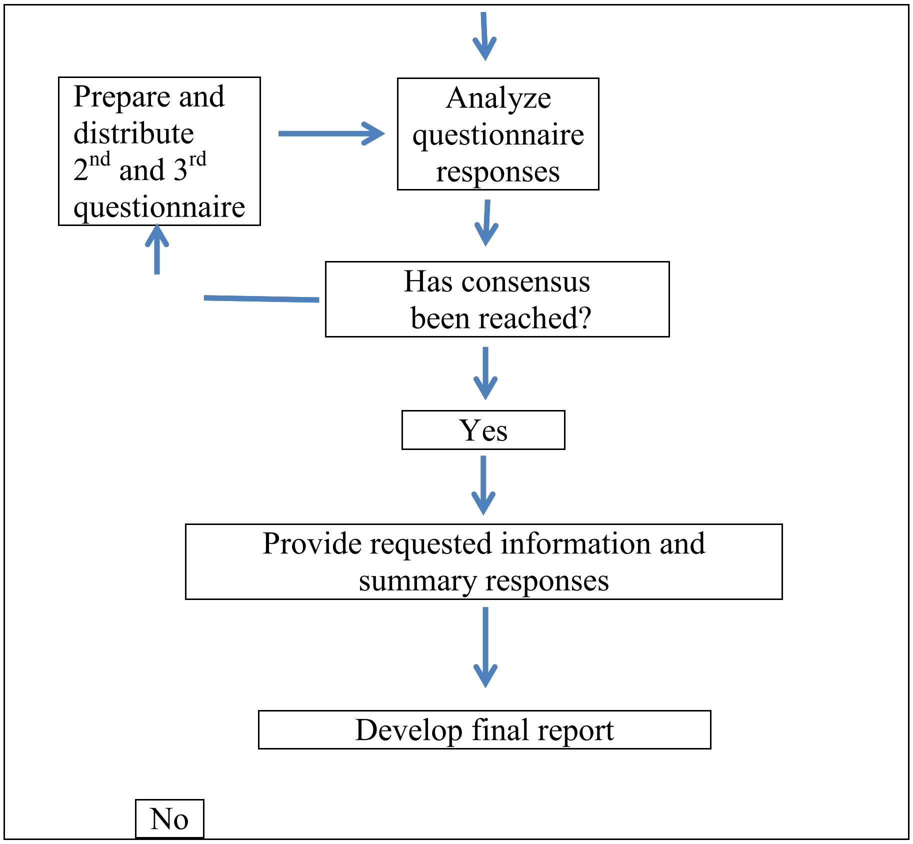
Now not all teachers will place each learning expectation in the same cell. The

	THE COGNITIVE PROCESS DIMENSION					
The KNOWLEDGE DIMENSION (Learner Expectations)	**1. REMEMBER** ○ **Recognizing** ○ **Recalling**	**2. UNDERSTAND** ○ **Interpreting** ○ **Exemplifying** ○ **Classifying** ○ **Summarizing** ○ **Inferring** ○ **Comparing** ○ **Explaining**	**3. APPLY** ○ **Executing** ○ **Implementing**	**4. ANALYZE** ○ **Differentiating** ○ **Organizing** ○ **Attributing**	**5. EVALUATE** ○ **Checking** ○ **Critiquing**	**6. CREATE** ○ **Generating** ○ **Planning** ○ **Producing**

procedure we are using to get consensus on the placements is called the Delphi Procedure. As shown in the diagram, this procedure involves rounds of placements, with each round after the first informed by the results of the previous round. The rounds continue until we reach consensus. Consensus is defined as 80% of the teachers place the learner expectations in the same cells.

Delphi Method Flowchart





Adopted from PARTICIPATORY METHODS TOOLKIT Practitioner's Manual Delphi: Nikki Slocum (2005) (United Nations University – Comparative Regional Integration Studies)

Instructions for each Round

Round 1

Please

1. place each learner expectation for the ________ strand in the cell of the Taxonomy table that you consider to be the cell of best fit,
2. note comments, on the sheet provided, that you have at all points of the process, and
3. return the completed Taxonomy Table to the researcher.

If 80% of the judges place each learning expectation in the same cell, then we will stop. If not, we will move to Round 2.

Round 2

For the second round, you will receive the summary of the placements of each learning expectation made by all of the judges in Round 1and your own placements in Round 1. Please

1. review the summary and your placements,

2. make any changes you wish to make using a red pen or pencil provided in your packet, and
3. return your revised Taxonomy Table to the researcher.

If 80% of the judges place each learning expectation in the same cell, then we will stop. If not, we will move to Round 3.

Round 3

For the third round, you will receive the summary of the placements of each learning expectation made by all of the judges in Round 2 and your own placements in Round 2. Please

1. review the summary and your placements,
2. make any changes you wish to make using a red pen or pencil provided in your packet, and
3. return your revised Taxonomy Table to the researcher.

If 80% of the judges place each learning expectation in the same cell, then we will stop. If not, we will move to Round 4.

The rounds continue until 80% or higher consensus is reached.

Examples

In what cells would you place the following learning expectations:

1. Demonstrate the differences between the exponent and the base by building models of a given power, such as 2^3 and 3^2.
2. Determine the difference of two given powers, e.g., $4^3 – 4^2$, and record the process.
3. Solve a given problem by applying the order of operations without the use of technology.
4. Solve a given problem involving operations on rational numbers in fraction or decimal form.
5. Explain, using repeated multiplication, the difference between two given powers in which the exponent and base are interchanged; (e.g., 10^3 and 3^{10}).

APPENDIX B

Teacher Survey Of Instructional Content

Grade 9 Mathematics: Patterns and Relations Strand Teacher Survey

Instructions:

Please complete the following table.

1. In the first column are the learning expectations for students in Grade 9 mathematics. The statements are in the form of achievement indicators as specified in the Program of Studies for Grade 9 mathematics.
2. In the second column it asks you to indicate if you have taught that particular learning outcome.
3. In the third column are six cognitive levels in ascending order of complexity. The codes stand for:

R – Remembering	U – Understanding	Ap – Applying	An – Analyzing	E – Evaluating	C – Creating
▪ **Recognize** ▪ **Recalling**	▪ **Interpreting** ▪ **Exemplifying** ▪ **Classifying** ▪ **Summarizing** ▪ **Inferring** ▪ **Comparing** ▪ **Explaining**	▪ **Executing** ▪ **Implementing**	▪ **Differentiating** ▪ **Organizing** ▪ **Attributing**	▪ **Checking** ▪ **Critiquing**	▪ **Generating** ▪ **Planning** ▪ **Producing**

4. Lastly, in the fourth column are four levels of emphasis in increasing order.

0 – Not Emphasized 1 – Some Emphasis 2 – Moderate Emphasis 3 – Strongly Emphasized

For each learner outcome, please indicate/circle:

1. "Yes" if you have taught it and "No" if you have not taught it,
2. the letter in the third column that corresponds to the level of thinking called for in the learner outcomes, and
3. the number in the fourth column that corresponds to the level of emphasis you give to this outcome in your class.

Learner Outcomes and Learner Expectations	Have you Taught It? No	Yes	Cognitive Level	Emphasis You Gave to the L0s
Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution.				
1. Write an expression representing a given pictorial, oral or written pattern.			R U Ap An E C	0 1 2 3
2. Write a linear equation to represent a given context.			R U Ap An E C	0 1 2 3
3. Describe a context for a given linear equation.			R U Ap An E C	0 1 2 3
4. Solve, using a linear equation, a given problem that involves pictorial, oral and written linear patterns.			R U Ap An E C	0 1 2 3
5. Write a linear equation representing the pattern in a given table of values, and verify the equation by substituting values from the table.			R U Ap An E C	0 1 2 3
Graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems.				
6. Describe the pattern found in a given graph.			R U Ap An E C	0 1 2 3
7. Solve a given problem by graphing a linear relation and analyzing the graph.			R U Ap An E C	0 1 2 3
8. Graph a given linear relation, including horizontal and vertical lines.			R U Ap An E C	0 1 2 3
9. Match given equations of linear relations with their corresponding graphs.			R U Ap An E C	0 1 2 3
10. Extend a given graph (extrapolate) to determine the value of an unknown element.			R U Ap An E C	0 1 2 3
11. Interpolate the approximate value of one variable on a given graph, given the value of the other variable.			R U Ap An E C	0 1 2 3

12. Extrapolate the approximate value of one variable from a given graph, given the value of the other variable.			R U Ap An E C	0 1 2 3
Model and solve problems, using linear equations of the form: ax = b; x - b , a ≠ 0; ax + b = c; x + b - c, a ≠ 0; ax = b + cx; a(x + b) = c; ax + b = cx + d; a(bx + c) = d(ex + f); a - b, x ≠ 0 (where a , b, c, d, e and f are rational numbers).				
13. Model the solution of a given linear equation, using concrete or pictorial representations, and record the process.			R U Ap An E C	0 1 2 3
14. Verify by substitution whether a given rational number is a solution to a given linear equation.			R U Ap An E C	0 1 2 3
15. Solve a given linear equation symbolically.			R U Ap An E C	0 1 2 3
16. Identify and correct an error in a given incorrect solution of a linear equation.			R U Ap An E C	0 1 2 3
17. Represent a given problem, using a linear equation.			R U Ap An E C	0 1 2 3
18. Solve a given problem, using a linear equation, and record the process.			R U Ap An E C	0 1 2 3
Explain and illustrate strategies to solve single variable linear inequalities with rational coefficients within a problem-solving context.				
19. Translate a given problem into a single variable using the symbols ≥ , >, < or ≤.			R U Ap An E C	0 1 2 3
20. Determine if a given rational number is a possible solution of a given linear inequality.			R U Ap An E C	0 1 2 3
21. Generalize and apply a rule for adding or subtracting a positive or negative number to determine the solution of a given inequality.			R U Ap An E C	0 1 2 3
22. Generalize and apply a rule for multiplying or dividing by a positive or negative number to determine the solution of a given inequality.			R U Ap An E C	0 1 2 3
23. Solve a given linear inequality algebraically, and explain the process orally or in written form.			R U Ap An E C	0 1 2 3
24. Compare and explain the process for solving a given linear equation to the process for solving a given linear inequality.			R U Ap An E C	0 1 2 3

25. Graph the solution of a given linear inequality on a number line.			R U Ap An E C	0 1 2 3
26. Compare and explain the solution of a given linear equation to the solution of a given linear inequality.			R U Ap An E C	0 1 2 3
27. Verify the solution of a given linear inequality, using substitution for multiple elements in the solution.			R U Ap An E C	0 1 2 3
28. Solve a given problem involving a single variable linear inequality, and graph the solution.			R U Ap An E C	0 1 2 3
Demonstrate an understanding of polynomials (limited to polynomials of degree less than or equal to 2).				
29. Create a concrete model or a pictorial representation for a given polynomial expression.			R U Ap An E C	0 1 2 3
30. Write the expression for a given model of a polynomial.			R U Ap An E C	0 1 2 3
31. Identify the variables, degree, number of terms and coefficients, including the constant term, of a given simplified polynomial expression.			R U Ap An E C	0 1 2 3
32. Describe a situation for a given first degree polynomial expression.			R U Ap An E C	0 1 2 3
33. Match equivalent polynomial expressions given in simplified form; e.g., 4x - 3x2 + 2 is equivalent to -3x2 + 4x + 2.			R U Ap An E C	0 1 2 3
Model, record and explain the operations of addition and subtraction of polynomial expressions, concretely, pictorially and symbolically (limited to polynomials of degree less than or equal to 2).				
34. Model addition of two given polynomial expressions concretely or pictorially, and record the process symbolically.			R U Ap An E C	0 1 2 3
35. Model subtraction of two given polynomial expressions concretely or pictorially, and record the process symbolically.			R U Ap An E C	0 1 2 3
36. Identify like terms in a given polynomial expression.			R U Ap An E C	0 1 2 3
37. Apply a personal strategy for addition or subtraction of two given			R U Ap An E C	0 1 2 3

polynomial expressions, and record the process symbolically.				
38. Refine personal strategies to increase their efficiency.			R U Ap An E C	0 1 2 3
39. Identify equivalent polynomial expressions from a given set of polynomial expressions, including pictorial and symbolic representation.			R U Ap An E C	0 1 2 3
40. Identify the error(s) in a given simplification of a given polynomial expression.			R U Ap An E C	0 1 2 3
Model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of degree less than or equal to 2) by monomials, concretely, pictorially and symbolically.				
41. Model division of a given polynomial expression by a given monomial concretely or pictorially, and record the process symbolically.			R U Ap An E C	0 1 2 3
42. Apply a personal strategy for multiplication and division of a given polynomial expression by a given monomial.			R U Ap An E C	0 1 2 3
43. Refine personal strategies to increase their efficiency.			R U Ap An E C	0 1 2 3
44. Provide examples of equivalent polynomial expressions.			R U Ap An E C	0 1 2 3
45. Identify the error(s) in a given simplification of a given polynomial expression.			R U Ap An E C	0 1 2 3

Part II - Planning, Teaching, and Assessing

1. Did you use the Program of Studies when you planned the unit of study in Patterns and Relations? ______Yes ______No

2. If yes, how did you use the Program of Studies?

3. How did you go about planning the instructional activities for this unit?

4. How did you go about planning for the assessment of student learning for this unit?

5. How did you ensure alignment between what you taught, the instructional activities that you used, and what you assessed for this unit?

Part III - You as a Teacher

1. Please indicate your gender ☐ 0 female ☐ 1 male
2. How many years have you taught mathematics prior to this year?
3. How long have you been at your present school?
4. What is the highest degree you hold?
5. What was your major field of study for the bachelor's degree?

Thank you for participating in this survey.

APENDIX C

Classroom Observation Checklist Grade 9 Mathematics: Patterns and Relations Strand

Name of Observer: ____

Date of Observation: ____

Classroom Observed____

Instructions:
Listed in the first column are the student learning expectations for mathematics' strand: *Patterns and Relations*. Not all of these will be covered in the class you observe today. In the third column are six cognitive levels in ascending order of complexity. The codes stand for

R – Remembering	U – Understanding	Ap – Applying	An – Analyzing	E – Evaluating	C – Creating
• **Recognize** • **Recalling**	▪ **Interpreting** ▪ **Exemplifying** ▪ **Classifying** ▪ **Summarizing** ▪ **Inferring** ▪ **Comparing** ▪ **Explaining**	• **Executing** • **Implementing**	▪ **Differentiating** ▪ **Organizing** ▪ **Attributing**	• **Checking** • **Critiquing**	• **Generating** • **Planning** • **Producing**

For each learner expectation, please:

1. Place a check mark in the second column only on the learner expectations that you observe the teacher teaching each day you observe.
2. Circle the letter in the third column that corresponds to the cognitive level of thinking taught for that particular learner expectation.

Please check only the ones that are covered today.

Did the teacher provide an opportunity for the students to …………	**Yes**	**Cognitive Level**
Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution.		
1. Write an expression representing a given pictorial, oral or written pattern.		R U Ap An E C
2. Write a linear equation to represent a given context.		R U Ap An E C
3. Describe a context for a given linear equation.		R U Ap An E C

4. Solve, using a linear equation, a given problem that involves pictorial, oral and written linear patterns.		R U Ap An E C
5. Write a linear equation representing the pattern in a given table of values, and verify the equation by substituting values from the table.		R U Ap An E C
Graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems.		
6. Describe the pattern found in a given graph.		R U Ap An E C
7. Solve a given problem by graphing a linear relation and analyzing the graph.		R U Ap An E C
8. Graph a given linear relation, including horizontal and vertical lines.		R U Ap An E C
9. Match given equations of linear relations with their corresponding graphs.		R U Ap An E C
10. Extend a given graph (extrapolate) to determine the value of an unknown element.		R U Ap An E C
11. Interpolate the approximate value of one variable on a given graph, given the value of the other variable.		R U Ap An E C
12. Extrapolate the approximate value of one variable from a given graph, given the value of the other variable.		R U Ap An E C
Model and solve problems, using linear equations of the form: ax = b; $\underline{x}$ - b , a ≠ 0; ax + b = c; $\underline{x}$ + b - c, a ≠ 0; ax = b + cx; a(x + b) = c; ax + b = cx + d; a(bx + c) = d(ex + f); $\underline{a}$ - b, x ≠ 0 (where a , b, c, d, e and f are rational numbers).		
13. Model the solution of a given linear equation, using concrete or pictorial representations, and record the process.		R U Ap An E C
14. Verify by substitution whether a given rational number is a solution to a given linear equation.		R U Ap An E C
15. Solve a given linear equation symbolically.		R U Ap An E C
16. Identify and correct an error in a given incorrect solution of a linear equation.		R U Ap An E C
17. Represent a given problem, using a linear equation.		R U Ap An E C
18. Solve a given problem, using a linear equation, and record the process.		R U Ap An E C
Explain and illustrate strategies to solve single variable linear inequalities with rational coefficients within a problem-solving context.		
19. Translate a given problem into a single variable using the symbols ≥ , >, < or ≤.		R U Ap An E C
20. Determine if a given rational number is a possible solution of a given linear inequality.		R U Ap An E C
21. Generalize and apply a rule for adding or subtracting a positive or negative number to determine the solution of a given inequality.		R U Ap An E C

22. Generalize and apply a rule for multiplying or dividing by a positive or negative number to determine the solution of a given inequality.		R U Ap An E C
23. Solve a given linear inequality algebraically, and explain the process orally or in written form.		R U Ap An E C
24. Compare and explain the process for solving a given linear equation to the process for solving a given linear inequality.		R U Ap An E C
25. Graph the solution of a given linear inequality on a number line.		R U Ap An E C
26. Compare and explain the solution of a given linear equation to the solution of a given linear inequality.		R U Ap An E C
27. Verify the solution of a given linear inequality, using substitution for multiple elements in the solution.		R U Ap An E C
28. Solve a given problem involving a single variable linear inequality, and graph the solution.		R U Ap An E C
Demonstrate an understanding of polynomials (limited to polynomials of degree less than or equal to 2).		
29. Create a concrete model or a pictorial representation for a given polynomial expression.		R U Ap An E C
30. Write the expression for a given model of a polynomial.		R U Ap An E C
31. Identify the variables, degree, number of terms and coefficients, including the constant term, of a given simplified polynomial expression.		R U Ap An E C
32. Describe a situation for a given first degree polynomial expression.		R U Ap An E C
33. Match equivalent polynomial expressions given in simplified form; e.g., 4x - 3x2 + 2 is equivalent to -3x2 + 4x + 2.		R U Ap An E C
Model, record and explain the operations of addition and subtraction of polynomial expressions, concretely, pictorially and symbolically (limited to polynomials of degree less than or equal to 2).		
34. Model addition of two given polynomial expressions concretely or pictorially, and record the process symbolically.		R U Ap An E C
35. Model subtraction of two given polynomial expressions concretely or pictorially, and record the process symbolically.		R U Ap An E C
36. Identify like terms in a given polynomial expression.		R U Ap An E C
37. Apply a personal strategy for addition or subtraction of two given polynomial expressions, and record the process symbolically.		R U Ap An E C
38. Refine personal strategies to increase their efficiency.		R U Ap An E C
39. Identify equivalent polynomial expressions from a given set of polynomial expressions, including pictorial and symbolic representation.		R U Ap An E C
40. Identify the error(s) in a given simplification of a given polynomial expression.		R U Ap An E C
Model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of		

degree less than or equal to 2) by monomials, concretely, pictorially and symbolically.		
41. Model division of a given polynomial expression by a given monomial concretely or pictorially, and record the process symbolically.		R U Ap An E C
42. Apply a personal strategy for multiplication and division of a given polynomial expression by a given monomial.		R U Ap An E C
43. Refine personal strategies to increase their efficiency.		R U Ap An E C
44. Provide examples of equivalent polynomial expressions.		R U Ap An E C
45. Identify the error(s) in a given simplification of a given polynomial expression		R U Ap An E C

Additional Comments:

APPENDIX D

Teacher Interviews

Name: ____

1. Did you use the Program of Studies for the unit on Patterns and Relations?

   ___ No (Please go to Question 3)   ____ Yes (Please go to Question 2)

   When did you use the Alberta Programs of Study for the unit on Patterns and Relations?

   a. When I planned what I was going to do in the Patterns and Relations unit.

      ___ No (Go to question 3)   ___ Yes (Please go to b)

   b. When I planned what I was going to do in the class on Patterns and Relations.

      ___ No   ___ Yes

   c. When I developed the tests/quizzes I gave during the Patterns and Relations unit.

      ___ No   ___ Yes

   d. When I developed the final test for the Patterns and Relations unit?

      ___ No   ___ Yes

2. Please describe what you did when you planned for

   a. the unit on Patterns and Relations:

      ____

      ____

b. a lesson on Patterns and Relations:

3. Please describe what you did when you developed your

   a. tests/quizzes you gave during the time you were teaching the unit on Patterns and Relations:

   b. the final unit test you gave on Patterns and Relations:

4. What do you do to get your students to see and understand higher order thinking skills and problem solving?

5. Do you have any comments or questions about the classes observed?

___

___

___

6. Do you have any comments or questions about the survey you completed?

___

___

___

7. What do you do to ensure that what you teach and test are aligned with the learning outcomes?

___

___

___

8. What training in curriculum alignment have you had in your pre-service program or since you have been teaching?

___

___

___

Thank you for participating in this study on curriculum alignment.

APPENDIX E

Manual for Classroom Observations

MANUAL FOR CLASSROOM OBSERVATIONS

Procedures for the Classroom Observations

Daily classroom visits will be made for the classes involved in the study. Specifically, you will be required to observe every day for the duration of the unit of study. In addition, you will make a pre- observation classroom visit in order for the teacher and the students to meet you and to have an opportunity to get used to a visitor in the classroom. The remainder of the visits will involve making observations using the observation checklist.

Purposes of the Classroom Observations

- to determine the extent to which the classroom teacher teaches the learner expectations from the unit of study being studied
- to determine the level of thinking being asked of the students

Conducting the Classroom Observations

The observation is carried out for the duration of the class. You will be given a list of learner expectations for the unit of study being observed. The learner expectations are taken from the Program of Studies document and are presented in a checklist format. Not all of these will be covered in the class you observe each day. Place a check mark only beside the learner expectations that you observe the teacher teaching each day you observe.

Additional notes regarding the coverage of the learner expectations can be added at the bottom of the checklist.

Feedback to Teacher

- At the end of each observation period, you will prepare a brief written report to be shared with the teacher in order to make sure that the teacher agrees with what was recorded.

Location and Schedule

The location of the school, the time of the class and the class schedule will be shared with you when the participating schools finalize the information.

APPENDIX F

Delphi Procedure Round 3 Results

Taxonomy Table	Cognitive Process Dimension					
General Learner Outcome for Math 9 Patterns and Relations Strand and Achievement Indicators	**1.** **REMEMBER** ○ **Recognizing** ○ **Recalling**	**2.** **UNDERSTAND** ○ **Interpreting** ○ **Exemplifying** ○ **Classifying** ○ **Summarizing** ○ **Inferring** ○ **Comparing** ○ **Explaining**	**3.** **APPLY** ○ **Executing** ○ **Implementing**	**4.** **ANALYZE** ○ **Differentiating** ○ **Organizing** ○ **Attributing**	**5.** **EVALUATE** ○ **Checking** ○ **Critiquing**	**6.** **CREATE** ○ **Generating** ○ **Planning** ○ **Producing**
Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution.						
1. Write an expression representing a given pictorial, oral or written pattern.			100%			
2. Write a linear equation to represent a given context.			90%	10%		
3. Describe a context for a given linear equation.		100%				
4. Solve, using a linear equation, a given problem that involves pictorial, oral and written linear patterns.		10%	90%			
5. Write a linear equation representing the pattern in a given table of values, and verify the equation by substituting values from the table.			80%	10%		10%

Graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems.						
6. Describe the pattern found in a given graph.		100%				
7. Solve a given problem by graphing a linear relation and analyzing the graph.			80%	20%		
8. Graph a given linear relation, including horizontal and vertical lines.		10%	90%			
9. Match given equations of linear relations with their corresponding graphs.		90%		10%		
10. Extend a given graph (extrapolate) to determine the value of an unknown element.		90%	10%			
11. Interpolate the approximate value of one variable on a given graph, given the value of the other variable.		90%	10%			
12. Extrapolate the approximate value of one variable from a given graph, given the value of the other variable.		90%		10%		
Model and solve problems, using linear equations of the form: ax = b; x - b , a ≠ 0; ax + b = c; x + b - c, a ≠ 0; ax = b + cx; a(x + b) = c; ax + b = cx + d; a(bx + c) = d(ex + f); a - b, x ≠ 0 (where a , b, c, d, e and f are rational numbers).						
13. Model the solution of a given linear equation, using concrete or pictorial representations, and record the process.		10%	90%			
14. Verify by substitution whether a given rational number is a solution to a given linear equation.		80%	20%			
15. Solve a given linear equation symbolically.		10%	90%			
16. Identify and correct an error in a give incorrect solution of a linear equation.		60%	10%	10%	20%	
17. Represent a given problem, using a linear equation.		10%	90%			

18. Solve a given problem, using a linear equation, and record the process.			100%			
Explain and illustrate strategies to solve single variable linear inequalities with rational coefficients within a problem-solving context.						
19. Translate a given problem into a single variable using the symbols ≥ , >, < or ≤.			100%			
20. Determine if a given rational number is a possible solution of a given linear inequality.		10%			90%	
21. Generalize and apply a rule for adding or subtracting a positive or negative number to determine the solution of a given inequality.			10%			90%
22. Generalize and apply a rule for multiplying or dividing by a positive or negative number to determine the solution of a given inequality.			10%			90%
23. Solve a given linear inequality algebraically, and explain the process orally or in written form.			100%			
24. Compare and explain the process for solving a given linear equation to the process for solving a given linear inequality.		80%		20%		
25. Graph the solution of a given linear inequality on a number line.		10%	90%			
26. Compare and explain the solution of a given linear equation to the solution of a given linear inequality.		90%		10%		
27. Verify the solution of a given linear inequality, using substitution for multiple elements in the solution.			10%		90%	
28. Solve a given problem involving a single variable linear inequality, and graph the solution.			90%	10%		
Demonstrate an understanding of						

polynomials (limited to polynomials of degree less than or equal to 2).						
29. Create a concrete model or a pictorial representation for a given polynomial expression.		40%				60%
30. Write the expression for a given model of a polynomial.		10%	90%			
31. Identify the variables, degree, number of terms and coefficients, including the constant term, of a given simplified polynomial expression.	70%	30%				
32. Describe a situation for a given first degree polynomial expression.		90%		10%		
33. Match equivalent polynomial expressions given in simplified form; e.g., 4x - 3x2 + 2 is equivalent to -3x2 + 4x + 2.		100%				
Model, record and explain the operations of addition and subtraction of polynomial expressions, concretely, pictorially and symbolically (limited to polynomials of degree less than or equal to 2).						
34. Model addition of two given polynomial expressions concretely or pictorially, and record the process symbolically.		80%	20%			
35. Model subtraction of two given polynomial expressions concretely or pictorially, and record the process symbolically.		80%	20%			
36. Identify like terms in a given polynomial expression.	90%	10%				
37. Apply a personal strategy for addition or subtraction of two given polynomial expressions, and record the process symbolically.			100%			
38. Refine personal strategies to increase their efficiency.					100%	

39. Identify equivalent polynomial expressions from a given set of polynomial expressions, including pictorial and symbolic representation.	10%	90%				
40. Identify the error(s) in a given simplification of a given polynomial expression.		70%			30%	
Model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of degree less than or equal to 2) by monomials, concretely, pictorially and symbolically.						
41. Model division of a given polynomial expression by a given monomial concretely or pictorially, and record the process symbolically.		80%	20%			
42. Apply a personal strategy for multiplication and division of a given polynomial expression by a given monomial.		10%	90%			
43. Refine personal strategies to increase their efficiency.					100%	
44. Provide examples of equivalent polynomial expressions.		90%		10%		
45. Identify the error(s) in a given simplification of a given polynomial expression.		70%			30%	

APPENDIX G

Matrix of Results: Grade 9 Mathematics Patterns and Relations Strand

The Matrix of Results table includes all the data collected from the Delphi Procedure (the intended curriculum), the classroom observations (the enacted curriculum), and the End of the Unit tests (the assessed curriculum). The results for the intended curriculum are expressed in the top line as a percentage. The placements from the classroom observations are shown in upper case letters and where the letters designate Teachers A, B, C, D, and E, respectively. The placements of the questions on the End of the Unit tests are provided in regular font. The use of the word "Section" of the assessed curriculum reflects the continuous manner in which Teacher B assessed her students. Given it is not possible to assess all 45 learning expectations in an end of unit test, not all learning expectations were assessed. However, all learning outcomes, which comprise a set of the learner expectations, were assessed.

The table is read as follows. For learning expectation 1, 100% of the members of the panel who established the intended curriculum agreed that the cognitive process required to *write an expression representing a given pictorial, oral, or written pattern* was Apply. The observers indicated Teachers A and B taught the Apply process to their students and Teachers C, D, and E taught the Create process to their students. Teacher B was the only teacher who assessed his students' performance for this learning expectation and she used two items to do so. Taken together, the results for learning expectation 1 reveal that there was mathematics alignment among the intended, enacted, and assessed curricula. By virtue of teaching the learning expectation, the mathematics content and operations of learning objective 1 was covered and assessed. In contrast, the results for learning expectation 1 reveal that there was partial cognitive process alignment. Whereas the two end of unit questions assessed the intended cognitive process, only two of the five teachers were observed teaching the intended cognitive process.

Taxonomy Table	**Cognitive Process Dimension**					
General Learner Outcome for Math 9 Patterns and Relations Strand and Achievement Indicators	**1. REMEMBER** ○ **Recognizing** ○ **Recalling**	**2. UNDERSTAND** ○ **Interpreting** ○ **Exemplifying** ○ **Classifying** ○ **Summarizing** ○ **Inferring** ○ **Comparing** ○ **Explaining**	**3. APPLY** ○ **Executing** ○ **Implementin g**	**4. ANALYZE** ○ **Differentiatin g** ○ **Organizing** ○ **Attributing**	**5. EVALUATE** ○ **Checking** ○ **Critiquing**	**6. CREATE** ○ **Generating** ○ **Planning** ○ **Producing**
Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution.						
1. Write an expression representing a given pictorial, oral or written pattern.			100% A, B Section I: 9. 10. B			C, D, E
2. Write a linear equation to represent a given context.			90% A, B 1. E, 2. E	10%		C, D, E
3. Describe a context for a given linear equation.		100%	A, D 4a. b. c. E			B, C, E
4. Solve, using a linear equation, a given problem that involves pictorial, oral and written linear patterns.		10% 6. A, C, D 7. A, C, D	90% B *NR. A, C, D*	A, C, D, E NR. A, C, D 13. A, C, D		

5. Write a linear equation representing the pattern in a given table of values, and verify the equation by substituting values from the table.		2. A, C, D Section C: 2. B	80% B 5. 8a. E Section C: 1. B	10% A, C, D, E	3. E	10%
Graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems.						
6. Describe the pattern found in a given graph.		100% 6. E Section C: 3a. 3b. 3d. 4a. 4b. B	C 4. A, C, D 7a. c. E		A, B, D, E	
7. Solve a given problem by graphing a linear relation and analyzing the graph.			80% C 8d. E	20% A, B, D		E
8. Graph a given linear relation, including horizontal and vertical lines.		10%	90% A, B, C 8b. E	*D*		*E*
9. Match given equations of linear relations with their corresponding graphs.		90%	*A, C, D* 21. A, C, D Section C: 5. B	10%	*B, E*	
10. Extend a given graph (extrapolate) to determine the value of an unknown element.		90%	10% A, B, C, D	E		
11. Interpolate the approximate value of one variable on a given graph, given the value of the other variable.		90%	10% A, C, D, 7b. E	8. A, C, D	B, E	
12. Extrapolate the approximate value of one variable from a given graph, given the value of the other variable.		90% Section C: 4c. B	A, B, C, D, E 7d. 8e. 8f. E Section C: 3c. B	10%		
Model and solve problems, using linear equations of the form: ax = b; $\underline{x}$ - b , a ≠ 0; ax + b = c; $\underline{x}$ + b - c, a ≠ 0; ax = b + cx; a(x + b) =						

c; ax + b = cx + d; a(bx + c) = d(ex + f); a - b, x ≠ 0 (where a , b, c, d, e and f are rational numbers).						
13. Model the solution of a given linear equation, using concrete or pictorial representations, and record the process.		10% Section A: 1. 2. 3. 4. 5. 6. 7. 8. B	90% A, B, C, D, E 15. A, C, D 9a. b. c. d. e. E Section B: 1. 2. 3. B			
14. Verify by substitution whether a given rational number is a solution to a given linear equation.		80%	20% A, B 10. E		C, D, E	
15. Solve a given linear equation symbolically.		10% NR. A, C, D	90% A, B, C, E Section D: 1. 2. 3. 4. B			(*D*: Not Observed)
16. Identify and correct an error in a give incorrect solution of a linear equation.		60%	10% B	10% A, C, D, E	20%	
17. Represent a given problem, using a linear equation.		10%	90% B 12a. E	A	C, D, E	
18. Solve a given problem, using a linear equation, and record the process.			100% B Section D: 5. 6. 7. 8. B 12b. E	8c. E	A, C, D	E
Explain and illustrate strategies to solve single variable linear inequalities with rational coefficients within a problem-solving context.						
19. Translate a given problem into a single variable using the symbols ≥ , >, < or ≤.		14. A, C, D Section E: 1a. 1b. 2a. 2b. B	100% A,B, C, D 13a. b. E			E

20. Determine if a given rational number is a possible solution of a given linear inequality.		10% 10. A, C, D	A, B, C, D, E		90%	
21. Generalize and apply a rule for adding or subtracting a positive or negative number to determine the solution of a given inequality.			10% B, C	A, D		90% E
22. Generalize and apply a rule for multiplying or dividing by a positive or negative number to determine the solution of a given inequality.			10% B, C	A, D		90% E
23. Solve a given linear inequality algebraically, and explain the process orally or in written form.		Section E: 4a. 4b. B Section F: 1a. 1b. B	100% A, B, D 5. A, C, D 11. A, C, D		E	*(C: Not observed)*
24. Compare and explain the process for solving a given linear equation to the process for solving a given linear inequality.		80%	A, B, C	20% D	E	
25. Graph the solution of a given linear inequality on a number line.		10% 16. A, C, D 18. A, C, D Section E: 3a. 3b. B	90% A, B, D Section F: 2a. 2b. 2c. B Section G: 1a. 1b. 1c. B		C	E
26. Compare and explain the solution of a given linear equation to the solution of a given linear inequality.		90%	A, B, D	10% *C, E*		
27. Verify the solution of a given linear inequality, using substitution for multiple elements in the solution.			10% B		90% A, C, D, E	
28. Solve a given problem involving a single variable linear inequality, and graph the solution.			90% B Section H: 1. 2. B	10%	A, C, D, E	

			14a. 14b. E 15a. 15b. E			
Demonstrate an understanding of polynomials (limited to polynomials of degree less than or equal to 2).						
29. Create a concrete model or a pictorial representation for a given polynomial expression.	B	40%	A, D 20. A, C, D			60% E (*C:* not observed)
30. Write the expression for a given model of a polynomial.		10% 11. E	90% A, B		D	E *(C: not observed)*
31. Identify the variables, degree, number of terms and coefficients, including the constant term, of a given simplified polynomial expression.	70% 1. A, C, D 22. A, C, D 17. E	30% Section I: 1. 3. 8. B Section J: 1. B	A, B, C Section I: 6. B Section J: 2. B		*D, E*	
32. Describe a situation for a given first degree polynomial expression.		90%	A, B, C, D, E	10% A		E 7e. E *(C: not observed)*
33. Match equivalent polynomial expressions given in simplified form; e.g., 4x - 3x2 + 2 is equivalent to -3x2 + 4x + 2.		100%	A		D, E	*(B and C: not observed)*
Model, record and explain the operations of addition and subtraction of polynomial expressions, concretely, pictorially and symbolically (limited to polynomials of degree less than or equal to 2).						
34. Model addition of two given polynomial expressions concretely or pictorially, and record the process symbolically.		80% C 19. A, C, D Section J: 3c. B	20% A, B Section I: 5, B 18a. c. e. E		D, E 16. E	
35. Model subtraction of two given polynomial		80%	20%			

expressions concretely or pictorially, and record the process symbolically.		C 17. A, C, D Section J: 3d. B	B 18b. d. E	A	D, E	
36. Identify like terms in a given polynomial expression.	90%	10% C	B	A	D, E	
37. Apply a personal strategy for addition or subtraction of two given polynomial expressions, and record the process symbolically.		12. A, C, D	100% A, B	Section J: 4. B	D	E *(C: not observed)*
38. Refine personal strategies to increase their efficiency.			B	A	100% *D, E*	*(C: not observed)*
39. Identify equivalent polynomial expressions from a given set of polynomial expressions, including pictorial and symbolic representation.	10% C	90%	B Section J: 5a. 5b. B	A	D, E	
40. Identify the error(s) in a given simplification of a given polynomial expression.		70%	A		30% D, E	*(B and C: not observed)*
Model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of degree less than or equal to 2) by monomials, concretely, pictorially and symbolically.						
41. Model division of a given polynomial expression by a given monomial concretely or pictorially, and record the process symbolically.		80% Section I: 2. B Section J: 3b. B	20% A, B, C 3 A, C, D Section I: 4. B Section J: B		D, E NR. A, C, D	
42. Apply a personal strategy for multiplication and division of a given polynomial expression by a given monomial.		10% 9. A, C, D Section I: 11. B Section J: 3a. B	90% A, B, C 19a. b. c. d. E		D	E

43. Refine personal strategies to increase their efficiency.		B	C	A	100% C, D	
44. Provide examples of equivalent polynomial expressions.		90%	Section I: 7. B	10%		E *(A B, C, and D: not observed)*
45. Identify the error(s) in a given simplification of a given polynomial expression.		70% B 20. E	C	A	30% D, E	