Sixty years of the Nova Scotia math curriculum:

What's changed?

by

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Abstract

The Department of Education is currently in the process of revising the educational curriculum to align with the Western and Northern Canadian Protocol (WNCP). This change was motivated by concerns that the curriculum objectives had become too numerous and too difficult to teach to. Prompted by this, the present retrospective review explores the ways that the NS curriculum has changed over the past 60 years in terms of: number of curriculum objectives, whether those objectives are well-defined, and their cognitive characteristics as defined by the Revised Bloom's Taxonomy of learning objectives. Findings suggest that the NS math curriculum has been shifting from concrete and practically oriented to increasingly abstract and conceptually oriented objectives, but that this shift to conceptual understanding is not necessarily accompanied by an increase in vague or ill-defined outcomes.

List of Abbreviations

WNCP	Western and Northern Canadian Protocol
NCTM	National Council of Teachers of Mathematics
NS P-3	Nova Scotia Primary-3
GCO	General Curriculum Outcome
KSCO	Key Stage Curriculum Outcome
SCO	Specific Curriculum Outcome
D, C	Development and Continuing practice

Sixty years of the NS Math Curriculum: What's Changed?

In 1996 the Atlantic Provinces Education Foundation published the Foundation for the Atlantic Canada Mathematics Curriculum, aligned with the National Council of Teachers of Mathematics (NCTM). This was the basis for a curriculum document that served as the Nova Scotian math curriculum from 1998 to 2013 (Nova Scotia English Program Services, 1998). However, the Department of Education is currently in the process of revising the educational curriculum to align with the Western and Northern Canadian Protocol (WNCP).

For the purposes of the present study, past and present Nova Scotia Primary-3 (NS P-3) math curricula will be compared. The purpose of this comparison is to characterize the changes that the NS P-3 curriculum has undergone from 1956 to the present WNCP-inspired document. Among the reported changes, the 2015 curriculum (Education Program Services, 2015) includes significantly fewer objectives per grade than the previous curriculum.

This curriculum revision and objective reduction is being done in response to concerns raised by both educators and parents that the high number of outcomes is untenable and ultimately negatively impacts educators (Minister's panel on education, 2014). For instance, teachers and parents reported that the high number of outcomes forces teachers to move away from subjects before their students have solid foundation in those topics (Minister's panel on education, 2014). This is a relevant area of concern as those nations which emphasize teaching for depth rather than breadth tend to rank favourably in international assessments (Milgram & Wu, 2005). For instance, since 2007 Japan has been ranked in the top 10 countries for math education as measured in the Trends in International Mathematics and Science Study (TIMSS; Mullis, Martin, Foy, & Arora, 2012). The Japanese math curriculum has been described as more narrow but also more in-depth; for comparison, according to Schmidt, McKnight, and Raizen (2007), approximately 50% of instruction time focuses on the top five topics covered in U.S.

schools, whereas approximately 75% of instruction time is dedicated to the top 5 topics in Japan.

Teaching for mastery is one way to add depth to a curriculum objective, as it involves training a student to a high level of proficiency in the content (e.g., 90% success rate in assessment) but often requires a greater time commitment than teaching a module of a predefined length on the subject before moving on (Anderson, 1975). However, if a curriculum requires teachers to cover a high number of outcomes, teaching for mastery becomes much more difficult. Indeed, the 2005 U.S. curriculum was panned on similar grounds, for being "a mile wide and an inch deep (Schmidt, McKnight, & Raizen, 1997 as cited in Milgram & Wu, 2005).

While the DoE suggests that this will allow a more in-depth coverage of the objectives still contained within the curriculum, this change has not been without its opponents who claim that the new curriculum underestimates the learning potential of NS students (e.g., Willick, 2014). This study will compare three past NS curricula to the new WNCP-aligned math curriculum in order to evaluate these changes in curriculum objectives, to determine how these new objectives differ from those of the past.

What is a curriculum document?

Though there is no one universally accepted definition of a "curriculum" among experts (Kelly, 2009), Wiles and Bondi (2007; as cited in Kelly, 2009) define a curriculum as "a set of desired objectives or values that are activated through a development process and culminate in successful learning experiences for students". The purpose of a curriculum then is to program for successful learning as defined by the values of the creator, and the usual means by which this is done is to set a series of objectives for educators and students.

The primary role of curricula in Nova Scotia is to align educational practices with the subjects endorsed by the Department of Education (Atlantic Provinces Education Foundation, 1996). In the case of the 1998 math curriculum, these subjects were number concepts, patterns and relations, shape and space, and data management and probability. In practice, this is accomplished by stipulating a series of objectives which teachers and their students are expected to achieve over the course of the academic year. In most cases, these objectives are accompanied with a recommended teaching or assessment method in order to clarify expectations for teachers. Some objectives may be achieved through students demonstrating their knowledge (e.g., the student is expected to skip count by 5s to 25) while other objectives are achieved through participating in a task (e.g., the student should have the opportunity to explore the concept of addition using blocks).

The NS curriculum objectives are referred to as *objectives* in the (Curriculum Division) 1956 and (Nova Scotia Education Office) 1976 documents, and as *outcomes* in the 1998 and 2015 documents. The two terms have a common meaning in that they both refer to the product of the curriculum, however outcomes are defined in several forms that warrant at least a brief discussion. In the 1998 and 2015 curricula, there are three different tiers of curriculum outcomes: General Curriculum Outcomes (GCOs), Key Stage Curriculum Outcomes (KSCOs), and Specific Curriculum Outcomes (SCOs). The GCOs are conceptually defined and each GCO is associated with several smaller and more operationalized KSCOs and SCOs. Each KSCO is an operationalized outcome that children are expected to achieve by the end of the “key stage” in question, which in the case of all outcomes reviewed here is the end of grade 3. Finally, SCOs are operationalized outcomes that are specific to each grade.

For the purposes of comparison across curricula, SCOs from the 1998 and 2015 documents are the most similar to the objectives of the 1956 and 1976 curricula. For this reason, both SCOs and objectives will be referred to from this point forward simply as objectives regardless of the curriculum document they originated from. Though these objectives are *more* operationalized than GCOs and more specific than KSCOs, some curriculum objectives are still highly conceptual in nature. For instance, one 1998 G2 objective reads: "By the end of grade 2, students will be expected to develop aspects of spatial sense, including perceptual constancy, perception of spatial relationships, and visual discrimination". While suggestions are provided in the document for teaching and assessment, the subject of whether the objectives themselves are clearly operationalized, teachable, and provable warrants further consideration.

Well-defined vs. Ill-defined objectives

Newell & Simon (1972) characterized a well-defined goal state as one for which "a test [proof] exists, performable by the system, that will determine whether an object proposed as a solution is in fact a solution". For the purposes of the present study, a well-defined objective is primarily defined as an objective for which we can generate a list of all correct responses before the answer is given (Though see Appendix A for additional criteria pertaining to objectivity). Consider the following examples: the objective "skip count by 5s up to 25" is well-defined because we know *a priori* that any and all correct answers will involve reciting the numbers "5, 10, 15, 20, 25" in ascending order. By contrast, the objective "To understand the meaning of division" is ill-defined, because there are many ways for a student to demonstrate their understanding of division and we do not know a-priori how they will choose to do so.

A curriculum is meant to ensure a degree of commonality of learning experiences across classrooms. Indeed, the reported purpose of the 2015 NS math curriculum is to ensure consistent objectives across NS, and to make within-province student transfers an easier process for students and teachers (Province of Nova Scotia, 2013). Well-defined objectives are an efficient means to achieve such common experiences as they require convergent problem-solving (e.g., require learning standard units, or common strategies) whereas ill-defined objectives require divergent problem-solving (e.g., the student determines the solution to the task, and so has freedom to solve the problem *without* using common tools or methods).

In some instances, objectives may be unnecessarily ill-defined. In these instances the objectives increase the complexity of assessment without enhancing the nature of the content to be taught. For instance, the 1998 grade 1 objective to "develop aspects of spatial sense, including figure ground perception" could be argued to be an unnecessarily ill-defined objective. This is because "identifying the figure as distinct from the ground" is well-defined, and other aspects of spatial sense tend to be equally well-defined, for instance "reassembling a 4x4 puzzle". Where well-defined objectives can be listed, they should be provided to provide concrete benchmarks for teachers. It is important to note that such objectives do not limit learning because students can expand their abilities following mastery of core content.

While well-defined objectives are more straightforward to assess for, ill-defined objectives sometimes are both necessary and appropriate. Objectives which are necessarily ill-defined might require a student to use their skills to adapt or create novel information. The 1998 grade 3 objective that children "implement plans with respect to the collection of data" is *necessarily* ill-defined because children are given the freedom to generate their own methods; there is no one correct answer that is known a-priori. Objectives such as this, which tap into higher order thought processes, are necessary to ensure that children can apply their knowledge in an adaptive fashion in the real world.

It has been argued that the use of ill-defined tasks in education may be necessary to promote practical skills in students (Jonassen, 1997). This argument is grounded in the fact that ill-defined tasks require the student to determine the correct manner with which to solve the problem. Proponents maintain that problems in everyday life are ill defined, requiring the problem-solvers to guide themselves toward a solution. For instance, moving one's belongings from one home to another requires reviewing and accessing different support resources (e.g., transportation, movers, boxes, etc) then using them (e.g., deciding how to efficiently pack a moving truck).

In summary, well-defined objectives are an efficient means to establish foundational knowledge that can later be leveraged in unstructured tasks. Ill-defined objectives may be useful for transitioning knowledge to a practical domain, and for making students flexible problem-solvers. We argue that while both have their place in a curriculum, well-defined objectives are an efficient means of achieving a primary goal of a curriculum (establishing a common knowledge-base for students). Ill-defined objectives are comparatively time and effort intensive to teach and test, and offer little benefit when covering standardized and discrete information (e.g., divergent problem-solving is not an efficient means to teach students to identify/order the numbers one to nine). Therefore, ill-defined objectives might best be used only when the student is meant to apply higher-order thinking to solve a problem. The degree to which a curriculum objective requires use of higher order knowledge or cognitive processing skills can be characterized utilizing Bloom's Revised Taxonomy of Educational Objectives (Anderson, Krathwohl, & Bloom, 2001).

Bloom's Revised Taxonomy of Educational Objectives

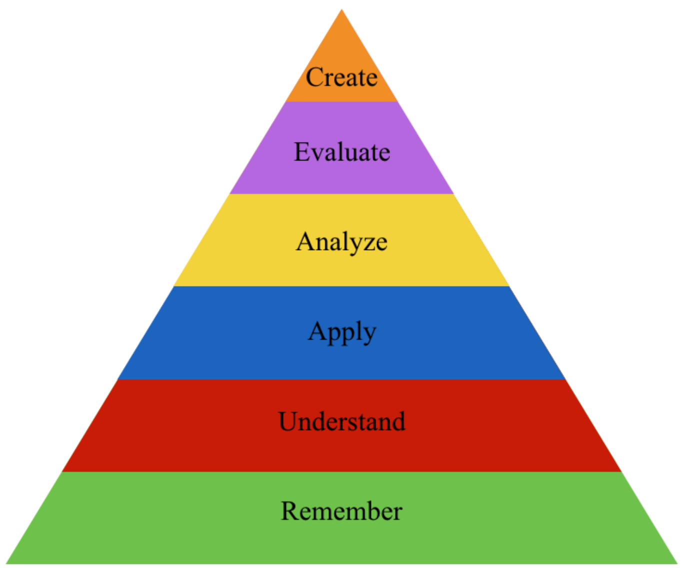
Bloom's Revised Taxonomy of Educational objectives (See table 1) serves as a common language about learning objectives, categorizing them based upon the complexity of the knowledge and cognitive processing demands which they place upon the student (Krathwohl, 2002). The categories within this taxonomy are separated across two dimensions: the *knowledge* dimension, and the *cognitive process* dimension. These two dimensions relate the type of knowledge required to do the task, and the complexity of the operation to be carried out by the student using that knowledge, respectively. In practice the various cognitive processes and knowledge types listed in the taxonomy are not isolable or independent of one-another, however the taxonomy is useful for thinking about the gradation of objectives from lower to higher-order processes.

Table 1- *Revised Bloom's taxonomy. The knowledge and cognitive process dimensions form a 4x6 taxonomy.*

The Knowledge Dimension	**The Cognitive Process Dimension**					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Meta-cognitive Knowledge						

The knowledge dimension. Along the knowledge dimension objectives are categorized into one or more of four types: *factual knowledge, conceptual knowledge, procedural knowledge, and meta-cognitive knowledge.* Factual knowledge pertains to terminology, details, and elements related to a subject. Factual knowledge of fractions would include (among other things) knowledge of numerators and denominators. Conceptual knowledge includes classifications, principles, and theories related to a subject. Conceptual knowledge of fractions would include an understanding of how numerators relate to denominators, or ability to separate a set of fractions into proper fractions from improper fractions. Procedural knowledge includes subject-specific skills, techniques, and decision-making skills. Procedural knowledge of fractions would include the skills required to create equal fractions with different denominators, or to calculate fractions of a set. Metacognitive knowledge includes awareness of comprehension strategies, the cognitive demands imposed by various tasks, and awareness of one's own cognitive and academic strengths and weaknesses. Metacognitive knowledge of fractions would include awareness that it is easier to compare fractions with like denominators, awareness that when the student rushes these types of questions s/he tends to make mistakes, or awareness that a teacher is likely to give a test on fractions in the true/false format.

Figure 1. Levels of cognitive processing in Bloom's revised taxonomy of learning objectives, arranged hierarchically to highlight the foundational nature of lower-level processes



The cognitive process dimension. Along the cognitive process dimension objectives are separated into six levels: *remembering, understanding, applying, analyzing, evaluating, and creating* (See Figure 1). These levels indicate what the student is expected to do with their knowledge. Remembering involves either recognizing or recalling knowledge from memory; the question "what are addition and multiplication" requires a student to remember their knowledge. Understanding involves deriving meaning from a message, the question "How are addition and multiplication related?" requires a student to understand their knowledge. Applying involves carrying out a procedure based upon your knowledge; the instruction "multiply 5 by 6" requires a student to apply their knowledge. Analyzing involves differentiating, organizing, and attributing information; the instruction "separate these addition problems by those that can be simplified as a multiplication problem and those that cannot" requires a student to analyze their knowledge. Evaluating involves checking and critiquing information; the instruction "Review these multiplication problems, and circle then correct any that contain errors" requires a student to evaluate their knowledge. Creating involves generating, planning, and producing; the instructions, such as "Use your measurement to build a better container for these jelly beans, and then show me why it's better".

From the point of view of teacher-directed instruction, the first three cognitive processes are inherently hierarchical in nature (Anderson, Lorin, Krathwohl, & David, 2001). In order to *apply* a concept we must first *understand* it, and to *understand* something we must first *remember* it. Consider the task "2+5=__"; first we must remember the meaning of the "+" symbol and the numbers "2" and "5", then we must understand that "2" and "5" are related and can be compared and combined, finally we must execute the operation of adding "2" to "5" arriving at "7". The *analyze*, *evaluate*, and *create* processes similarly draw heavily upon the first three processes, and are viewed as being higher-order uses of those processes. To create a new math problem, we must still use the first three processes in addition to being able to generalize our math knowledge to a new form.

Due to the foundational and hierarchical nature of the cognitive processes, a child's learning trajectory could benefit from instruction that progresses through the cognitive processes from remembering to creating. If this were the case, it might be expected that at lower grades more objectives would reflect "lower" cognitive processes whereas at higher grades they would reflect "higher" ones. Comparing objectives across grades may provide insight on how students' learning is being scaffolded.

The Present Study

The 1998 NS P-3 math curriculum has been criticized for containing too many objectives to practically teach (Minister's panel on education, 2014). This study will describe and compare the NS curricula from 1956 to the present day to determine whether the number of curriculum objectives vary across documents. Additionally, those objectives will be evaluated to determine where they fall on the cognitive process and knowledge dimensions of Bloom's taxonomy, and to determine whether they are well or ill-defined.

In addition to addressing its own research questions, this work is meant to serve as a practical, structured, and modular springboard for future retrospective explorations of the curriculum documents. This has been carried out in several ways. The 652 objectives that comprise the four documents have been collated and indexed by curriculum year, grade, instruction type (in the case of the 1976 curriculum). In the same table, the objectives have been rated as to whether they are well or ill-defined, and as to their category in terms of type of knowledge and cognitive processes required to carry out the objective. This table is available in an online appendix in excel and comma separated value format (Available at: https://docs.google.com/spreadsheets/d/1BQ-Sa8Z7JikNAeB5JWxsPCYUGaFeyoEXeLfpmwNrgBM/edit?usp=sharing) for ease of access and analysis. The curriculum documents, many of which could only be found in print form at locations that do not index their catalogue on the web, are converted to electronic documents and appended to this paper for future explorations.

Brief Review of Curriculum Documents

1956 (Arithmetic primary - grade VI: A teaching guide; See Appendix B). The Curriculum Division of the Department of Education published this document as a standard math curriculum. In their opening statement, the authors argue that children must be taught the curriculum content to mastery, and that the fundamental math skills therein ought to be applied to situations of meaning to the child so as to ensure that they see the value of math knowledge. The authors also point out that math knowledge is cumulative in nature, and so all new skills need to be based upon skills already mastered. The document also alludes to past curriculum documents, asserting that the present one is a shift from the theoretical to the practical, consider the following excerpt:

> "In years gone by it was customary to require children to do problems which people almost never meet or which are so far from reality that they had no real meaning. Involved problems may have a place in senior high school in order to strengthen a complete command of the intricacies of the number system. In the common school grades, however, the arithmetic taught should consist of the basic skills of addition, subtraction, multiplication, and division of whole numbers with an understanding of them; simple fractions and how to use them; decimals and their uses; and an application of all of these to the kinds of problems which one meets in everyday situations. | Most of these problems involve numbers under one hundred." (Curriculum Division, 1956, p. 6)

The initial 12 pages of the 1956 document include a foreword and general comments on teaching math, with reference to such subjects as drilling, problem-solving, and individual student differences. Following this, the curriculum is broken down into grades, with a common format for each grade. For each grade there is a short preliminary statement after which the grade's objectives are itemized. For grade primary, there are nine objectives. One example objective is "to know the meaning of a dozen". The document then provides recommendations regarding time allotment, student grouping, method, and content. The last section breaks the objectives into "units" for teachers, and describes the content of those units. The entire primary grade section spans eight paperback novel sized pages (that would convert into roughly four pages on 8 ½" x 11" paper), and is in my opinion clear and straightforward for the reader.

1976 (Mathematics - primary-6: A teaching guide; See appendix C). The authors provide six general aims of this curriculum; (1) having students discover the order, relationships, and patterns that are the basis for mathematics, (2) developing the ability to describe, record, and extend patterns, (3) providing opportunities to develop increased facility in basic math skills such as numeracy, (4) the ability to relate situations or events to mathematical representations, (5) the ability to solve problems, and (6) developing the self-confidence to use math to one's advantage in life.

This curriculum guide separates math objectives into three subject areas: Space and Shape, Number, and Measurement. Each subject area has a corresponding section of the document, wherein all of its P-3 objectives are listed. Alongside each objective are four codes, one for each grade from Primary to grade three. These codes denote the expectations for the students and teachers with regard to the listed objectives for a given grade. These codes are listed, along with their definitions, on page 5 of appendix C.

One example objective from this curriculum reads "Recognize and order sets from 0 to 10 and identify the numeral for each set." (To view the objective as it appears in the curriculum document, See p.9 of appendix C). In this case; grade primary classes are in the D (Development) stage where learning is teacher-directed, concrete, and specific to the subject, grade one classes are in the C (Continuing practice) stage where the teacher provides students with experiences that allow them to explore the content from an applied or "deeper" sense, grade two classes are in the M (Mastery) stage where the student should already know the concept well, but practice is encouraged to maintain the skill, and finally in grade 3 the presence of a dash indicates that the objective does not apply.

The next section of the curriculum document provides teaching notes for many (but not all) objectives within a given subject area. These teaching notes are not specific to grade, but instead broadly expand upon the objectives. This section frequently includes recommendations (e.g., "unifix cubes work well in this case" or "do not be afraid to have some children work with very small numbers for a relatively long time), and in some cases provides full examples of lessons.

A teacher would likely have had to read the entire curriculum document (89 pages of 8½" x 11") in order to teach students of a single grade. This is because the curriculum is separated into sections by subject area rather than grade, and many objectives have a corresponding code for three to four grades.

1998 (Atlantic Canada mathematics curriculum guide: Grades primary-3; See appendix D). This curriculum document was published accompanied by a foundation document wherein its rationale was discussed (Atlantic Provinces Education Foundation, 1996). The document contains separate sections for each grade, and then within each grade contains separate sections for GCOs. These GCOs correspond to broad concepts such as number sense or measurement, and are categorically similar to the 1974 Curriculum's "subject areas". Within each section is contained a number of SCOs, these are grade-specific curriculum objectives. One example objective reads, "By the end of grade primary, students will be expected to interpret ordinal numbers”.

Accompanying these objectives are two further sections presented in columns: “Elaboration-Instructional Strategies/Suggestions”, and “Worthwhile Tasks for Instruction and/or Assessment”. These sections include recommendations rather than prescriptions related to the objective in question. The primary section is 59 pages (of 8 ½ x 11 paper) in length.

2015 (Mathematics- Specific curriculum outcomes; See appendix E). This curriculum has not been published as a single document, instead there is a separate document for each grade. An additional document is available which tabulates these objectives across grades (Education Program Services, 2015), and is included in Appendix E. In the grade-specific documents, separate sections pertaining to GCOs (e.g., number sense) list the objectives (referred to there as SCOs) corresponding to those GCOs. Each objective is listed accompanied with several “performance indicators” that are meant to illustrate the depth, breadth, and expectations of the objective. These performance indicators can be used to demonstrate that the objective has been achieved.

One example objective reads, “Students will be expected to demonstrate an understanding of counting to ten”. Below the objective are three performance indicators: “Answer the question, “How many are in the set?” using the last number counted in a set”, “In a fixed arrangement, starting in different locations, show that the count of the number of objects in a set does not change”, and “Count the number of objects in a given set, rearrange the objects, predict the new count, and recount to verify the prediction”.

The SCOs from this curriculum document were selected for objective analysis in the present study due to the fact that they reflect the concepts the teachers are expected to teach. Performance indicators were not selected for this analysis as they were described as an analytic cross-section of the concept to be taught, rather than a complete description of the content to be taught.

Research questions

Question 1. Does the overall number of curriculum objectives vary across curricula?

Question 2. Does the relative frequency of well-and-ill-defined objectives vary across curricula?

Question 3. Do the relative frequencies of types of knowledge represented in the objectives vary across curricula?

Question 4. Do the relative frequencies of levels of cognitive complexity of objectives vary across curricula?

Question 5. Does the proportion of well-defined objectives vs. ill-defined objectives vary depending upon where those objectives fall within Bloom's revised taxonomy? Does this vary across curricula?

Methods of Qualitative Coding

Qualitative Coding Process- Round 1

The objectives from the dataset were coded in the following manner. Two raters were given the same materials for use in categorizing objectives as being well or ill defined, and for determining the cognitive process and knowledge domain relevant to the objective (See materials in Appendix F). One rater (R1) coded the entire dataset of 652 objectives, and a second rater (R2) scored one tenth of the objectives for the purpose of evaluating inter-rater agreement. Of the 652 objectives to be coded, 17 (less than 3%; shown in Table 2) were determined by the R1 to be unscorable due to their general or abstract nature (e.g., develop aspects of spatial sense, including perceptual constancy, perception of spatial relationships, and visual discrimination).

Table 2- *Unscorable Curriculum Objectives (Counted as unscorable for scoring round one only)*

Curriculum	Grade	Objective
1976	Primary	Develop a sense of personal time
	One	Develop a sense of personal time
	Two	Have explored the results of multiplying by the grouping number when playing grouping or chip trading games
		Explore the faces, edge, and vertices of geometric solids: cuboids, rectangular prisms, tetrahedrons, etc.
		Develop a sense of personal time
	Three	Have explored the results of multiplying by the grouping number when playing grouping or chip trading games
		Explore the faces, edge, and vertices of geometric solids: cuboids, rectangular prisms, tetrahedrons, etc.
		Explore parallel lines and right angles
		Develop a sense of personal time
1998	Primary	Develop spatial sense, including position-in-space and the language associated with it
		Develop spatial sense, including eye-motor co-ordination
		Explore a variety of physical representations of numbers
	One	Develop aspects of spatial sense, including visual memory
		Develop aspects of spatial sense, including figure ground perception
		Explore the meaning of the numbers between 10 and 20
	Two	Develop aspects of spatial sense, including perceptual constancy, perception of spatial relationships, and visual discrimination
	Three	Continue their development of spatial sense with emphasis on perceptual constancy

Summary of Inter-Rater Agreement

Overall, the two raters agreed on which of the six cognitive processes were associated with a given outcome 57% of the time, on which of the four levels of the knowledge domain were associated with a given outcome 63% of the time, and on whether a given outcome was well-defined 63% of the time (See descriptive statistics reported in Appendix F for details). While inter-rater agreement was substantially above chance, it was lower than originally expected. Therefore, a second round of coding was completed given the significant differences between the two raters' scoring.

Qualitative Coding Process- Round 2

To determine whether inter-rater agreement could be improved, the data were subjected to a second round of coding. Before recoding, the two raters held a meeting where they reviewed the discrepancies between their scoring on a case-by-case basis to clarify their rationale. Where answers remained unclear, consultation was sought from the project supervisor. After this meeting, 65 objectives were again randomly drawn from the data set for the second rater to code, and the first rater re-coded the full dataset.

In round 2, the following changes were made to the rating process. Rather than evaluating whether each objective was well-defined or ill-defined overall, each objective was assigned two codes reflecting "teaching" and "evaluation". This was done based upon the raters' anecdotal reports that objectives sometimes seemed well-defined in terms of how to teach them, but ill-defined in terms of how students should be evaluated. In other words, an objective may be clear enough for teachers to be able to target the skill to be taught, but not explicit enough to determine when the student has attained sufficient mastery of the skill for the objective to be "achieved". Where analysis includes a consideration of well and ill-defined objectives, both forms will be reported for comparison purposes. Additionally, the option to score items as "unscorable" was removed, and raters instead assigned codes of best fit to those items. In light of the subjectivity of the scoring process, it was determined that scoring these items based on best fit was a valid component of the scoring process

Summary of Inter-Rater Agreement

Overall, the two raters agreed on which of the six cognitive processes were associated with a given outcome 60% of the time (a 3% increase), on which of the four levels of the knowledge domain were associated with a given outcome 66% of the time (a 3% increase). Additionally, raters agreed and on whether a given objective corresponded to a well-defined teaching process 83% of the time and a well-defined evaluation process 65% of the time (a 20% and 2% improvement, respectively). Refer to the tables in Appendix F for a more detailed descriptive analysis.

Results

All data were drawn from four NS curriculum documents published on the dates 1956, 1976, 1998, and 2015. Whereas most objectives in each of the curricula were separately listed for each grade, in the 1976 document single objectives often spanned over several grades. These objectives were accompanied by a code that indicated the form that teaching the objective should take. These codes were reviewed in the section for this curriculum. In this dataset, the 1976 data are listed twice, once as “1976” and once as “1976 (D,C)”. The former listing includes all curriculum objectives regardless of their accompanying code, whereas the latter includes only those objectives that corresponded to the codes D (Development) and C (Continuing practice). The first listing is meant to be a broad and general overview of the curriculum, whereas the second listing is meant to more closely parallel the objectives in the other curricula. The D and C codes are those that are associated with direct classroom teaching of the content related to the objective.

Question 1. The objectives contained within each curriculum document were tabulated. The cells containing each objective were summed for each document, and are provided in Table 3 and Figure 2 for comparative purposes.

Figure 2- *The number of objectives contained within each curriculum.*

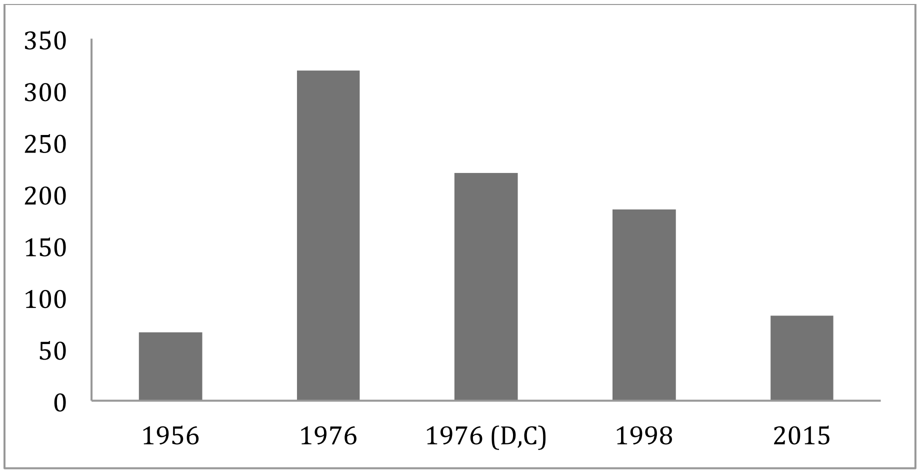


Table 3- *The number of objectives contained within each curriculum*

Curriculum	Objectives
1956	66
1976	319
1976 (D, C)	220
1998	185
2015	82

Question 2. All curriculum objectives were evaluated to determine whether they satisfied the characteristics of a well-defined objective to teach and whether they satisfied the characteristics of a well-defined objective to evaluate (Appendix A). One rater assigned either a W (well-defined) or an I (ill-defined) to each objective in the curriculum, whereas a second rater was given a 10% cross-section of the data to score for the purpose of estimating inter-rater agreement. The relative frequency of well-and-ill-defined objectives as determined by this rating process is provided in Table 4, comparing across curricula. The proportion of objectives that were well-defined for evaluation are also shown in Figure 3.

Figure 3- *The relative frequency of well or ill-defined objectives to evaluate by curriculum.*

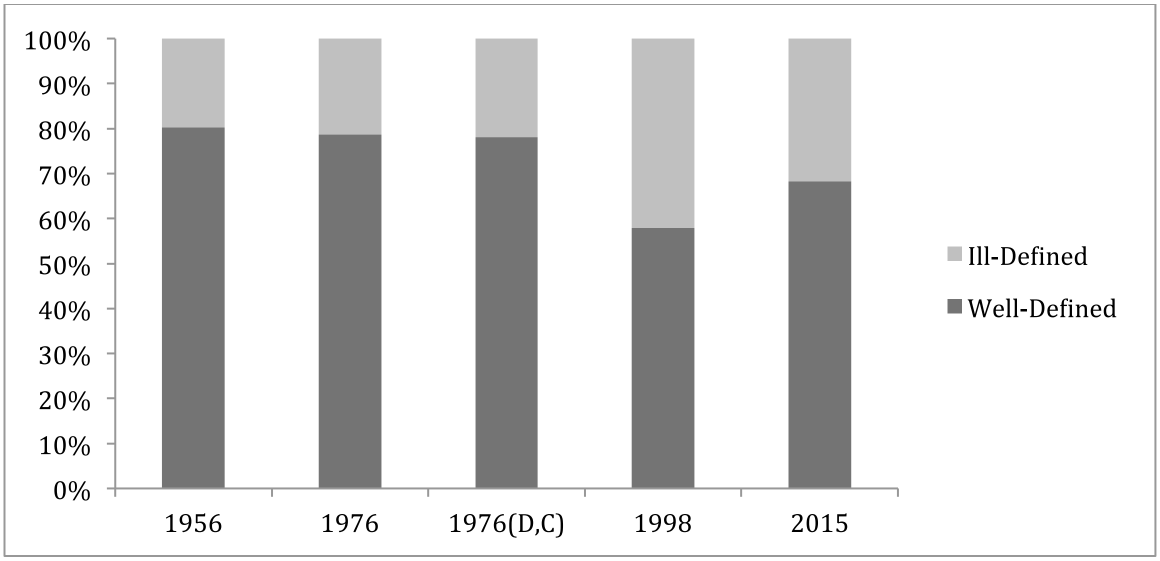


Table 4- *The relative proportion of well- and ill-defined objectives across curricula*

	To teach		To evaluate	
Curriculum	Well-Defined	Ill-Defined	Well-Defined	Ill-Defined
1956	57 (.86)	9 (.14)	53 (.80)	13 (.20)
1976	303 (.95)	16 (.05)	251 (.79)	68 (.21)
1976 (D, C)	210 (.95)	10 (.05)	172 (.78)	48 (.22)
1998	145 (.78)	40 (.22)	107 (.58)	78 (.42)
2015	78 (.95)	4 (.05)	56 (.68)	26 (.32)

Question 3. The same rating process was used here as was used for the scoring of question 2, except that raters reported which of the four categories of the knowledge dimension the objective was relevant to. In instances where the objective fell into more than one category and a "primary category" was not clear to the rater, the higher-order of the categories was

selected. To assist the rater in making this decision, they were supplied with a list of the types and subtypes of knowledge, and related examples (See Appendix G). Raters assigned each objective a value between “A” and “D” depending upon which category of the knowledge dimension the objective reflected. Factual knowledge was coded as “A”, conceptual knowledge as “B”, practical knowledge as “C”, and metacognitive knowledge as “D”. Once all values were tabulated, the relative frequencies of the different types of knowledge represented by the objectives were compared across curricula. The results of that comparison are provided in Table 5 and Figure 4, with raw frequencies accompanied by relative frequencies in parentheses. Relative frequencies are calculated relative to the curriculum, and so sum to 1 (allowing for rounding error) in each row.

Figure 4- *The relative frequency of objectives by knowledge level across curricula.*

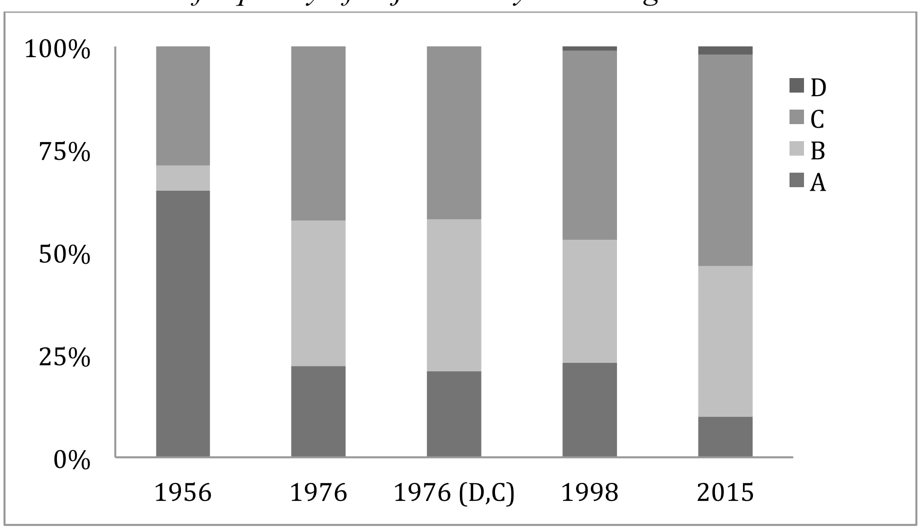


Table 5- *The relative frequency of objectives by knowledge level across curricula.*

Curriculum	A	B	C	D
1956	43 (.65)	4 (.06)	19 (.29)	0 (0)
1976	71 (.22)	113 (.35)	135 (.42)	0 (0)
1976 (D, C)	46 (.21)	82 (.37)	92 (.42)	0 (0)
1998	43 (.23)	55 (.30)	85 (.46)	2 (.01)
2015	8 (.10)	30 (.37)	42 (.52)	2 (.02)

Note: A = Factual, B = Conceptual, C = Procedural, D = Metacognitive.

Question 4. All curriculum objectives will be evaluated to determine which of the six categories of cognitive processing dimension the objective is most relevant to, again using the same methodology as question 2. To assist the raters in making this decision, they were supplied with a list of terms, alternate names that are commonly associated with each category, a definition, and examples (See Appendix H). Raters assigned each objective a value between "1" and "6" depending upon which level of cognitive processing the objective reflected. Objectives associated most closely with remembering were coded as 1, Understanding was coded as 2, Applying was coded as 3, Analyzing was coded as 4, Evaluating was coded as 5, and Creating was coded as 6.

Once all values were tabulated, the relative frequencies of the different types of cognitive processes represented by the objectives were compared across curricula. The results of that comparison are provided in Table 6 and Figure 5, with raw frequencies accompanied by relative frequencies in parentheses. Relative frequencies are calculated relative to the curriculum, and so sum to 1 (allowing for rounding error) in each row.

Figure 5- *The relative frequency of objectives by cognitive process level across curricula.*

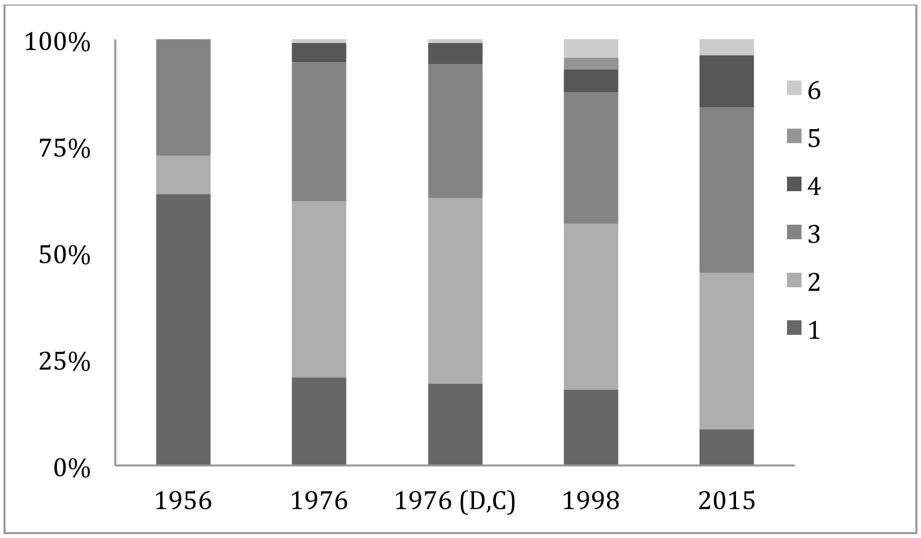


Table 6- *The relative frequency of objectives by cognitive process level across curricula*

Curriculum	1	2	3	4	5	6
1956	42 (.64)	6 (.09)	18 (.27)	0 (0)	0 (0)	0 (0)
1976	66 (.21)	132 (.41)	104 (.33)	14 (.04)	0 (.0)	3 (.01)
1976 (D, C)	42 (.19)	96 (.44)	69 (.31)	11 (.05)	0 (.0)	2 (.01)
1998	33 (.18)	72 (.39)	57 (.31)	10 (.05)	5 (.03)	8 (.04)
2015	7 (.08)	30 (.37)	32 (.39)	10 (.12)	0 (.0)	3 (.04)

Note: 1 = Remember, 2 = Understand, 3 = Apply, 4 = Analyze, 5= Evaluate, 6 = Create.

Question 5. Two relative frequency charts were generated from the tabulated and categorized objectives (See Appendix I for the complete tabulated data) one to evaluate the relationship between whether or not objectives are well-defined and the knowledge dimension of Bloom's revised taxonomy, and one to evaluate the relationship between whether or not objectives are well-defined and the processing stages dimension of Bloom's revised taxonomy. In two tables the relative frequencies of well vs. ill-defined objectives (one table for teaching, another for evaluating) were compared across types of cognitive processes represented by the objectives across curricula. In another two tables the same was done replacing cognitive processes with types of knowledge. The results of these four comparisons are provided in Tables 7, 8, 9, and 10, with raw frequencies of well and ill-defined objectives listed as "Well/ill" accompanied by the relative frequency of well-defined objectives in parentheses. For example, "29/20 (.59)" indicates that 29 objectives were rated as being well-defined whereas 20 objectives were rated as ill-defined, and that the proportion of objectives that are well defined is .59.

Table 7- *The proportion of well-defined to teach objectives by cognitive process level across curricula*

Curriculum	1	2	3	4	5	6
1956	37/5 (.88)	2/4 (.33)	18/0 (1)	0/0 (NA)	0/0 (NA)	0/0 (NA)
1976	60/6 (.91)	122/10 (.92)	104/0 (1)	14/0 (1)	0/0 (NA)	0/3 (0)
1976 (D, C)	39/3 (.93)	89/7 (.93)	69/0 (1)	11/0 (1)	0/0 (.67)	0/2 (0)
1998	24/9 (.73)	50/22 (.69)	52/5 (.91)	8/2 (.8)	5/0 (1)	6/2 (.75)
2015	5/2 (.71)	29/1 (.97)	32/0 (1)	9/1 (.9)	0/0 (0)	3/0 (.43)

Note: 1 = Remember, 2 = Understand, 3 = Apply, 4 = Analyze, 5= Evaluate, 6 = Create.

Table 8- *The proportion of well-defined to evaluate objectives by cognitive process level across curricula*

Curriculum	1	2	3	4	5	6
1956	33/9 (.79)	2/4 (0.33)	18/0 (1.0)	0/0 (0)	0/0 (0)	0/0 (NA)
1976	60/6 (.91)	94/38 (.71)	83/21 (.80)	14/0 (1.0)	0/0 (0)	0/3 (0)
1976 (D, C)	39/3 (.93)	67/29 (.70)	55/14 (.80)	11/0 (1.0)	0/0 (0)	0/2 (0)
1998	19/14 (.58)	33/39 (.46)	42/15 (.74)	7/3 (.7)	5/0 (0)	1/7 (.12)
2015	3/4 (.43)	24/6 (.8)	19/13 (.59)	9/1 (.90)	0/0 (0)	1/2 (.33)

Note: 1 = Remember, 2 = Understand, 3 = Apply, 4 = Analyze, 5= Evaluate, 6 = Create.

Table 9- *The relative frequency of well-defined to teach objectives by knowledge level across curricula*

Curriculum	A	B	C	D
1956	38/5 (.88)	0/4 (0)	19/0 (1)	0/0 (NA)
1976	66/5 (.93)	102/11 (.90)	135/0 (1)	0/0 (NA)
1976 (D, C)	43/3 (.93)	75/7 (.91)	92/0 (1)	0/0 (NA)
1998	31/12 (.72)	36/19 (.65)	77/8 (.91)	1/1 (.5)
2015	6/2 (.75)	29/1 (.97)	40/1 (.98)	2/0 (1)

Note: A = Factual, B = Conceptual, C = Procedural, and D = Metacognitive.

Table 10- *The relative frequency of well-defined objectives by knowledge level across curricula*

Curriculum	A	B	C	D
1956	34/9 (.79)	0/4 (0)	19/0 (1.0)	0/0 (NA)
1976	62/9 (.87)	81/32 (.72)	111/24 (.82)	0/0 (NA)
1976 (D, C)	40/6 (.87)	59/23 (.72)	75/17 (.82)	0/0 (NA)
1998	19/24 (.44)	28/27 (.51)	60/25 (.71)	0/2 (0)
2015	4/4 (.5)	24/6 (.80)	28/14 (.67)	0/2 (0)

Note: A = Factual, B = Conceptual, C = Procedural, and D = Metacognitive

Discussion

Number of Objectives in the NS Math Curriculum

The current curriculum change was motivated in part by reports that the objectives in the 1998 document were too numerous to spend an appropriate amount of time teaching each one. Given that, it is not surprising that the new NS math curriculum does indeed have fewer than half as many objectives compared to the 1998 curriculum. What is more surprising is the discovery that the 1998 curriculum itself had fewer educational objectives than its predecessor, the 1976 curriculum.

In terms of the actual number of objectives, the current curriculum is most similar to the 1956 curriculum. Further in-depth explorations and comparisons of these two curricula may be warranted to determine the degree of similarity of content between the two documents. It is after all worth noting that the abbreviated 1956 curriculum was eventually replaced by the greatly expanded 1976 document. Understanding why this was done could provide perspective on the new NS curriculum, and assist in identifying hidden pitfalls before they are made apparent by the performance of Nova Scotia's students.

Well-Defined and Ill-Defined Objectives in the NS Math Curriculum.

In terms of the teaching process, the current curriculum was found to contain a higher proportion of well-defined objectives than the previous 1998 curriculum. This suggests that the objectives should be more behaviourally and instructionally explicit in their design and therefore more straightforward to teach. The 1998 curriculum in particular contained a higher proportion of ill-defined objectives. While it is likely given these results that the new curriculum will lighten the load on teachers and permit instructing to a higher degree of mastery, we may benefit from future explorations of these data with particular focus on the academic impact of fewer objectives *and* fewer ill-defined objectives.

In terms of the evaluation process, the current curriculum was found to contain more ill-defined objectives than past curricula, though still fewer than the 1998 curriculum. However, in reviewing those items that were coded as ill-defined it was noted that often the outcomes were necessarily and appropriately ill-defined. Specifically, outcomes were frequently ill-defined due to the inclusion of student-directed problem-solving tasks rather than vague terminology or a lack of a minimum expected standard for evaluation.

Revised Bloom's Taxonomy and the NS Math Curriculum.

Knowledge. In general, there has been a trend for the successive math curricula to place progressively more focus on higher order types of knowledge, as illustrated in Figure 4. All four curricula placed heavy emphasis upon procedural knowledge (29-52% of objectives), which is not surprising considering the inherent linkage between mathematics and procedural knowledge. The 1956 curriculum objectives placed a comparatively heavy emphasis upon the use and acquisition of factual knowledge and a comparatively light emphasis on conceptual knowledge. Each of the remaining three curricula placed a strong emphasis upon conceptual knowledge. Many objectives related to conceptual knowledge by requiring the student to relate information, draw comparisons, and transform information. Objectives related to procedural knowledge often required the student to continue patterns or carry out numerical operations.

While there were relatively few objectives overall that tapped into metacognitive knowledge, both the 1998 and 2015 curricula each included two objectives that were related to this knowledge type. These objectives required students to apply their interests to their work, or develop and/or apply personal strategies to complete their work.

Cognitive process. As with knowledge types, there was an overall trend for each successive curriculum to place increased focus on higher-order cognitive processes, observable in Figure 5. Across all curricula the majority of objectives (91% of them, when estimated using the restricted criteria for 1976 objectives) were found to correspond to one of the first three cognitive processes (Remember, Understand, and Apply) whereas only a minority (9%) corresponded to the three higher-order processes (Analyze, Evaluate, and Create). The 1976 and 1998 curricula had a similar balance of objectives, though the 1998 curriculum had a somewhat greater emphasis on objectives involving evaluating and creating.

The 1956 and 2015 curricula, which bore some similarity in terms of their low number of objectives, are stark contrasts of one-another on the cognitive process dimension. The aforementioned trend toward lower-order cognitive processes is most evident in the 1956 curriculum. Its authors had cited it as a shift toward practical everyday mathematics, and indeed nearly all objectives corresponded either to remembering or applying. By contrast, the 2015 curriculum emphasizes understanding among the lower order processes, for instance by frequently asking the student to relate or compare numbers rather than simply identifying them. The 2015 document also contains a higher proportion of objectives in the three higher-order categories than any other curriculum reviewed here, and tied the 1998 curriculum for proportion of objectives that require the student to create novel material. The objectives from the 1998 and 2005 curricula were four times more likely to involve creating novel content than the 1976 curriculum.

The Taxonomy and well/ill-defined objectives. The likelihood that an objective would be well-defined in terms of teaching did not differ substantially based on cognitive processing levels. By contrast, objectives that required the student to recognize or recall information were frequently well-defined in terms of student evaluation. Conversely, objectives that required students to create novel work were more frequently found to be ill-defined to evaluate as compared to those objectives that did not. This likely reflects the increased requirement for student autonomy to complete such tasks as are involved for these objectives. This pattern is clear in the 2015 curriculum, wherein the majority (> 85%) of objectives are well-defined with the exception of those that fall under the create category (43%).

In comparing the objectives along the knowledge domain, it was noted that the likelihood of objectives being well or ill defined did not seem to vary substantially based upon this dimension. Instead, it was observed that overall the 1998 curriculum contained many ill-defined to evaluate objectives at the factual and conceptual level compared to other curricula (approximately half of objectives were determined to be ill-defined). In the 2015 curriculum, half of objectives coded as pertaining to factual knowledge also were ill defined to evaluate, however this may be an artefact of fewer observations as only 8 objectives were coded as pertaining to factual knowledge.

Future Directions

The core data provided in this document are expandable, with many dimensions not yet indexed for analysis given the scope of the present study. All curricula with the exception of the 1956 document nested objectives into discrete subjects such as “number sense” or “measurement”. Similarly, performance indicators and sample tasks are provided in these documents, and may warrant future consideration. It is expected that when these smaller facets are taken into account, the WNCP-based 2015 curriculum may not be as extreme a curriculum downsize as it seems at first blush.

The collection and inclusion of historical math student performance measures would be invaluable to this dataset. These measures could take many forms, with some obvious possibilities being provincial rankings in math assessment, or number of students failing to complete class requirements. However, interpreting such measures in a vacuum would likely prove misleading; for instance if all students succeed in their coursework it may be that the curriculum is brilliantly balanced and structured, but it is equally plausible that the content was overly facile. The collection and compilation of *various* performance measures collected across the time span of these curriculum documents would be invaluable in comparing the success or failure of these curriculum documents.

If the goal of public education is to train students toward becoming successful adults, then we should hope that variance in the quality of the curriculum should have a measurable effect on success. As many students taught using the 1956, 1976, and 1998 P-3 curricula have matured to adulthood, further retrospective analysis might focus upon measures of success in adulthood related to mathematics. Directly causally linking the curricula to a given measure of success in adulthood would be a staggering feat, but accounting for major historical trends and comparing across historically similar referents (not all Canadian provinces used the NS curriculum) we may hope to at least find patterns to forward our thinking about mathematics education. Did the practical approach to mathematics promoted in the 1956 curriculum correspond to adults better able to manage everyday household costs? Does the proportion of objectives associated with "creating" correlate to the number of students growing up to become inventors or small business owners? It is my hope that these data may serve as a springboard toward such broader explorations.

Conclusions

With each successive new math curriculum, Nova Scotia has seen a shift to higher-order knowledge types and cognitive processes, but the most recent (2015) curriculum does so while using fewer ill-defined objectives than the 1998 curriculum. The 2015 curriculum is also a departure from the previous NS curriculum in part due to its reduction in curriculum objectives. However, 1956 the NS curriculum contained even fewer educational objectives than the present one and did not add further complexity with performance indicators. Understanding the similarities and differences between these two documents, and determining why the 1956 curriculum was ultimately replaced with the larger and much more technical 1976 curriculum, could allow us to predict and correct concerns regarding our current curriculum. Understanding the shift from factual and practical objectives to abstract and conceptual ones may also offer us perspective on our province's academic trajectory.

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Appendix A

A well-defined objective is defined as one for which:

1. A teacher can ask a student to perform a task involving observable behaviours and meeting a minimum acceptable standard related to the objective,

2. A finite list of all possible correct methods by which the task may be completed is known to the teacher, and;

3. The student completing that task correctly would demonstrate that they had achieved the objective.

Appendix B- The 1956 NS P-3 Math Curriculum

Appendix C- The 1976 NS P-3 Math Curriculum

Appendix D- The 1998 NS P-3 Math Curriculum

Appendix E- The 2015 NS P-3 Math Curriculum

Appendix F- Inter-rater Agreement Round 1

Each table contains the frequency scores, with one rater's coding on the X axis, and the other rater's coding on the Y axis. Greyed boxes indicate scoring matches.

Table 1- Inter-Rater Reliability for Well or Ill Defined Variables

Well/Ill	W	I
W	27	17
I	7	14

Table 2- Inter-Rater Reliability for Cognitive Processing levels

Cognitive Process	1	2	3	4	5	6
1	11	5	2	0	0	0
2	0	12	1	2	0	0
3	4	1	11	0	0	3
4	1	0	3	1	0	2
5	0	2	0	0	0	0
6	0	2	0	0	0	2

Table 3- Inter-Rater Reliability for the knowledge domain

Knowledge	A	B	C	D
A	5	8	4	0
B	0	14	7	0
C	0	2	22	1
D	0	1	1	0

Appendix F (Cont'd)- Inter-rater Agreement Round 2

Each table contains the frequency scores, with one rater's coding on the X axis, and the other rater's coding on the Y axis. Greyed boxes indicate scoring matches.

Table 1- Inter-Rater Reliability for Well or Ill Defined Variables

Well/Ill	W	I
W	32	15
I	8	10

Table 2- Inter-Rater Reliability for Cognitive Processing levels

Cognitive Process	1	2	3	4	5	6
1	16	5	2	0	0	0
2	2	9	5	0	0	0
3	2	3	13	3	0	0
4	0	0	3	0	0	0
5	0	0	0	0	0	1
6	0	0	1	0	0	1

Table 3- Inter-Rater Reliability for the knowledge domain

Knowledge	A	B	C	D
A	14	1	0	0
B	6	7	4	0
C	2	7	22	0
D	0	1	1	0

Appendix G

4.1 THE KNOWLEDGE DIMENSION

MAJOR TYPES AND SUBTYPES	EXAMPLES
A. FACTUAL KNOWLEDGE—The basic elements students must know to be acquainted with a discipline or solve problems in it	
AA. Knowledge of terminology	Technical vocabulary, music symbols
AB. Knowledge of specific details and elements	Major natural resources, reliable sources of information
B. CONCEPTUAL KNOWLEDGE—The interrelationships among the basic elements within a larger structure that enable them to function together	
BA. Knowledge of classifications and categories	Periods of geological time, forms of business ownership
BB. Knowledge of principles and generalizations	Pythagorean theorem, law of supply and demand
BC. Knowledge of theories, models, and structures	Theory of evolution, structure of Congress
C. PROCEDURAL KNOWLEDGE—How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	
CA. Knowledge of subject-specific skills and algorithms	Skills used in painting with water colors, whole-number division algorithm
CB. Knowledge of subject-specific techniques and methods	Interviewing techniques, scientific method
CC. Knowledge of criteria for determining when to use appropriate procedures	Criteria used to determine when to apply a procedure involving Newton's second law, criteria used to judge the feasibility of using a particular method to estimate business costs
D. METACOGNITIVE KNOWLEDGE—Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	
DA. Strategic knowledge	Knowledge of outlining as a means of capturing the structure of a unit of subject matter in a text book, knowledge of the use of heuristics
DB. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge	Knowledge of the types of tests particular teachers administer, knowledge of the cognitive demands of different tasks
DC. Self-knowledge	Knowledge that critiquing essays is a personal strength, whereas writing essays is a personal weakness; awareness of one's own knowledge level

Appendix H

5.1 The Cognitive Process Dimension

Categories & Cognitive Processes	Alternative Names	Definitions and Examples
1. Remember—Retrieve relevant knowledge from long-term memory		
1.1 Recognizing	Identifying	Locating knowledge in long-term memory that is consistent with presented material (e.g., Recognize the dates of important events in U.S. history)
1.2 Recalling	Retrieving	Retrieving relevant knowledge from long-term memory (e.g., Recall the dates of important events in U.S. history)
2. Understand—Construct meaning from instructional messages, including oral, written, and graphic communication		
2.1 Interpreting	Clarifying, paraphrasing, representing, translating	Changing from one form of representation (e.g., numerical) to another (e.g., verbal) (e.g., Paraphrase important speeches and documents)
2.2 Exemplifying	Illustrating, instantiating	Finding a specific example or illustration of a concept or principle (e.g., Give examples of various artistic painting styles)
2.3 Classifying	Categorizing, subsuming	Determining that something belongs to a category (e.g., concept or principle) (e.g., Classify observed or described cases of mental disorders)
2.4 Summarizing	Abstracting, generalizing	Abstracting a general theme or major point(s) (e.g., Write a short summary of the events portrayed on a videotape)
2.5 Inferring	Concluding, extrapolating, interpolating, predicting	Drawing a logical conclusion from presented information (e.g., In learning a foreign language, infer grammatical principles from examples)
2.6 Comparing	Contrasting, mapping, matching	Detecting correspondences between two ideas, objects, and the like (e.g., Compare historical events to contemporary situations)
2.7 Explaining	Constructing models	Constructing a cause-and-effect model of a system (e.g., Explain the causes of important 18th-century events in France)
3. Apply—Carry out or use a procedure in a given situation		
3.1 Executing	Carrying out	Applying a procedure to a familiar task (e.g., Divide one whole number by another whole number, both with multiple digits)
3.2 Implementing	Using	Applying a procedure to an unfamiliar task (e.g., Use Newton's Second Law in situations in which it is appropriate)

Appendix H (Cont'd)

5.1 THE COGNITIVE PROCESS DIMENSION (CONTINUED)

CATEGORIES & COGNITIVE PROCESSES	ALTERNATIVE NAMES	DEFINITIONS AND EXAMPLES
4. ANALYZE—Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose		
4.1 DIFFERENTIATING	Discriminating, distinguishing, focusing, selecting	Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material (e.g., Distinguish between relevant and irrelevant numbers in a mathematical word problem)
4.2 ORGANIZING	Finding coherence, intergrating, outlining, parsing, structuring	Determining how elements fit or function within a structure (e.g., Structure evidence in a historical description into evidence for and against a particular historical explanation)
4.3 ATTRIBUTING	Deconstructing	Determine a point of view, bias, values, or intent underlying presented material (e.g., Determine the point of view of the author of an essay in terms of his or her political perspective)
5. EVALUATE—Make judgments based on criteria and standards		
5.1 CHECKING	Coordinating, detecting, monitoring, testing	Detecting inconsistencies or fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented (e.g., Determine if a scientist's conclusions follow from observed data)
5.2 CRITIQUING	Judging	Detecting inconsistencies between a product and external criteria, determining whether a product has external consistency; detecting the appropriateness of a procedure for a given problem (e.g., Judge which of two methods is the best way to solve a given problem)
6. CREATE—Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure		
6.1 GENERATING	Hypothesizing	Coming up with alternative hypotheses based on criteria (e.g., Generate hypotheses to account for an observed phenomenon)
6.2 PLANNING	Designing	Devising a procedure for accomplishing some task (e.g., Plan a research paper on a given historical topic)
6.3 PRODUCING	Constructing	Inventing a product (e.g., Build habitats for a specific purpose)

Appendix I

A well-defined objective in terms of teaching is defined as one for which:

1. A teacher can infer the content to be taught from the wording of the objective, and

2. A finite list of content can be assembled by the teacher and taught to the student relevant to the objective.

A well-defined objective in terms of evaluation is defined as one for which:

1. A teacher can ask a student to perform a task involving observable behaviours and meeting a minimum acceptable standard related to the objective,

2. A finite list of all possible correct methods by which the task may be completed is known to the teacher, and;

3. The student completing that task correctly would demonstrate that they had achieved the objective.