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Developing a Mathematics Common Assessment System: Using Data to Drive Instruction

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Open Access

Abstract

There is an ongoing demand for school and district based educators to connect curriculum, instruction and assessment practices to monitor and increase student achievement. This paper describes the development of a Common Assessment system that connects curriculum, instruction and assessment. It can be implemented from a school based (teacher) or district based perspective. This model addresses the role of curriculum guides, instructional pacing, assessment system selection, test types, professional development and issues related to data disaggregation and dissemination. This model has implications for curriculum development, professional development, instruction and policy articulation.

Keywords

Standards Based Assessment, Mathematics, Common Assessment, Cognitive Complexity, Curriculum Alignment

1. Introduction

This paper will provide a systematic approach to developing a districtwide Mathematics common assessment system from a top-down (central office) and a bottom-up building based (teacher-developed) perspective. Participants will examine:

- 1) Timeline
- 2) Item development
- 3) Assessment system
- 4) Professional development
- 5) Instructional implications
- 6) Data dissemination/disaggregation issues

This cyclical approach to an assessment system is highly replicable across all standards based content areas.

2. Literature Review

Assessing student learning is a critical element of the teaching and learning process (Schmoker, 2018). In public schools across the United States, teachers begin with a set of state content standards. In areas like Mathematics, the standards are typically provided by grade and content level. Within each standard content, level of cognitive complexity and sometime assessment limits are provided. Teachers then must translate these standards into instructional and assessment practices that ensure that students have mastered the content within the standards. Researchers question whether the adoption of rigorous standards leads to increased student achievement (Song et al., 2022). The responsibility of the teacher is to translate the standards by planning instructional approaches and lessons that meet the needs of their individual classroom. Research had identified lesson planning as one of the most critical aspects of teaching (Lika, 2017). Yet, aligning curriculum, instruction and assessment is critical to ensuring that what is taught is assessed. The alignment of assessments with standards must ensure that the content is addressed, and that it is assessed at the appropriate cognitive level. Research has shown that this can be challenging for educators (Drost, 2016, 2017, 2018; Drost & Levine, 2015; Popham, 2017, 2019). This model uses the work of Benjamin Bloom. His taxonomy describes the cognitive (thinking/reasoning) processes involved in learning. It provides the level of cognitive demand and the corresponding activities to ensure that lessons/activities are aligned to specific levels (Adams, 2015). Teachers can then use the work of Bloom to design classroom instruction and assessment practices that align with the cognitive demand within the published standards. When this occurs, curriculum, instruction and assessment meet in the same sphere of cognitive complexity. When it does not occur, the effects may not be evident with classroom assessment data but may be evident with state and national assessments (Popham, 2017, 2019). The lack of connectivity within curriculum, instruction and assessment practices is the primary issue that is addressed within this model. The model provides the process to ensure alignment of these entities and a cognitive complexity tool to ensure that curriculum, instruction and assessment practices focus on content and depth of knowledge.

3. Timeline

- 1) Develop District Curriculum: include pacing guides aligned with Local, State or National Expectations/Standards.
- 2) Determine the Assessment system you will use
- 3) PD on Assessment System and Item Development
- 4) Develop or “secure” items aligned with content expectations
- 5) Administer Assessments
- 6) Data Analysis—Analyze results by expectation, district, building, student,

subgroup, teacher...

7) Instructional Implications—Address revisions to curriculum, instruction, assessment...

4. What Is a Common Assessment?

Def—Any assessment given by 2 or more instructors with the intention of collaboratively examining the results for:

- shared learning,
- instructional planning for individual students, and/or
- Curriculum, instruction, and/or assessment modifications.

Districtwide Common Assessments should not be administered without a common district curriculum. The curriculum should include:

- Curriculum aligned to state or (agreed upon) expectations (content and cognitive level!)
- Pacing Guides/Charts are critical—Daily, Weekly, Monthly (see **Tables 1-3**)

Table 1. Sample pacing guide/chart—daily.

WK	Algebra Topic	Algebra Topic Lab	Materials Needed for Lab
1	Introduction to Class: Grading Guidelines Explain the meaning of weighted averages (1-1) Describe relationships between sets of data (1-2)	Day 1: Class Introductions, Grading Guidelines and Class rules and procedures Day 2: Activity on Weighted Averages	<ul style="list-style-type: none"> • Tape measures • Graphing Calculators • Ch. 1 Support File • Re - teaching 1 - 2 • Practice 1 - 2
2	Finding absolute values	Day 1: Practice 1 - 4	<ul style="list-style-type: none"> • Ch. 1 Support File • Re - teaching 1 - 3 • Practice 1 - 3

Table 2. Sample pacing guide/chart—weekly.

Unit 1: Lines, Angles and Logic	
Week 1	Introduction to Class 1.1 Patterns and Inductive Reasoning 1.2 Points, Lines and Planes
2	1.3 Segments and Their Measures 1.4 Angles and Their Measures Quiz on Sections 1.2 - 1.4
3	1.5 Segment and Angle Bisectors 1.6 Angle Pair Relationships 1.7 Introduction to Perimeter, Circumference and Area
4	Chapter 1 Test 2.1 Conditional Statements 2.2 Deductive Reasoning
5	2.3 Reasoning with Algebraic properties

Table 3. Sample pacing guide/chart—monthly

Unit 1: Lines, Angles and Logic	
September	Introduction to Class
	1.8 Patterns and Inductive Reasoning
	1.9 Points, Lines and Planes
	1.10 Segments and Their Measures
	1.11 Angles and Their Measures
	Quiz on Sections 1.2 - 1.4
	1.12 Segment and Angle Bisectors
	1.13 Angle Pair Relationships
	1.14 Introduction to Perimeter, Circumference and Area
	Chapter 1 Test
October	2.1 Conditional Statements
	2.2 Deductive Reasoning
	2.3 Reasoning with Algebraic properties
	2.4 Application of Reasoning
	2.5 Proofs with Segments
	2.6 Proofs with Angles
	Chapter 2 Test
	3.1 Lines and Angles
	3.2 Lines

Top-down (central office) support may include:

- Curriculum Department
- Curriculum Specialists
- Instructional Departments

Bottom-up perspective are:

- Teacher developed

Top-down (central office) vs. Bottom-up (teacher) requires developers to:

- Examine the Political Culture
- Examine Union Issues
- Examine Administrator Issues
- Examine Teacher Issues
- Examine Parental Issues
- Examine...Collaboration Is Critical

Step 1: Develop Curriculum Guides and Pacing ChartsCurriculum Guides should include:

- Content Expectations
- Understandings
- Essential Questions
- Key Concepts
- Performance Tasks
- ...

Pacing

You must ensure that ALL parties involved are covering the same content for each assessment.

Do not make assumptions!

Step 2: Determine the assessment system you will use. Before beginning, decide how detailed you need your data to be. The system should have the ability to provide immediate feedback by

- District
- Building
- Teacher
- Strand/Standard/Content Expectation
- Subgroup
- Over time
- ...

Step 3: Determine the assessment system you will use

Consider

1) Cost—Examine the cost over several years—Your assessment system may be good, but cost prohibitive.

2) Accessibility—Can all parties involved easily access the data? If teachers cannot access the data in a timely manner, then the data (and process) become useless.

3) Usability—Is the system user friendly?

4) Monitoring—Who, at the district level, will monitor the system? (Instructional Support)

5) Support—How will the system be supported? (Technical Support at the company and district level)

Test Type?

What type of common assessment will we administer?

Is our choice doable or cost prohibitive?

- Multiple Choice
- Essay
- Short Answer
- Project
- Performance
- ...

Test Grades/Subjects

- Grade 3 Math?
- Algebra?
- Geometry?
- ELA?
- Science?
- Social Studies?
- ???

Professional Development must be provided on the Assessment System and Item Development.

Test Types

Formative vs. Summative

- ⦿ **Formative**—Formative assessment is often done at the beginning or during a program, thus providing the opportunity for immediate evidence for student learning in a particular course or at a particular point in a program.
- ⦿ **Summative**—Summative assessment is comprehensive in nature, provides accountability and is used to check the level of learning at the end of the program.

Research consistently shows that use of regular, high-quality **Formative Assessments** increases student achievement.

Standards-Based Common Assessments

- ⦿ Step 1
 - > Identify Standards being taught
 - Unit Plans
 - Lesson plans
 - Pacing Charts
- ⦿ Step 2
 - > Rank order the Standards based on instructional intensity (time spent teaching)
 - > Power Standards
- ⦿ Step 3
 - > Develop a Table of Specifications
- ⦿ Step 4
 - > Select and write test items targeting identified Standards
- ⦿ Step 5
 - > Construct test according to Table of Specifications

Table of Specifications

Curriculum Content	Content Expectation(s)	Level of Cognitive Demand					# of items in each area
		<i>Knowledge</i>	<i>Comprehension</i>	<i>Application</i>	<i>Analysis</i>	<i>Synthesis</i>	
Algebra A1: Expressions, Equations and Inequalities	A1.2.8 Solve an equation involving variables for a designated variable			X			3*
Total	N/A						

Item Type

- ⦿ Item type is determined by the outcome being measured
 - > Bloom’s Taxonomy of Educational Objectives
 - > T/F, short answer, multiple choice, short response, extended response, performance tasks

Bloom’s Taxonomy

- ⦿ **Knowledge:** arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state.

- ⊙ **Comprehension:** classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate,
- ⊙ **Application:** apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write.
- ⊙ **Analysis:** analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
- ⊙ **Synthesis:** arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write.
- ⊙ **Evaluation:** appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, evaluate.

Step 4:

Develop or Secure Items aligned with content expectations

Instructional Benefits of Developing Standards-Based Assessments

- ⊙ Forces reflection of teaching practices
- ⊙ Provides validation and accountability for how instructional time is spent
- ⊙ Targets feedback for what information students are learning and identifies areas requiring re-teaching

Student Benefits of Administering Standards-Based Assessments

- ⊙ Provides targeted feedback on student learning
- ⊙ Establishes what students will be responsible for knowing on exams
- ⊙ Provides students and teachers a context for discussing learning progress in the classroom

Question Stems

The “stem” of a multiple-choice item poses a problem or states a question.

Write the stem as a single, clearly stated problem. Direct questions are best, but incomplete statements are sometimes necessary to avoid awkward phrasing or convoluted language.

Question Design

- The question should be stated as briefly as possible, avoiding wordiness and undue complexity.
- The question should be stated in *positive* form because students often misread negatively phrased questions.
- Order your answer choices from least to greatest (or greatest to least)
- Randomize the position of the correct responses. (All the answers should not be “C”—Avoid the “Abacadabba” method)
- Provide ONE and only ONE correct answer (key).
- Include plausible options that demonstrate a student’s level of understanding.
- Use clear wording/vocabulary that is both age and grade-level appropriate
- Maintain a consistent or “parallel” style, length, and visual display.
- Have a colleague review the answer choices.

Test Items-Sources

- Texts or Other Resource Materials
- Item Banks

- Local ISD/District
- State Test Released Items
- Teacher Created
- ...

(Consider Copyright Issues!—Your librarian can help)

Let the development begin...

(Helpful if developed during the creation of your original curriculum documents.)

Step 5: Administer Assessments

Considerations

- State Testing Calendar
- District Testing Calendar
- School Calendar (Assemblies)
- Provide a Testing Window (Calendar)

Step 6: Data Analysis

Consider reporting your results by

- District
- Expectation
- Building
- Teacher
- Grade Level
- Student
- AYP Subgroups (ex. Male, Economically Disadvantaged)
- Educational Initiative (ex. New Program, CTE)

5. Research Process

If your school or district utilizes district, state or national data to monitor student achievement, examine the prior (semester/year's) data (pretest) and compare it to the data (posttest) after implementation of the common assessment system. Classroom based educators might also use the assessment results from the prior year (Chapter/Unit Tests...) as a basis for examining the data. In either case, it is important to disaggregate the data to examine performance across subgroups (ex. Male, Economically Disadvantaged), by teacher and content standard. The results could lead to substantive changes and to the sharing of instructional best practices.

Disaggregation/Dissemination Issues

- Who will disseminate the data?
- Does the assessment system allow you to disaggregate the data? If not, how will it be done?
- Does your Common Assessment data mirror your state testing data?
- What will occur if AYP subgroup issues are occurring in one building? What will occur if content or subgroup issues are occurring in one teacher's class?

Instructional Implications

Results by District

- May point to issues within the district's curriculum as it addresses a particular content expectation
- May point to a need for districtwide PD

Results by Expectation

- May point to issues within the district's curriculum as it addresses a particular content expectation
- May point to a need for districtwide PD

Results by Building

- May point to issues within the building's implementation of the district's curriculum, as it addresses a particular content expectation
- May point to a need for building wide PD

Results by Teacher

- May point to issues within the teacher's implementation of the district's curriculum as it addresses a particular content expectation
- May point to a need for PD
- ⊙ Forces reflection of teaching practices
- ⊙ Provides validation and accountability for how instructional time and money are spent
- ⊙ Targets feedback for what information students are learning and identifies areas requiring re-teaching
- ⊙ Provides targeted feedback on student learning
- ⊙ Establishes what students will be responsible for knowing on exams
- ⊙ Provides students and teachers a context for discussing learning progress in the classroom

Data dissemination/disaggregation issues

- What does data say about the district, a program, building or teacher?
- Will the data be used for non-instructional purposes?

Practical Application of Research Results

If achievement is low across an entire district, the district's curriculum as it addresses a particular content expectation should be examined to ensure the curriculum, instruction and assessment practices contained therein are aligned and at the appropriate level of cognitive complexity. There may also exist a need for districtwide professional development that addresses content, complexity and alignment.

If achievement is low across a building, the building's implementation of district's curriculum as it addresses a particular content expectation should be examined to ensure the curriculum, instruction and assessment practices contained therein are aligned and at the appropriate level of cognitive complexity. There may exist a need for building wide professional development that addresses student needs, content, complexity and alignment.

If achievement is low in a teacher's classroom, the teacher's implementation of district's curriculum as it addresses a particular content expectation should be

examined to ensure the curriculum, instruction and assessment practices contained therein are aligned and at the appropriate level of cognitive complexity. There may exist a need for professional development that addresses student needs, content, complexity and alignment

The proposed Mathematics Focused Common Assessment System was developed to assist educators in better connecting and evaluating curriculum, instructional and assessment practices. This system focuses on the level of cognitive demand within academic standards and the importance of content and content complexity demand alignment within curriculum, instruction and assessment practices. The use of the system and complexity tool has implications for curriculum development, professional development, instruction and policy articulation.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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