Graduation Numeracy Assessment

Draft Design Specifications

This document describes the draft design specifications for the graduation numeracy asessment and how numeracy will be assessed.

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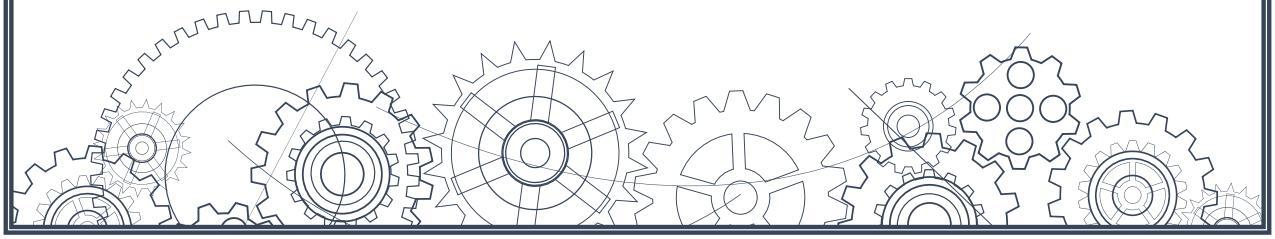


Graduation Numeracy Assessment

As with the development of the revised BC K–12 curricula, the Graduation Numeracy Assessment is being informed and shaped by multiple stakeholders, including the Advisory Group on Provincial Assessments, educators from across the province, and post-secondary colleagues. As well, the new directions of the Foundation Skills Assessments and research on best practices in large-scale assessments have informed this work.

Numeracy

Numeracy is the willingness and perseverance to interpret and apply mathematical understanding to solve problems in contextualized situations, and to analyze and communicate these solutions in ways relevant to the given context.

Assessment Design

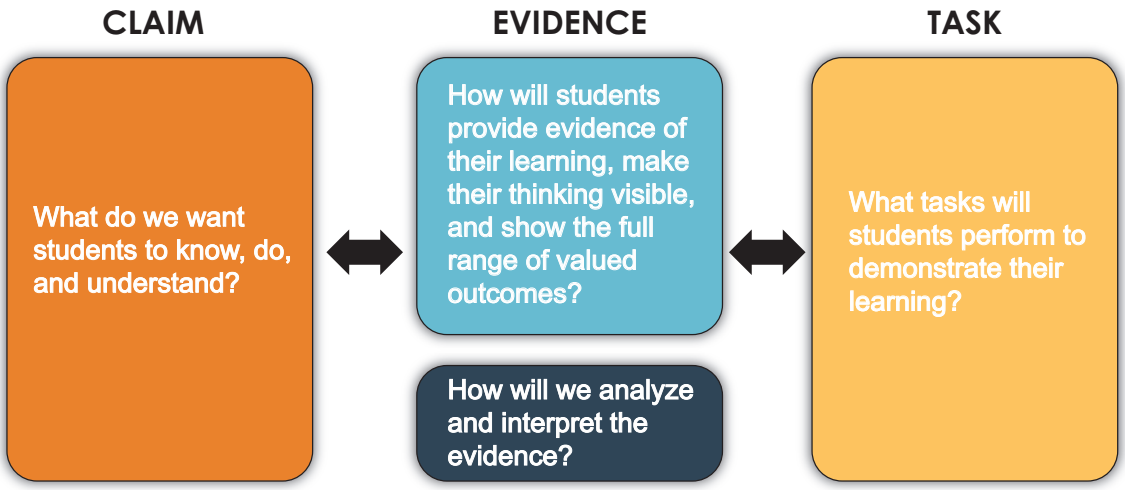
The Graduation Numeracy Assessment uses an evidence-centred design (ECD; see Figure 1; Pellegrino, DiBello, & Brophy, 2014; Riconscente, Mislevy, & Corrigan, 2016).

ECD focuses on:

- making claims about student learning (what we want students to know, do, and understand) based on the purpose of the assessment
- determining the evidence that needs to be demonstrated to provide support for the claims and how this evidence will be analyzed and interpreted
- writing task specifications to create tasks that will allow students to demonstrate the depth of their learning

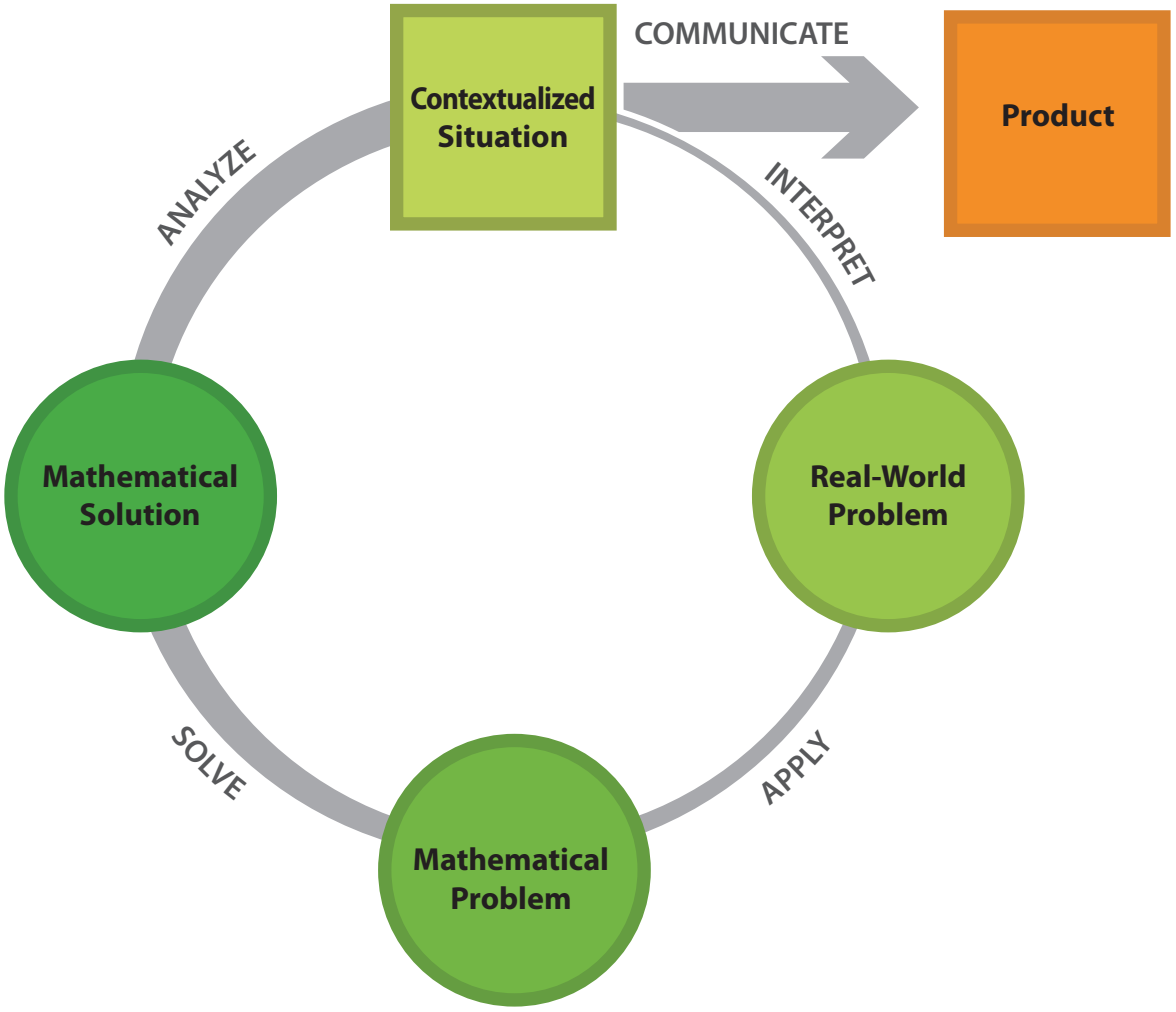
ECD strengthens the validity of assessments by supporting the inclusion of tasks that elicit higher levels of cognitive processing and enhancing score interpretation through increasing comparability of assessment scores across forms (Lane & Iwatani, 2016; Riconscente, Mislevy, & Corrigan, 2016).

Figure 1: Evidence-centred design



(Adapted from Pellegrino, DiBello, and Brophy, 2014)

Process for Solving Numeracy Tasks



The diagram above illustrates the numeracy processes involved when solving a numeracy task.

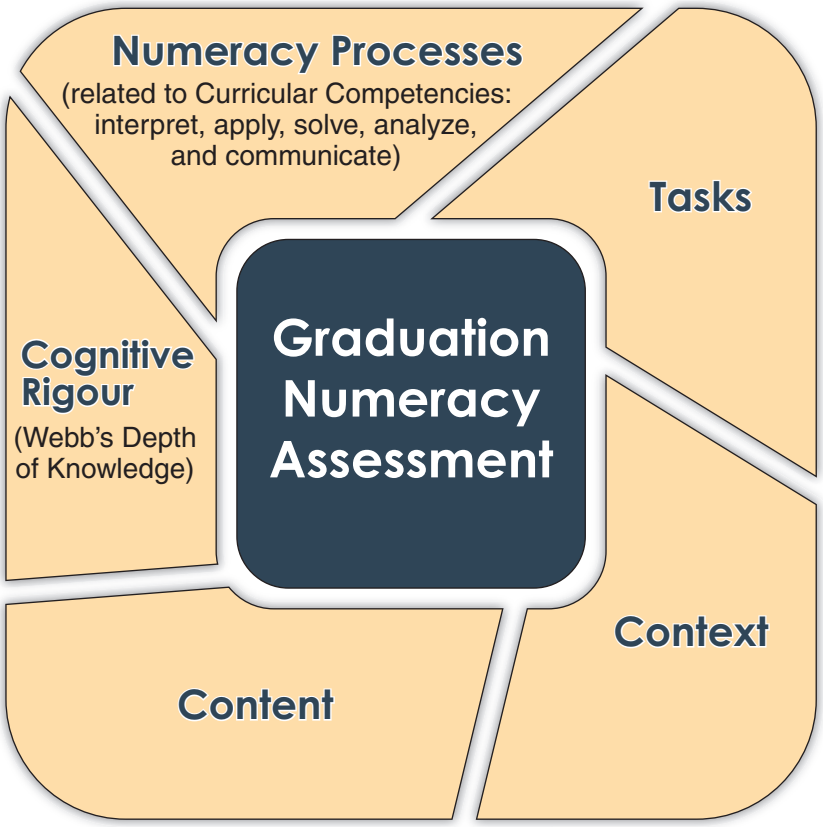
- The process starts with a **contextualized situation** to provide context.
- This is followed by interpreting the contextualized situation to identify the **real-world problem**; from the real-world problem one or more mathematical approaches are applied (mathematize) to create relationship(s) to solve the **mathematical problem**.
- The resulting **mathematical solution** is analyzed and evaluated in context in order to determine if another cycle is needed.
- Once the contextualized situation is resolved, a solution or recommendation is communicated.

One may need to go through the cycle several times or go back and forth between the numeracy processes prior to communicating a solution or recommendation.

(The process above is based on a mathematical modelling cycle; for example, see Perrenet & Zwaneveld, 2012)

Five Dimensions

The Graduation Numeracy Assessment will focus on five interrelated dimensions:



The identification of these five interrelated dimensions supports the development of an assessment that includes a range of competencies, content, contexts, and cognitive rigour. The assessment will include numeracy tasks embedded in contextualized situations. These situations may be based on contexts unfamiliar to students and include non-routine tasks.

While the previous Grade 10 Mathematics examinations, for example, focused only on the content knowledge within the Grade 10 Mathematics curriculum, the Graduation Numeracy Assessment focuses more on students applying sophisticated mathematical reasoning, understanding, and insight across Areas of Learning (see, for example, Pead, 2012).

Numeracy Processes

The Graduation Numeracy Assessment will assess five numeracy processes, which are the five processes in the Assessment Model:

- Interpret
- Apply
- Solve
- Analyze
- Communicate

Numeracy Process 1: Interpret

Students are able to read and decode a range of contextualized situations in order to identify real-world problems that need to be solved. These situations may contain insufficient or excess information, where students will need to decide what information is relevant to solving the problem. This process is about students making decisions. Contextualized situations may require students to identify constraints and ambiguities, and make decisions about next steps (e.g., possible simplifications).

Numeracy Process 2: Apply

Students are able to identify and activate their mathematical understanding in order to translate real-world problems into mathematical problems (mathematize). This involves choosing mathematical tools, determining how to organize the information, and creating relationship(s) in order to represent the real-world problems. This phase is supported by being able to flexibly apply mathematical tools to a range of real-world problems.

Numeracy Process 3: Solve

Students are able to use a variety of approaches and representations to solve mathematical problems. Students may need to implement an approach, use representations, and check mathematical solutions to see if they make mathematical sense.

Numeracy Process 4: Analyze

Students are able to interpret mathematical solutions in context, such that the solutions make sense within the contextualized situations. Students may need to assess the practicality and possible limitations of solutions. In doing this, students consider how contextual factors may impact the results. For example, they reflect on their solutions to assess risks and address social, ethical, and environmental implications. Through the analysis, students may be asked to identify sources of error, possible improvements to an approach, or alternate situations to which the solution can be applied.

Numeracy Process 5: Communicate

Students are able to clearly and precisely construct valid logical arguments to defend their decisions and assumptions, explain their tools and approaches used, and present their solutions in context. This may require students to make recommendations and use a variety of ways (e.g., tables, diagrams, equations, symbols) to visibly represent their thinking and solution.

Tasks

A balanced mixture of the following types of tasks will be used on the Graduation Numeracy Assessment (Liljedahl, 2016; Pead, 2012; Smarter Balanced Assessment Consortium, 2015):

- Fair Share – These tasks require students to decide how to best share something fairly. As fairness is not well defined, these tasks have ambiguity (e.g., giving out bonuses).
- Reasoned Estimates – These tasks require students to make or use estimates across multiple variables in order to build a logical argument for a possible solution (e.g., travelling to Australia).
- Plan and Design – These tasks may require the combined analysis of time, space, cost, and people in order to make a recommendation (e.g., shipping containers).
- Model – These tasks involve coming up with a model or strategy, given a data set. Students are then required to apply this model or strategy to a new data set and, if necessary, refine their model (e.g., ranking criteria).

Numeracy tasks may contain more than one type of task; for example, a task may require students to plan and share fairly. Tasks may have students respond as designers, planners, commentators, evaluators, managers, and so on. Numeracy tasks will be embedded in contextualized situations, and these situations can be categorized according to the context. A narrative is constructed throughout each task, based on the contextualized situation.

Context

The numeracy tasks on the Graduation Numeracy Assessment will connect mathematical understanding with a variety of contextualized situations. Situations for numeracy tasks will be based in contexts that offer relevant and natural settings for generating evidence for the five numeracy processes, including applications in areas of learning such as Science and Social Studies. Tasks will be situated across the following four contexts relating to daily life: personal, career, societal, and scientific (OECD, 2013). These contexts may be connected to place, story, cultural practices, and perspectives relevant to local First Peoples communities, the local community, and other cultures.

Personal – These tasks focus on one's self, family, or peer group. Tasks may be situated in (but not limited to) personal health, finance, scheduling, games, travel, food preparation, fashion, shopping, popular music, or sports (e.g., bentwood boxes, weaving, Olympics, dieting, budget, Internet packages, museum cost, using bus schedules).

Career – These tasks focus on employment. Problems may involve (but are not limited to) measuring, costing and ordering materials, accounting, quality control, scheduling, or design (e.g., payroll, construction estimates, carving).

Societal – These tasks focus on one's community. Problems may involve (but are not limited to) elections, media, public transportation, government, public policies, demographics, advertising, statistics, evolution, and economics (e.g., circle dwellings, ethics in sports).

Scientific – These tasks focus on the environment, science, and technology. Problems may be situated in (but not limited to) ecology, agriculture, medicine, and weather (e.g., mould, fish traps, global warming, science experiments, infectious diseases, invasive species, extreme weather events).

Content

The Mathematics curriculum provides information about the range of content that will be assessed within the numeracy processes. The sampling of content in Mathematics will be balanced. As numeracy is about using mathematical tools and approaches flexibly to resolve contextualized situations, students need to be comfortable with these tools in order to allow flexible application. Further, for each contextualized situation, there is no one best tool to choose, but a range of tools with various levels of sophistication that can be used to resolve the contextualized situation. Most of the numeracy processes will therefore include Mathematics curriculum content from up to and including Grade 8 (i.e., a range of mathematics topics from the following five areas: number sense, patterns, geometry and measurement, data and probability, and financial literacy). As well, the assessment may include the following content from Grade 9 or 10:

- operations with rational numbers
- linear relations
- spatial proportional reasoning
- statistics in society
- experimental probability (simulations)
- financial literacy (simple budgets, transactions, and gross and net pay)

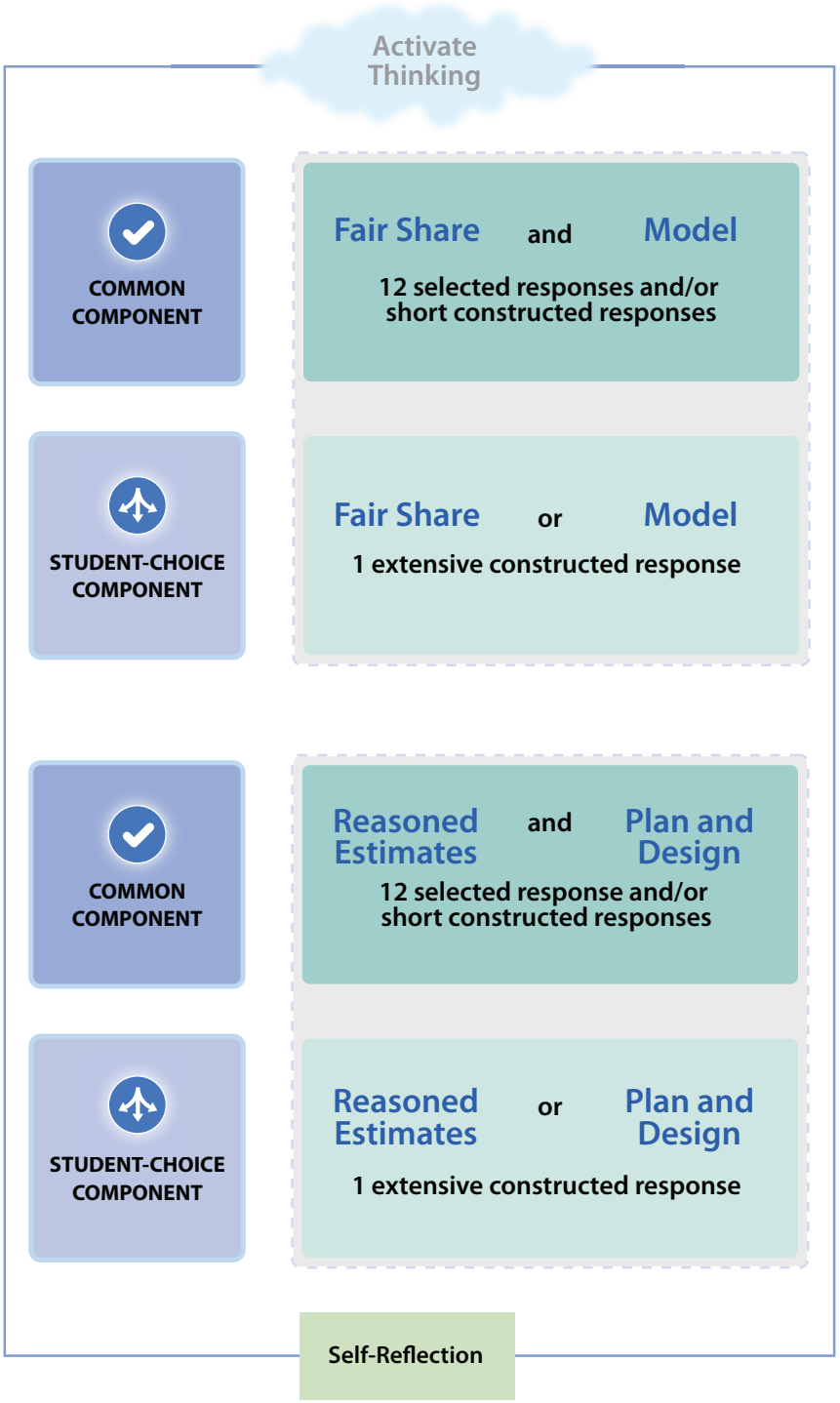
Cognitive Rigour (Webb's Depth of Knowledge)

	Level 1 – RECALL The student is able to recall or locate information such as a fact, definition, or term; use a procedure; or apply a formula.	Level 2 – SKILLS AND CONCEPTS The student is able to demonstrate conceptual understanding through models and explanations, and to make decisions on how to approach a problem or activity.	Level 3 – STRATEGIC THINKING The student is able to solve a problem and explain his or her thinking through reasoning, planning, and using evidence.
Interpret ⇧ Apply ⇧ Solve ⇧ Analyze ⇧ Communicate	a. Recall, observe, and recognize facts, principles, properties b. Recall/identify conversions among representations or numbers, and make conversions c. Evaluate an expression d. Locate points on a grid or numbers on a number line e. Solve a one-step problem f. Represent math relationships in words, pictures, or symbols g. Follow simple procedures (recipe-type directions) h. Calculate, measure, apply a rule (e.g., rounding) i. Apply algorithm or formula (e.g., area, perimeter) j. Solve linear equations k. Retrieve and use information from a table or graph l. Identify a pattern/trend m. Brainstorm ideas, concepts, or perspectives related to a topic	a. Specify and explain relationships (e.g., non-examples/examples; cause-effect) b. Make and record observations c. Explain steps followed d. Summarize results or concepts e. Make basic inferences or logical predictions from data/observations f. Use models/diagrams to represent or explain concepts g. Make and explain estimates h. Select a procedure according to criteria and perform it i. Apply multiple concepts or decision points to solve problems j. Retrieve information from a table, graph, or figure and use it to solve a problem requiring multiple steps k. Translate between tables, graphs, words, and symbolic notations (e.g., make a graph from table of data) l. Construct models given criteria m. Categorize, classify materials, data, figures based on characteristics n. Organize or order data o. Compare/contrast figures or data p. Select appropriate graph to display data q. Interpret data from a simple graph r. Extend a pattern s. Generate conjectures or hypotheses based on observations or prior knowledge and experience	a. Explain, generalize, or connect ideas using supporting evidence b. Make and justify conjectures c. Explain thinking when more than one response is possible d. Design an approach for a specific purpose e. Perform a designed approach f. Use and show reasoning, planning, and evidence g. Compare information within or across data sets or texts h. Analyze and draw conclusions from data, citing evidence i. Generalize a pattern j. Interpret data from a complex graph k. Describe, compare, and contrast approaches and solutions l. Cite evidence and develop a logical argument for concepts or solutions m. Verify reasonableness of solutions n. Synthesize information within one data set, source, or text o. Formulate an original problem given a complex situation p. Develop a model for a complex situation

(Adapted from Hess, 2009, and Webb, 2002.)

Assessment Overview

The following chart shows the components of the Graduation Numeracy Assessment. The assessment will include an "activate thinking" component, common online components consisting of selected or short constructed responses, student-choice components consisting of extensive constructed responses, and a self-reflection component.



Assessment Specifications

Each Graduation Numeracy Assessment will include a common component consisting of 4 numeracy tasks (6 items per task) and a student-choice component (2 items) in which students expand on 2 of the numeracy tasks in the common component, for a total of 26 items.

Numeracy tasks will include items distributed across Webb's Depth of Knowledge (DOK) levels, following the guidelines outlined in *Criteria for High-Quality Assessment* (Darling-Hammond et al., 2013):

- ☑ maximum 1/3 of the items at DOK Level 1
- ☑ minimum 2/3 of the items at DOK Level 2 and 3

Table of Specifications

		Cognitive Rigour[a]		
		Level 1 Recall	Level 2 Skills and Concepts	Level 3 Strategic Thinking
Numeracy Processes	Interpret Apply Solve Analyze	4–8 selected responses and/or short constructed responses	16–20 selected responses and/or short constructed responses	2 extensive constructed reponses (each scored on a 4-point rubric)
	Communicate[b]			
Weighting		TBD	TBD	TBD

[a]Webb's Depth of Knowledge.
[b]Only assessed at Level 3.

Types of Items

The Graduation Numeracy Assessment will include a variety of items that assess the application of mathematical concepts and processes. Items will be either selected response or constructed response.

Selected-response items provide answer choices. *Constructed-response* items require students to develop answers.

Types of Items	Description
Selected response	
Multiple choice	Provide choices with a single correct response.
Multiple correct responses multiple choice (check boxes)	Provide choices with multiple correct responses.
Matching/sorting	Drag and drop single or multiple elements to desired position(s).
Highlight	Select desired response.
Hot spot	Select desired spot in figure.
Constructed response	
Short	Manipulate/complete graphs (plot points, draw lines, or move points on a sliding scale), enter numeric responses, and write equations.
Extensive	Create diagrams, graphs, equations, and/or expressions, and compose sentences to explain response.

Reporting

A proficiency scale such as the following will be implemented to report overall performance on the assessment. It will be descriptive in nature and will contain information about what students can do at each level.

Proficiency Level				
	Emerging	Developing	Proficient	Extending

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