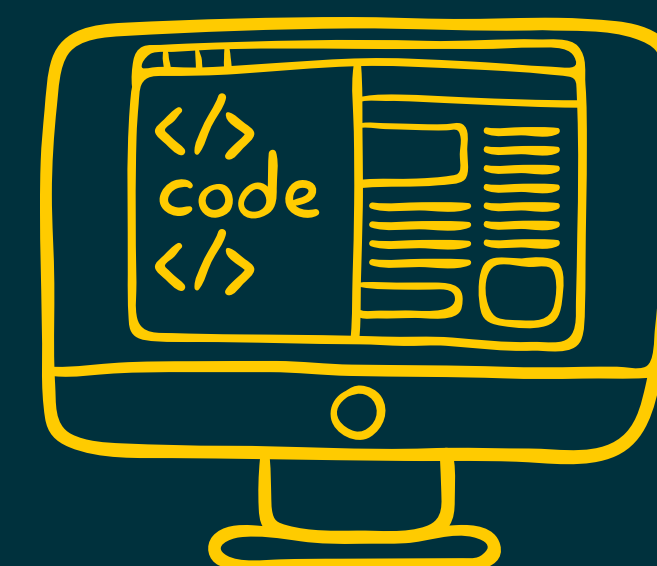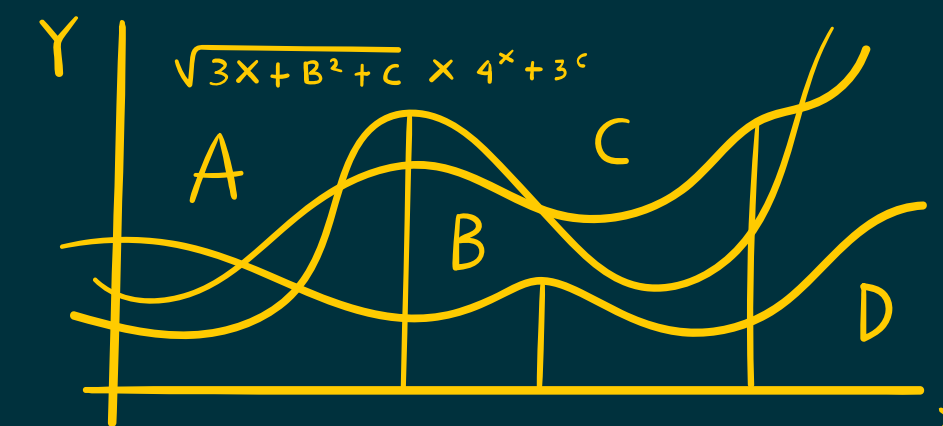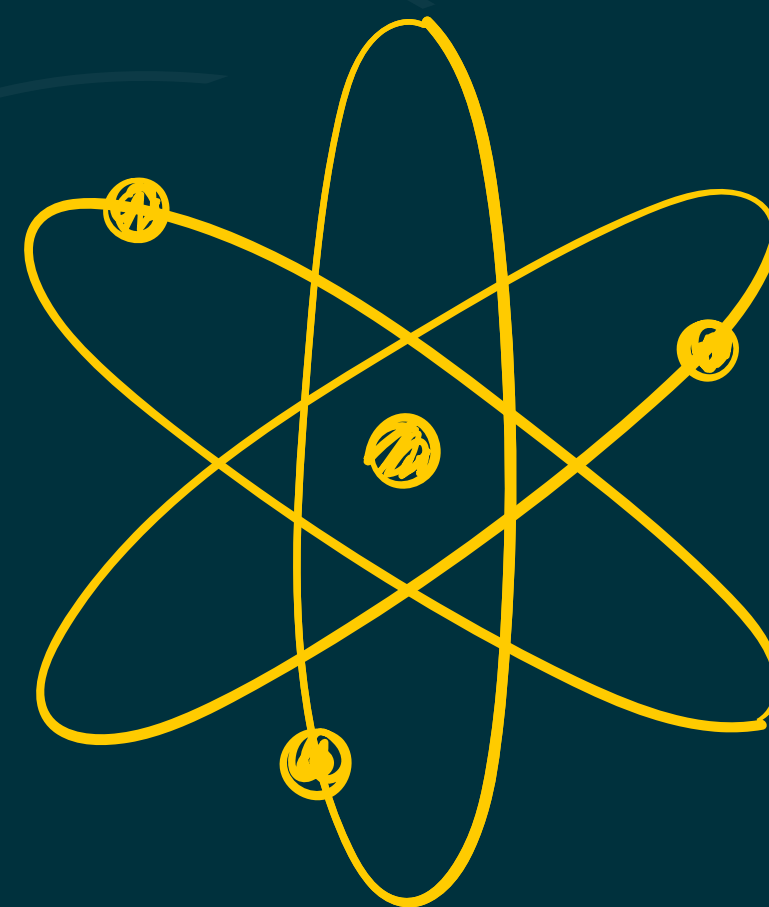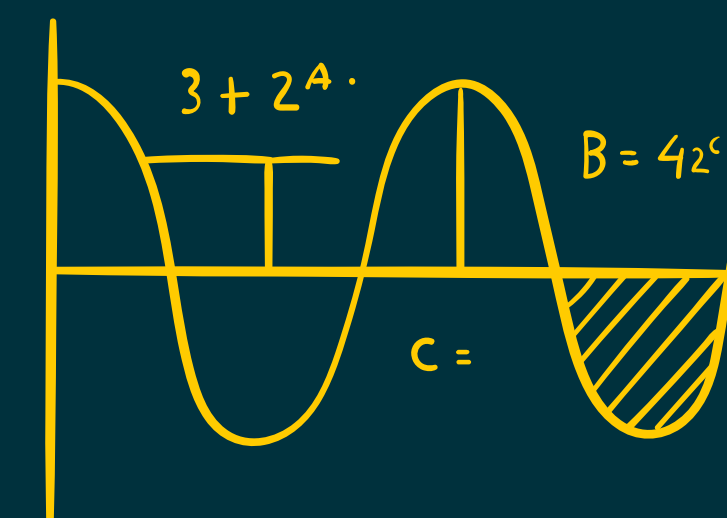# STEM, coding, & innovation

A guide to future-proof assessment solutions for complex problems

$$F = G \frac{m_1 m_2}{r^2}$$

$$i\hbar \frac{\partial}{\partial t} \Psi(\mathbf{r}, t) = \hat{H}\Psi(\mathbf{r}, t)$$

Learnosity

STEM involves some of the most complex content in the world of learning. In order to offer dynamic assessments in topics ranging from calculus to chemistry to coding, your learning platform needs extensive capabilities.

Learnosity Product Manager Kathleen Hake PhD strives to support STEM product developers around the world with best-in-class technology. In this guide, Kate details what's required to deliver engaging STEM assessments that support the learner's acquisition of knowledge, enable high interactivity, and provide a modern digital experience.

1.7B

Math questions delivered and scored per year

12M

Math questions authored to date

Smarter scoring—form and syntax aware

Auto-scoring is the beating heart of online math assessments. It saves content authors time generating the correct answers, frees instructors from the rote work of grading assessments, and provides instant feedback on progress to learners.

Simplified approaches to auto-scoring, such as text or string matching, are too rigid. They cannot handle the variety of equivalent but different ways learners may respond to a single question, especially as content becomes more complex.

For a scoring engine to be effective in supporting your learning objectives, it should be both rules-based and flexible in its interpretation of mathematical form and syntax. Authors should be capable of easily adjusting scoring behavior to be as lenient or strict as desired. The engine should recognize different forms of the correct answer, even for advanced math and science content, and authors must be able to set a tolerance to allow for approximately correct values. They should also have the capability to set specific requirements that a correct answer must meet.

> **The interpretation of notation should also be customizable, from which symbols are used for decimal and thousands separators to whether characters be treated as units or variables.**

By offering this level of fine-grained control over your scoring engine, you have the freedom to deliver an assessment experience that meets learners' exact needs.

Use any method to evaluate

$$\int \frac{x}{\sqrt{x^2+4}}\, dx.$$

Use C as an integration constant.

$\sqrt{x^2+4}+C$ ✔

Check Answer

Use any method to evaluate

$$\int \frac{x}{\sqrt{x^2+4}}\, dx.$$

Use C as an integration constant.

$2\sec\left(\arctan\left(\frac{x}{2}\right)\right)+C$ ✔

Check Answer

Full and partial scoring made easy

One of the joys (and challenges) of scoring a math assessment is that there are multiple pathways to solve a single question. This is something an instructor recognizes instantly and rewards, but it can be hard to automate.

A rules-based scoring engine makes it easy to configure a comprehensive scoring scheme to assess each step of a solution, supporting detailed formative feedback and any (partial) credits to be awarded.

A rules-based approach makes a range of scoring schema available: dichotomous, partial, per question, and dependent. This flexibility is essential to content creators and educators setting open-ended digital math assessment to deeply explore mastery of expressions, equations, or graphs concepts—all supported by auto-scoring.

> " A rules-based scoring engine makes it easy to configure a comprehensive scoring scheme. "

0.5/1   ✔ Show Answers   Edit   Preview

Expand the expression.

$(x^2 + 6x - 2)(x - 5)$

$x^3 + x^2 - 32x + 10$ ✔

Evaluate the expression for $x = -2\frac{1}{2}$.

80.623 ✘

Correct answers:

80.625

Intuitive
STEM authoring

A good content authoring user experience drives productivity. The goal of your STEM authoring workflow and user interface (UI) is to help authors concentrate on content creation with minimum friction.

A purpose-built math editor is essential to efficiently handle mathematical notation. This lets authors create and accurately display specialized math questions to meet standard curricula requirements without resorting to flat text or more cumbersome conventions.

Combined with a rich text editor, the math editor expands the breadth of STEM questions you can author—making a variety of question types available for your assessments, such as math formula, fill in the blanks with math, label images with math, classification, drawing, hotspot, and multi-step solutions.
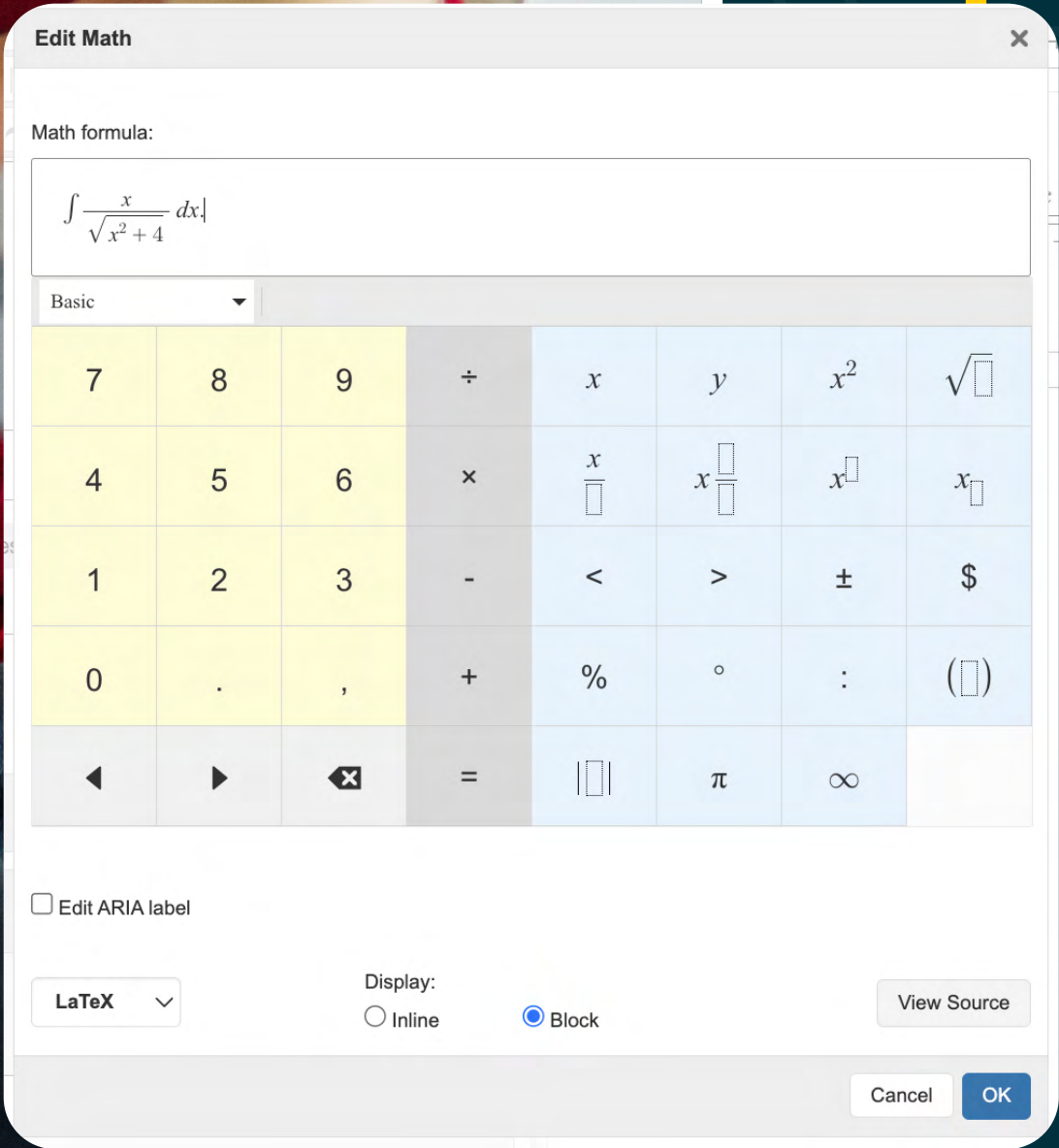
> A purpose-built math editor is essential to efficiently handle mathematical notation.

Edit Math

Math formula:

$$\int \frac{x}{\sqrt{x^2 + 4}}\, dx$$

Basic

7	8	9	÷	x	y	x^2	$\sqrt{\Box}$
4	5	6	×	$\frac{x}{\Box}$	$x_\Box^\Box$	$x^\Box$	$x_\Box$
1	2	3	-	<	>	±	$
0	.	,	+	%	°	:	$(\Box)$
◀	▶	⌫	=	$|\Box|$	π	∞	

☐ Edit ARIA label

LaTeX ▾

Display:
○ Inline ● Block

View Source

Cancel OK

Tooling to streamline content prep

Authoring assessment problems of a similar type—a necessary chore for math practice—is repetitive and time-consuming, making it an ideal target for automation.
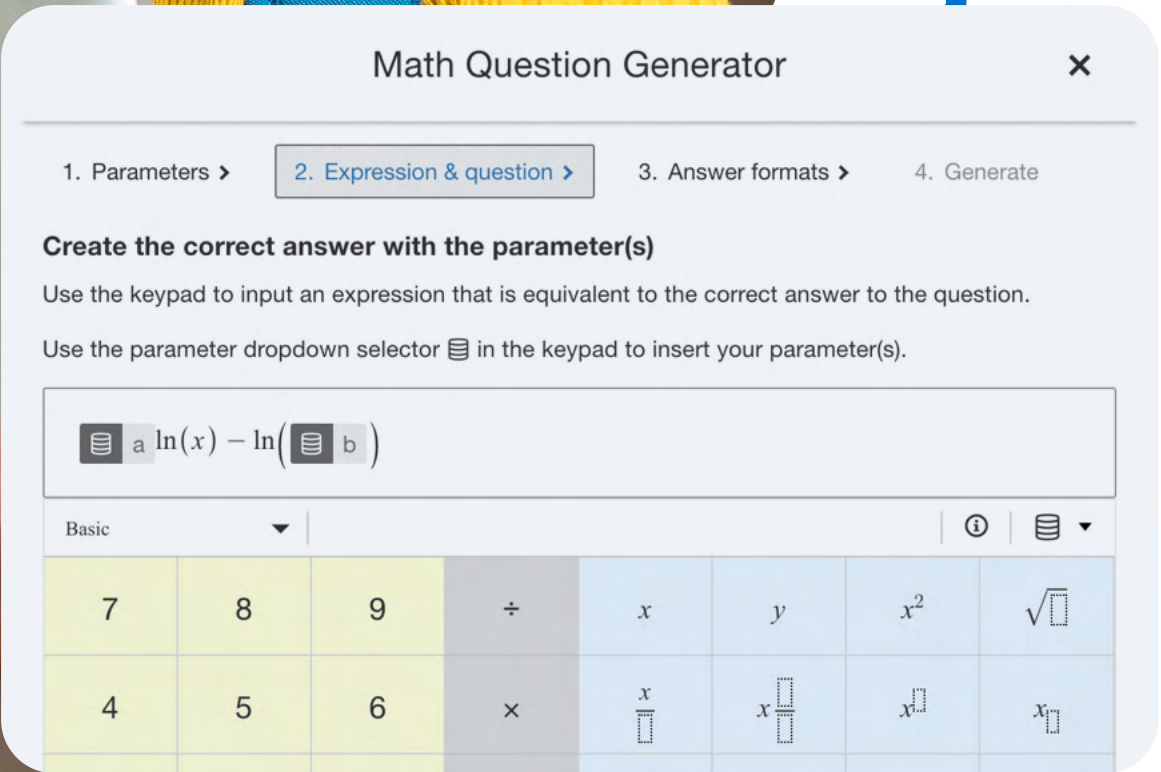
While it's possible to use dynamic content items to streamline such tasks, the effort and programming required to set this up can be off-putting.

A math question generator can transform the process for content authors.
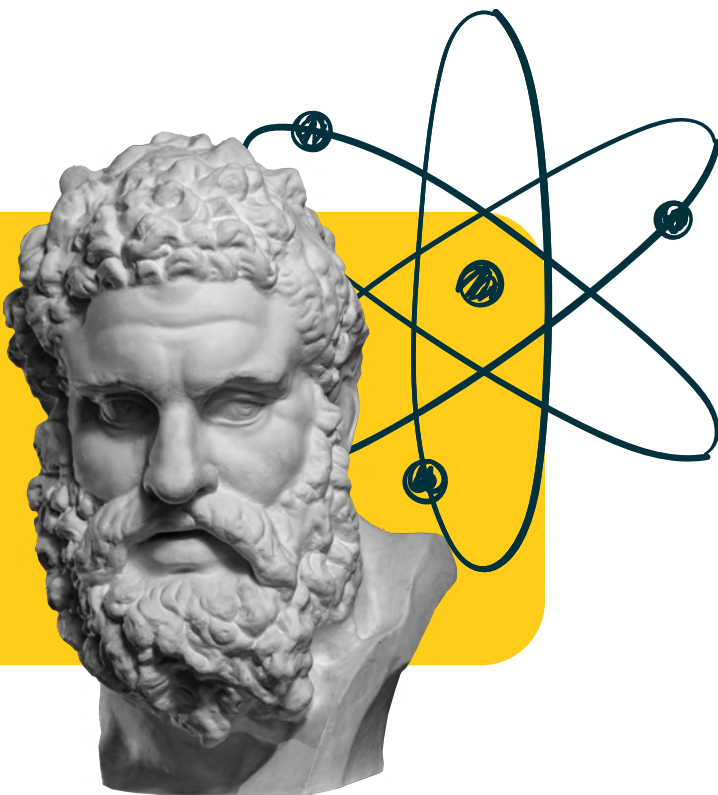
Applying new wizard-based approaches dramatically cuts the effort required. Just set the parameters and expressions or equations to be defined and the question generator takes care of the math-specific dynamic content (i.e. preparing the datasets, formulating the items, and calculating validations).

Of course, content automation shouldn't be done blindly. Your author can review and choose what's to be published from this list of prepared questions, saving time while remaining in control of the assessment.

Math Question Generator ✕

1. Parameters ›   2. Expression & question ›   3. Answer formats ›   4. Generate

Create the correct answer with the parameter(s)

Use the keypad to input an expression that is equivalent to the correct answer to the question.

Use the parameter dropdown selector 🗒 in the keypad to insert your parameter(s).

$$a \ln(x) - \ln(b)$$

Basic ▼ | ⓘ | 🗒 ▼

| 7 | 8 | 9 | ÷ | x | y | x^2 | $\sqrt{\Box}$ |
| 4 | 5 | 6 | × | $\dfrac{x}{\Box}$ | $x^{\Box}_{\Box}$ | $x^{\Box}$ | $x_{\Box}$ |

Crafting the user experience

The user experience is where the rubber meets the road with instructor and learner engagement.

To deliver the desired experience, your product designers and content authors need complete control over the look, feel, and interactivity of your assessments.

The functionality and symbols available within the main end-user interface, for both authors and learners, must be easily configurable to support different content areas and grade levels. By putting only what's needed at users' fingertips, you reduce cognitive load for learners and save time for authors.

To bring your product's design experience to life, you may want to consider how easy it is for your product team to refine color and accessibility settings or to style your own custom buttons and review panels.

To level up your user experience, give learners the tools to respond in their own words using short text or essay-length text (that's also capable of inserting math and code formatting), images, file uploads, and mobile-friendly video and audio capabilities.

We partner with companies like Alchemie because they know how to deliver immersive assessment experiences. Using interactive 3D assessment tools, Alchemie builds visualization and spatial reasoning skills by making abstract concepts come to life, while also delivering immediate feedback as learners explore content.
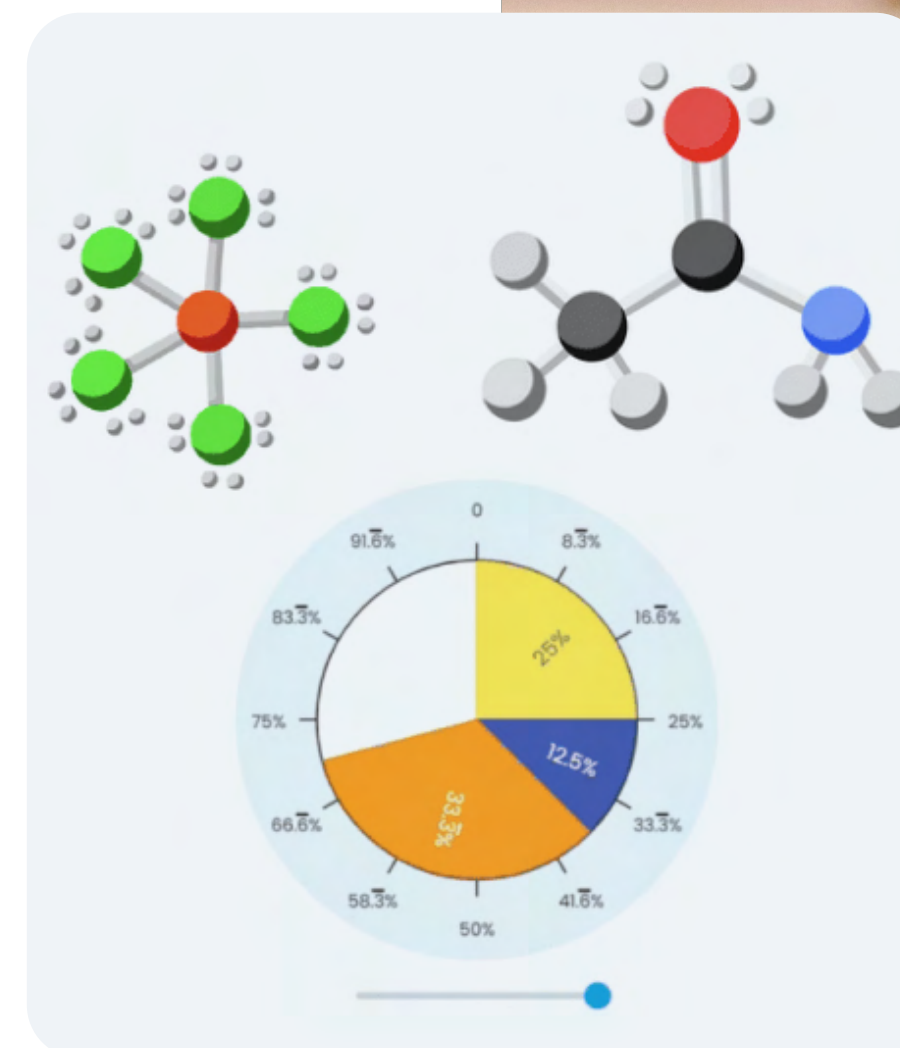
Real-time feedback with auto-scoring

Timely feedback is a cornerstone of education, letting instructors and learners know where they are, and pointing the direction to where they need to be in their learning. This places robust assessment analytics at the core of an effective digital STEM assessment solution.

Real-time analytics, enabled by auto-scoring, results in a more powerful digital learning experience. It gives educators the data they need to identify and take early action on issues through detailed breakdowns of learning outcomes. When individualized, it empowers learners to take control, providing live feedback to deepen their understanding.

To support these higher learning goals, you'll need analytics which are configurable enough to enable the swift identification and tracking of learning problems at any scale—from individual to regional to international. With these insights, you can take targeted actions to overcome challenges and help learners achieve positive outcomes.

Our partner AlgebraKit harnesses the power of feedback. Their step-by-step math question type detects mistakes and provides meaningful feedback through automated, personalized hints that allow learners to develop essential math skills.

If $f(x) = x - 2$ and $g(x) = 6x^2 - 4x + 32$, determine $g(f(x))$.

Please expand your answers.

$g(f(x)) = $ 1 $6x^2 - 28x + 62$ ✖

Correct answers:

1 $6x^2 - 28x + 64$

Extended
functionality

In the real world, learners have a myriad of specialist tools at their disposal to help them solve STEM problems, such as calculators, geometry tools, and graphing options. These tools need to be replicated online, ideally fully integrated into question types.

> An essential item for every STEM learner is the math editor. Whether you're looking for a math keypad that's out-of-the-box or custom-built, you should consider how it can be configured for functionality and usability.

At a minimum, you'll need to consider customizing items such as the number pad keys, keypad groups, custom grouping, and keypad orientation.

Moving onto more advanced functionality, Cartesian graphing may have to be factored into your plans. While there is any number of mathematical graphing packages available, integrating these question types into your assessment solution affords greater control over the experience. This includes flexible authoring options to define the graph plane and set validation for auto-scored graphs.

Desmos, a member of our Partner Ecosystem, creates digital math tools that extend platform functionality. Using Desmos's best-in-class tools, their customers deliver more interactive, engaging content by adding graphing, scientific, and four-function calculators to questions.

Decoding
assessment

Enable the makers of the future by delivering coder-friendly question experiences.

Your learning platform should allow software programming and engineering learners to enter code in two different ways: either formatted inline with the body text or as a discrete code block. This removes the need for learners to upload any additional documents when submitting code.

Our partner Qualified extends coding assessment even further. Using their question types, their customers can build their own coding challenges, choose from a library of coding assessments, and use actual unit testing to validate submitted code.

By simulating real-world coding experiences, you can unlock opportunities to assess content in computer science courses, coding bootcamps, and certification programs.

Accessibility, equity, and inclusivity

STEM content has to be accessible to learners who require assistive technology. Products should not be only "theoretically" usable, but go beyond the WCAG 2.1 web standards to be suitable for day-to-day usage too.

Authors should have the tools to create accessible STEM content, such as offering screen reader support through assistive MathML or going a step further by enabling auto-population (and customization) of ARIA labels for math content. While on the learners' side of the experience, math tools like calculators, keypads, and graphs should be keyboard and screen reader accessible. To give visually impaired learners an exceptional screen reader experience that assists their navigation of the UI, provide the capability to dynamically generate ARIA labels for math responses in real time.

But being inclusive isn't just about solving the problem of accessibility—it's about solving a variety of problems. Luckily, solutions to those problems already exist—and Learnosity has solved many of them ourselves: our assessments can work across any device, learners can complete assessments offline, and we offer internationalization and localization capabilities to break down language barriers.

Rigorous testing for
the real-world

> Testing STEM content is not a job for developers or QA. Experienced STEM educators who are familiar with curricula standards are best placed to write the use cases.
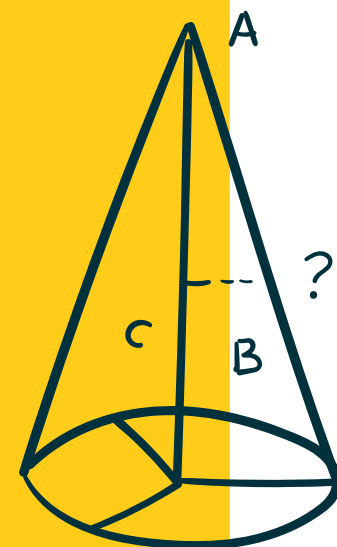
An unsung hero in the success of any software product is the testing strategy. When it comes to evaluating assessment solutions, the testing strategy has to be a factor.

Testing STEM content is not a job for developers or QA. Experienced STEM educators who are familiar with curricula standards are best placed to write the use cases. Most importantly, testing needs to be focused on the use cases that your end-users value most. Using content directly from learning products battle tests the software, ensuring that assessment behavior doesn't change unexpectedly from release to release.

With agile delivery models prevailing, testing is now a continuous cycle. You need to make sure the tooling is in place to support every release to process the thousands of regression tests necessary to ensure that nothing is broken by the latest changes.

Delivery
and scaling up

You put your product's reputation at risk by not putting enough thought into assessment delivery. With the many challenges associated with scaling your business, this is a trap to be avoided.

When it comes to cloud-based infrastructure, the main obstacles aren't simply technical in nature. Even poorly written applications can scale (somewhat), if you're prepared to pay for computing power. The real skill is balancing the right technology in the applications with the appropriate design criteria to meet the requirements as efficiently as possible with the budget and resources available.
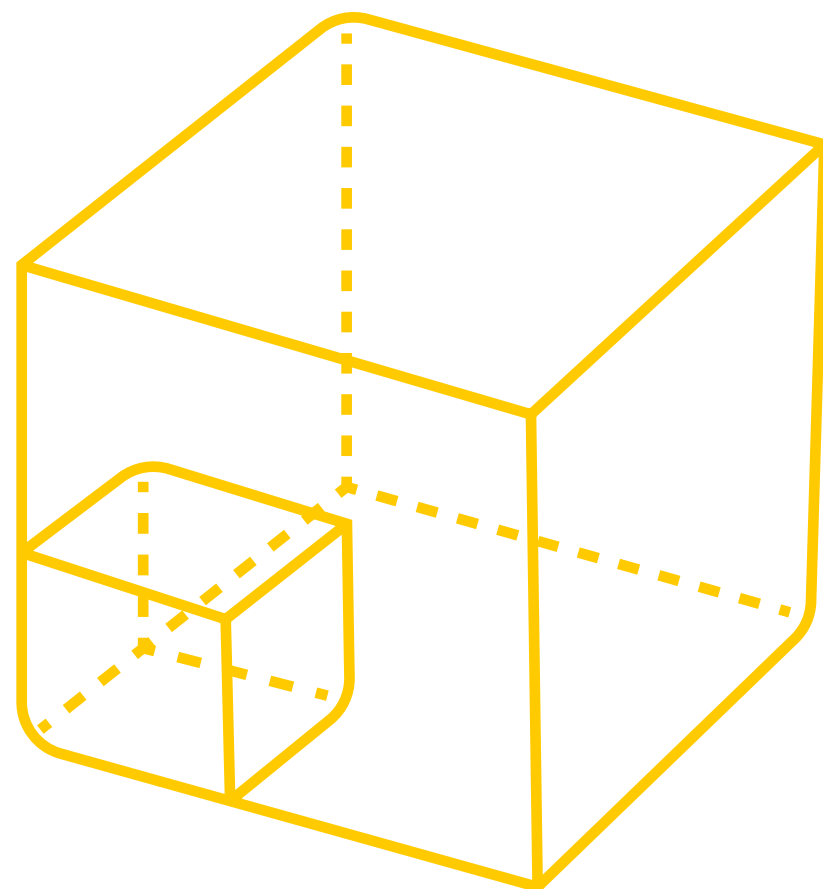
> **When it comes to cloud-based infrastructure, the main obstacles aren't simply technical in nature.**

About Learnosity

Learnosity is the global leader in assessment solutions. Serving over 700 customers and more than 40 million learners, our mission is to advance education and learning worldwide with best-in-class technology.

Our APIs make it easy for modern learning platforms to quickly launch fully featured products, scale on demand, and always meet fast-evolving market needs.