2024 Personalized Adaptive Learning Platforms Evaluation

Acrobatiq
Canvas Mastery Paths
Grasple
LibreTexts ADAPT
MyOpenMath
Realizeit
OLI Torus

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Introduction

In spring 2024, the Assistant Vice Provost of the University of Central Florida's Center for Distributed Learning tasked the Personalized Adaptive Learning (PAL) team with evaluating adaptive learning platforms. To fulfill this charge, a team consisting of five instructional designers and two PAL assistants dedicated three months to a comprehensive evaluation of seven platforms: Acrobatiq, Canvas Mastery Paths, Grasple, LibreTexts ADAPT, MyOpenMath, Realizeit, and OLI Torus.

Among the evaluated platforms, Grasple, LibreTexts ADAPT, MyOpenMath, and OLI Torus are open personalized learning systems. Acrobatiq and Realizeit are proprietary PAL systems that the PAL team has previously supported and maintained. Mastery Paths is a native feature within Canvas, the learning management system currently deployed at the University of Central Florida.

The PAL team conducted a thorough assessment of these seven platforms, considering various factors such as functionality, system capabilities, accessibility, efficacy, and alignment with the University's strategic goals for personalized and adaptive learning. Our findings and recommendations will inform the future development of PAL at UCF and the selection process for potential adoption and implementation of adaptive learning platforms to enhance the educational experience for UCF students.

Methodology

The evaluation process utilized the rubric developed by CourseGateway (2023), version 3.1. This rubric was originally developed to assess existing digital courseware in the market. It encompasses five categories of system considerations, with each category containing between three and seven specific considerations, resulting in a total of 28 considerations. Furthermore, each consideration consists of two to seven detailed criteria.

The five categories outlined in the rubric are as follows: Accessibility (3 considerations - 19 criteria), Efficacy (5 considerations - 11 criteria), Equity (7 considerations - 13 criteria), Functionality (7 considerations - 19 criteria), and System Capabilities (6 considerations - 15 criteria). The detailed evaluation categories and relevant product considerations are provided in **Appendix A**.

For the purpose of this evaluation, four out of the five categories were utilized. As the Equity category primarily pertains to the specific learning content rather than the platform itself, it was excluded from the assessment. Additionally, a new category of Math Capabilities, comprising 4 criteria, was incorporated due to the extensive use of mathematical inputs and variables in the majority of our PAL courses, which predominantly originate from STEM disciplines.

Each criterion was rated on a four-point scale (0-3), as specified in the rubric. A score of 0 indicated a lack of evidence for the feature's existence, 1 represented minimum evidence, 2 signified moderate evidence, and 3 denoted significant evidence of the feature's presence in the system. In instances where the evaluation team could not access a particular feature, the corresponding criteria were omitted from that system assessment.

For each platform, the team reviewed associated resources, documentation, and vendor demonstration. For OLI Torus, the team also reviewed an initial evaluation, which was shared based on a rubric developed for EdPlus at Arizona State University.

Limitations

It is important to acknowledge certain limitations that existed within the scope of this evaluation:

- Rubric Comprehensiveness: The rubric employed, while extensive, may not encompass an exhaustive assessment of all possible system considerations. For example, the adaptivity feature does not evaluate the systems' adaptive algorithms.

- Limited User Experience: With regard to Grasple, LibreTexts ADAPT, MyOpenMath, and OLI Torus, the evaluation team's assessments were based on vendor presentations, relevant documentation, websites, and brief testing periods with these platforms. The team did not have the opportunity to engage as long-term users of these platforms, which could have provided more comprehensive insights into their practical usage and functionality.

- Evaluator Consistency: To streamline the evaluation process, the team divided into groups, with each group assessing a subset of the platforms. While efforts were made to ensure consistency in the application of the rubric criteria, the distributed nature of the evaluation process introduces the possibility of varying interpretations or perspectives across the different groups.

It is crucial to interpret the following evaluation findings within the context of these limitations.

Personalized Adaptive Platforms

In this section, we provide a comprehensive analysis of each evaluated platform, highlighting their respective adaptive features, math capabilities, accessibility compliance, efficacy impact, functionalities, system capabilities, strengths, and limitations. The description below was summarized based on our evaluation results with the aid of Claude, an AI writing assistant by Anthropic. All content was reviewed and revised by the authors.

Acrobatiq

Acrobatiq by VitalSource is an eText-based learning platform that delivers active, personalized learning experiences through embedded practice activities. Its core adaptive capability is providing personal practice with targeted difficulty levels based on a student's performance on previous formative questions. A major strength is its accessibility compliance demonstrated through published VPATs. While direct efficacy research is limited, VitalSource highlights its research support services. Acrobatiq offers clean UI, automated question generation, seamless LMS integration, and dedicated customer support. However, it lacks variabilization capabilities and is limited to VitalSource's content repository.

Adaptive Features: Adaptivity is facilitated through chapter-end personal practice exercises. Questions are tagged with learning objectives and difficulty levels (low, medium, high) to estimate the appropriate level of challenge. Based on a student's performance on previous formative activity questions, personalized practice activities with targeted difficulty estimates are delivered to each learner.

Math Capabilities: Students can enter numbers and equations within the platform. However, there are currently no capabilities for variabilization, which limits the ability to generate unique problem sets or randomize numerical values.

Functionality: The personal practice questions adapt based on students' performance data from formative assessments. Additionally, instructors can incorporate summative assessments within the platform.

System Capabilities: Content is sourced from the VitalSource repository, and comprehensive documentation for instructors and students is available on the website. The platform integrates seamlessly with Canvas.

Accessibility Compliance: VitalSource demonstrates its adherence to Section 508 accessibility standards by publishing Voluntary Product Accessibility Templates (VPATs) for its products (VitalSource, 2024b).

Efficacy Impact: VitalSource maintains a strong research presence and supports partnering institutions with research efforts, as outlined on their Acrobatiq webpage (VitalSource, 2024a).

Strengths:
- Easy content authoring and setup process.
- Clean and user-friendly interface.
- SmartStart feature automatically generates formative questions and chunks content for optimal learning.
- First Day ready capability for seamless course access.
- Dedicated support from an Acrobatiq Engagement manager.

Limitations:
- Lack of variabilization capabilities limits the generation of unique problem sets.
- Content is limited to the VitalSource repository, restricting customization options.

Overall, Acrobatiq by VitalSource offers an easy-to-design platform for delivering personalized learning experiences, with strong accessibility compliance and research-backed efficacy. However, its lack of variabilization and reliance on the VitalSource content repository may pose limitations for certain instructional needs.

Canvas Mastery Paths

Canvas Mastery Paths is a native Canvas LMS feature enabling automated differentiation of learning pathways based on student performance or student choice (depending on the design configuration). Strengths include zero-extra-cost, seamless integration for instructors and students, pre-built templates, and nested module requirements (i.e., prerequisites). Limitations include the lack of a centralized pathway analytics dashboard (although some pathway data are available at the quiz level), and while variablized questions are configurable to an extent, the Canvas quiz tool does not have a math panel available for students, which prevents formula-based student responses. While direct efficacy research is limited, differentiated learning is an empirically supported teaching method.

Adaptive Features: Canvas Mastery Paths' core adaptive capability is automatically routing students through differentiated content pathways based on their performance on graded assignments. This adaptive functionality can be coupled with the Mastery Gradebook feature, which ties student progress to specific course learning outcomes and mastery levels.

Math Capabilities: For math-based courses, Mastery Paths supports a basic formula question type with variabilization to randomize values. However, it lacks more advanced math-specific features like a dedicated entry tool or widget for handling complex mathematical expressions and equations from students.

Functionality: As part of the comprehensive Canvas LMS, Mastery Paths inherits the full suite of tools needed to facilitate personalized learning experiences beyond just adaptive pathways. This includes communication features, content authoring, diverse assessment options, learning analytics, and grading functionality.

System Capabilities: Mastery Paths leverages Canvas' robust content management infrastructure and follows established procedures for importing, publishing, and updating course materials. Canvas Commons also houses many user-created Mastery Paths templates to simplify implementation. However, centralized reporting across all student pathway interactions is currently lacking.

Accessibility Compliance: Canvas adheres to accessibility standards and WCAG guidelines, helping ensure Mastery Paths courses remain inclusive and usable for all learners. Specific accessibility practices and documentation are available on the company's VPAT website (Instructure, 2024).

Efficacy Impact: While direct research on Mastery Paths' efficacy is limited, the underlying principles of differentiated instruction and mastery-based learning align with established, effective instructional practices.

Strengths:

A major strength is Mastery Paths' availability at no extra cost for institutions already using the highly adopted Canvas LMS platform. This lowers barriers for implementing personalized learning capabilities at scale and reduces designer, instructor, and student learning curves.

Limitations:

Key limitations include the lack of a centralized reporting dashboard with pathway analytics, and the absence of robust math input capabilities beyond the basic formula question type.

Overall, Mastery Paths provides a solid personalization solution, though with some functionality constraints in math domains and reporting needs. At UCF, Mastery Paths is available at no additional cost under our existing license, lowering barriers to implementing personalized capabilities.

Grasple

Grasple is an adaptive learning platform that specializes in mathematics and statistics instruction and practice. Its major strength lies in its robust, accessible math editor that supports complex notation and expressions, including the ability to create parameterized questions with variables directly embedded into equations. Grasple provides rule-based feedback logic and adaptively selects practice questions based on student performance. The platform integrates with OpenStax materials and adheres to accessibility standards like WCAG and HECVAT.

While Grasple highlights customer success stories from European universities using it for math courses, its documentation is limited. The user interface is clean and intuitive, with keyboard accessibility for math input. However, some noted limitations are the lack of group interaction tools, challenges with embedding multimedia, and inability to create interactive image-based questions. Overall, Grasple emerges as a specialized, user-friendly platform well-suited for facilitating adaptive math practice activities within an accessible, OpenStax-aligned environment.

Adaptive Features: Grasple offers adaptive capabilities through specific feedback mechanisms and rule-based conditional logic that tailors the feedback to student responses. It also adaptively selects questions for each topic, with a default of 5 questions per topic that instructors can adjust. Mastery icons on the main page help visualize student progress.

Math Capabilities: A major strength of Grasple is its robust math editor that supports complex mathematical input and notation. It allows for the creation of parameterized questions with variables incorporated directly into equation components. Graph creation tools can also enable visually complex read-only math visualizations.

Answer capabilities are strong and robust that allow complex answer types. This is provided using ‘Answer Rules’, which allow the teacher to add additional answers and create customized feedback. Each Answer Rule is made up of 3 parts: Statement; Correctness; Feedback.

Some other noteworthy math capabilities include Parametrization and Multiple Clauses. Parametrization is the same as creating variables, Grasple offers major types such as: Random, Range and Formula parameters. Random and Range can be used to create input type parameters (variables) which can be used in Formula type for the next steps of calculating the answer.

Multiple Clauses offer the capability to check student answer at various steps, this is especially important in Calculus questions, where the checking of answers at multiple stages can be used for noting exact problem areas for students.

Functionality: Grasple is primarily an assessment-based system focused on providing effective math practice activities. While integrated with LMSs, it lacks explicit communication or group interaction features beyond its adaptive questioning capabilities.

System Capabilities: Grasple includes a repository of statistics and math content coordinated with OpenStax materials. Clear documentation guides instructors and designers. It offers SSO integration and complies with standard data privacy policies.

Accessibility Compliance: Grasple prioritizes accessibility, complying with WCAG and HECVAT standards. All functionality is designed to be fully keyboard-accessible, and the math content remains accessible to users with disabilities. Detailed accessibility documentation is available at their accessibility webpage (Grasple, 2022).

Efficacy Impact: While limited, Grasple highlights four customer success stories available on their website, all from European universities utilizing the platform for math and statistics instruction.

Strengths: Key strengths include the intuitive yet powerful math editor, clean user interface, strong accessibility practices, and suitability as an adaptive math practice environment integrated with OpenStax.

Limitations: Some limitations are the lack of group interaction tools, challenges with embedding videos/images, and an inability to incorporate interactive image-based questions.

Overall, Grasple stands out as a robust adaptive learning platform tailored for mathematics, statistics, and quantitative disciplines, excelling in its math input capabilities while providing integrated LMS functionality.

LibreTexts ADAPT

LibreTexts ADAPT uses a proprietary platform that provides access to repositories of openly available reading content and assessment questions, especially for math and quantitative disciplines. A major strength is its support for creating highly variabilized math questions that allow for parametric input of variables directly into equations and expressions. LibreTexts ADAPT enables granular configuration of individual problem sets, including scoring logic and prerequisite mappings.

However, the user experience is reported as unintuitive, requiring juggling multiple interfaces during the authoring process. While LibreTexts ADAPT integrates with major LMSs, its analytics capabilities are limited. The platform demonstrates a commitment to accessibility but lacks centralized empirical efficacy research.

Adaptive Features: LibreTexts ADAPT offers limited adaptive capabilities focused primarily on variability within individual questions and predetermined decision trees. However, it does not provide robust adaptive pathways across broader learning sequences.

Math Capabilities: A core strength of LibreTexts ADAPT is its advanced math capabilities. Rather than having a native math editor, it integrates to open-source software programs (iMathAS and WebWork) and leverages their large 'open problem repositories' to facilitate the creation of variabilized math questions that allow for students to input responses via a math entry panel and incorporate interactive graphing components. However, these math programs often require coding in languages like PHP and Perl.

Functionality: While providing granular control over learning experiences down to individual question configuration (timing, scoring, prerequisites, etc.), LibreTexts ADAPT overall user experience is cited as unintuitive. It requires juggling multiple platforms and interfaces during authoring.

System Capabilities: LibreTexts ADAPT can integrate with major LMSs through LTI connections or function as a standalone LMS itself. Its learning data interfaces are relatively simple, though there is potential for expanded data visualization capabilities.

Accessibility Compliance: LibreTexts outlines its commitment to accessibility principles and standards on its website (including details around ADAPT) (LibreTexts, 2023).

Efficacy Impact: While empirical research on efficacy is limited, LibreTexts highlights use cases and experiential evidence of successful implementation of its general platform (which may include ADAPT) across various disciplines.

Strengths: Key strengths include access to open problem repositories like WebWork OPL and H5P, enabling easy reuse and sharing of content. Authors have granular control over configuring individual problem sets.

Limitations: Cited limitations are the lack of user-friendliness across multiple editing interfaces, limited automation in structuring content hierarchies, and the coding requirements to develop advanced math problems.

Overall, LibreTexts ADAPT caters well to quantitative STEM fields by providing open-access content repositories along with robust math expression and variabilization capabilities for assessment authoring. But it may prove challenging for inexperienced users due to its authoring complexity. LibreTexts ADAPT emerges as a powerful but niche solution for creating variabilized STEM assessments within an open content ecosystem.

MyOpenMath

MyOpenMath is a free, open-source platform focused on delivering robust math assessment capabilities, particularly for STEM disciplines. A major strength is its versatile support for creating variabilized math questions and expressions through both easy-to-use visual tools as well as more advanced code-based editors. It offers multi-part questioning, native graphing widgets, and algorithmic variables.

While the user interface appears dated, MyOpenMath provides flexibility through if-then logic coding to customize feedback. It can integrate with LMSs or function independently (as its own LMS). MyOpenMath has an active community contributing open content, and its reporting features, while not highly sophisticated, offer item (question / response) analysis down to the question level.

The platform adheres to accessibility standards and voluntary efficacy research exists from the user community, though not centrally compiled. Overall, MyOpenMath emerges as a powerful free solution excellently suited for STEM educators looking to create rigorous variabilized math assessments, despite lacking some modern UI features. Its community-driven open model provides access to a vast range of STEM content.

Adaptive Features: MyOpenMath offers limited adaptive capabilities through if-then logic that can be implemented via PHP coding. However, it does not provide robust out-of-the-box adaptive pathways or personalized learning experiences.

Math Capabilities: A major strength of MyOpenMath is its powerful math functionality tailored for STEM disciplines. The software is powered by iMathAS; therefore, it supports a wide range of question types, including multi-part questions with robust variabilization capabilities. Both easy-to-use (tutorial) and code-based math editors are available, along with native graphing widgets that incorporate algorithmic variables.

Functionality: While the user interface appears dated, MyOpenMath shines in its math-focused features ideal for STEM education. It enables detailed feedback that can be customized via if-then logic coding.

System Capabilities: MyOpenMath can integrate with major LMSs via LTI or function independently as a standalone LMS itself. Its platform interface and data reporting capabilities are functional, offering item analysis, but limited in terms of data visualizations / dashboards.

Accessibility Compliance: MyOpenMath aims to comply with the Level AA Success Criteria set out by the W3C in the Web Content Accessibility Guidelines 2.0 (WCAG). An overview of MyOpenMath's accessibility features and compliance with standards is available on this accessibility document (IMathAS, n.d.).

Efficacy Impact: While not centrally compiled, voluntary research from MyOpenMath's global user community exists to support the platform's efficacy and examine student perceptions of its impact.

Strengths: Core strengths include its free and open-source model (with an actively maintained source code and direct access to the creator / developer) and an active user community, access to a sizable repository of STEM content for reuse (**Appendix B**), and its capabilities in mathematical expression, graphing, and variabilized assessments.

Limitations: The platform is heavily geared towards STEM disciplines, with content and functionality less suited for other subjects. The user interface also appears outdated compared to modern standards.

Overall, MyOpenMath stands out as a powerful, free, community-driven platform excellently suited for creating variabilized math assessments and learning activities within the STEM fields, despite lacking some adaptive personalization.

Realizeit

Realizeit is a highly customizable adaptive learning platform that uses complex algorithms to personalize curriculum sequencing, content recommendations, and practice activities tailored to each student's performance data. Its strengths lie in powerful variabilization capabilities, integrated math tools, and flexibility to function with or without an LMS. Realizeit has undergone accessibility testing, provides learning analytics dashboards, and cites research evidence of efficacy from past UCF partnerships. However, limitations include a lack of transparency around its recommendation engine, inconsistencies from the platform's complexity, and difficulties with certain authoring tasks. Overall, Realizeit stands out for its adaptive features and customization options backed by responsive service.

Adaptive Features: Realizeit uses a complex algorithm that goes beyond just correct/incorrect responses to determine adaptivity and learning completion. It considers factors like time spent and practice effort. Based on student performance, Realizeit offers personalized curriculum sequencing via learning maps, supplemental content slips, alternative explanations, and dynamically generates unique recommendations tailored to each student through instructor-defined or global variables.

Math Capabilities: Realizeit supports a variety of question types and has strong variabilization capabilities. It includes an accessible math editor and an integrated graphing widget for creating interactive math visualizations and expressions.

Functionality: Realizeit can function with or without an LMS. It provides adaptivity, communication tools, extensive customization, measurement and learning analytics, learner guidance resources, and prioritizes overall usability in its design.

System Capabilities: The platform allows for high degrees of customization backed by responsive customer service, though it lacks an existing content repository. Course data and administration functions are available, and Realizeit complies with data privacy standards. However, the designer interface is reported to be complicated.

Accessibility Compliance: Realizeit has undergone third-party assessment for WCAG 2.0 AA accessibility compliance. A 508c VPAT is available, internal testing is conducted, and the company adheres to ADA requirements (Realizeit, 2020).

Efficacy Impact: Realizeit cites a proven research record demonstrating the efficacy of adaptive learning from past UCF partnerships, though its current research trajectory appears refocused on workforce training over higher education contexts.

Strengths: Key strengths are the powerful customization capabilities for tailoring the user experience, content presentation, and variabilized activities, backed by data streams and dashboards. There is also an established partnership with UCF.

Limitations: Cited limitations include lack of transparency around the recommendation engine's algorithms, inconsistencies stemming from the platform's complexity, difficulty authoring some content, and the absence of batch content ingestion tools.

Overall, Realizeit stands out for its algorithmic adaptive features, customization options, content authoring capabilities, and strong math functions.

OLI Torus

OLI Torus is a flexible platform that enables advanced adaptive capabilities through pathways utilizing conditional logic mapped to learning objectives. A core focus is facilitating interactive "learn by doing" experiences by integrating simulations and multimedia activities. OLI Torus provides basic and advanced authoring tools, including variabilization and math support powered by LaTeX. While documentation is limited, OLI Torus offers LMS integration, instructor analytics dashboards, and customizable accessibility features. Key strengths are its powerful back-end customization abilities, with reported limitations around documentation, abundance of content controls, and ability to ingest external resources. Torus emerges as a powerful platform for designing highly interactive, simulation-enriched adaptive learning experiences.

Adaptive Features: In OLI Torus, designers can create pathways incorporating conditional if/then logic to dynamically route students between different content modules mapped to specific objectives based on performance.

Math Capabilities: OLI Torus includes variabilization functions, numeric math input response types, and formulaic math entry powered by LaTeX rendering. The if/then logic enables adaptive sequencing of mathematical concepts.

Functionality: The platform emphasizes a "learn by doing" model facilitated by customizable back-end development, basic/advanced content authoring options, and the ability to integrate external resources and simulations.

System Capabilities: OLI Torus offers LMS integration via LTI standards and allows tagging content to learning objectives for data tracking. Instructor dashboards provide analytics, with more robust data visualization capabilities on the roadmap.

Accessibility Compliance: OLI Torus provides a wide range of accessibility formatting options. A 2021 VPAT from Argos Education (which uses OLI Torus) indicates general accessibility testing, though comprehensive documentation is limited (Argos Education, 2021).

Efficacy Impact: No specific efficacy research studies could be easily located for OLI Torus, but the lack of readily available information does not definitively mean none exists.

Strengths: Strengths include the flexibility in customizing both user-facing and back-end components, advanced adaptive capabilities, and integration with interactive resources like simulations.

Limitations: Some potential limitations are sparse documentation, an overwhelming degree of granular control over content that may hinder ease-of-use, limited external adoption examples, and an apparent inability to easily ingest/import external content resources in batch.

Overall, OLI Torus emerges as a powerful platform for designing highly interactive, personalized learning experiences.

Platform Comparison

This section includes three tables and five comparison charts that evaluate the seven platforms across several key categories: adaptivity, math capabilities, functionalities, system capabilities, accessibility, efficacy and costs. Notably, adaptivity was compared using a qualitative table (Table 1), as the team determined that quantitatively comparing the adaptive capabilities of these platforms would not adequately capture the nuances involved.

Adaptivity Comparison

Table 1: Platform Adaptivity

Acrobatiq	Acrobatiq uses the performance data to provide personalized practice opportunities for students of different learning estimates (low, medium, high).
Canvas Mastery Paths	Canvas modules can be enhanced through automated differentiated learning pathways based on scores from graded assignments. Mastery Paths can be coupled with Mastery Gradebook, which is connected to course outcomes.
Grasple	Grasple provides specific feedback to students based on rule-based conditional logic; it adaptively selects questions for each topic, typically presenting five questions per topic, although instructors have the flexibility to modify this setting. The platform's main page features mastery icons that visually represent students' progress and proficiency levels across different topics, enabling them to easily identify areas requiring further practice or reinforcement.
LibreTexts ADAPT	LibreTexts ADAPT offers algorithmic question creation with adaptivity confined to a single problem head that contains a pre-configured decision tree or branching logic that allows for time and accuracy controls, while offering students agency in their learning pathways (to the extent that an instructor allows).
MyOpenMath	MyOpenMath incorporates adaptivity through its ability to implement "if-then" logic using PHP coding. This feature allows the platform to adapt the learning / feedback experience based on certain conditions or criteria.
Realizeit	Realizeit employs a complex algorithm to determine adaptivity, considering factors such as time spent, and practice efforts in addition to student performance. Based on these variables, Realizeit offers personalized curriculum sequencing guided by a learning map, as well as content slips and alternative content tailored to individual needs. Furthermore, instructors have the option to use variables to provide students with targeted problems and content, while the platform makes unique and dynamic recommendations to each individual student, ensuring a highly personalized learning experience. However, a notable limitation is the lack of transparency regarding the specifics of the adaptivity algorithm, which may raise concerns about the decision-making process behind the personalization.
OLI Torus	OLI Torus allows for highly customizable adaptivity through its backend development capabilities. Designers can create personalized learning pathways

	that utilize conditional (if/then) logic to dynamically redirect students between various content chunks based on their performance or responses. These content chunks can be mapped to specific learning objectives, enabling the platform to deliver a tailored learning experience aligned with individual needs.

Math Capabilities Comparison

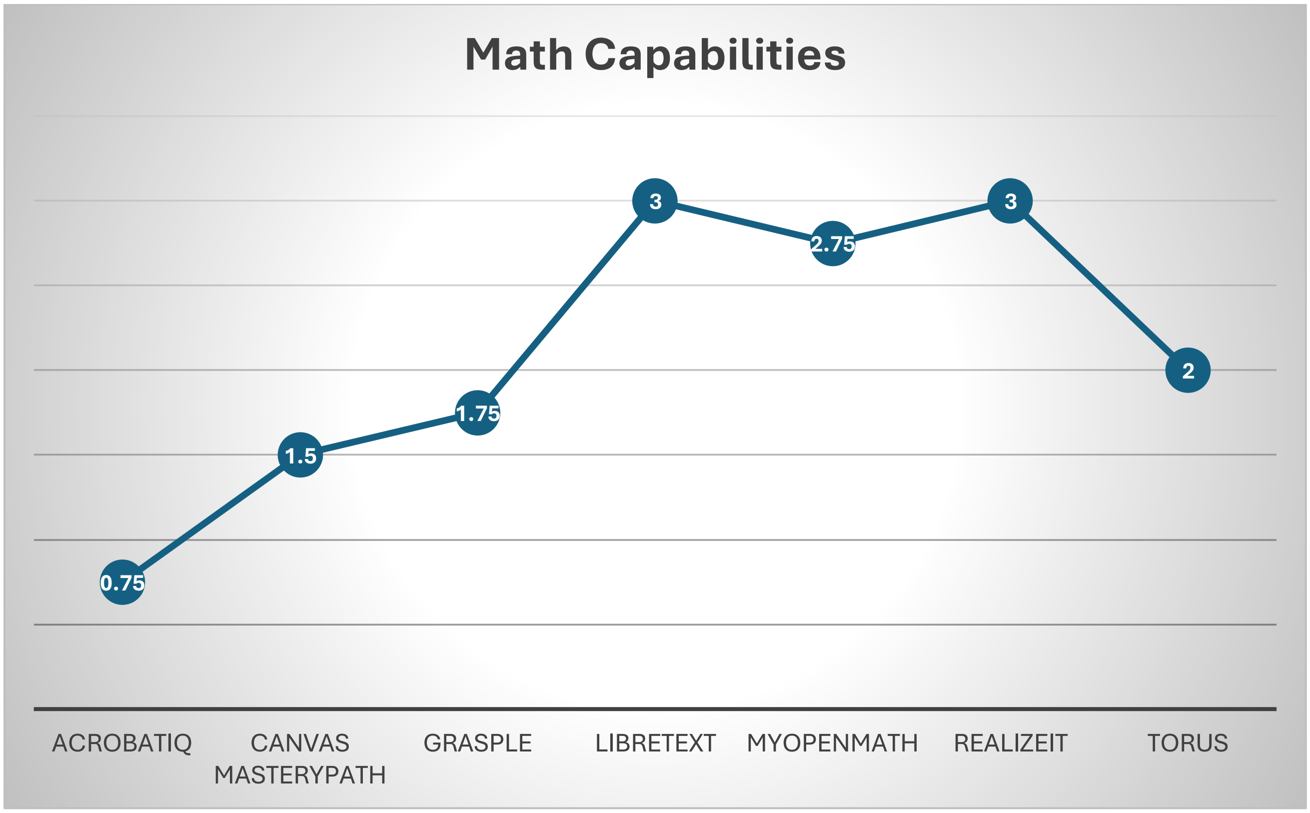

Figure 1. Platform Comparison in Math Capabilities

The math capabilities category was not part of the original CourseGateway rubric (2023) but was added by the PAL team to address the specific needs of the institution's STEM faculty, who heavily rely on math inputs and variabilized questions. This category assesses factors such as the availability of various question types, variabilization capabilities, math editor functionality, and graphing widget support. Among the evaluated platforms, **LibreTexts ADAPT** and **Realizeit** received the highest ratings in this category, closely followed by **MyOpenMath**. Table 2 provides detailed math capabilities of each platform.

Table 2: Math Capabilities

Platform	Question Types	Variabilization	Math Editor	Native Graphing
Acrobatiq	Multiple choice; Multiple select; True/False; Pulldown; Multiple-Choice Grid; Text Input; Muber Input; Equation; Passage Selection; Drag and Drop Table; Drag and Drop Image; Image Hotspot; Submit & Compare; Self Report; Hints; Feedback	No	Yes	No
Canvas Mastery Paths	Categorization; File Upload; Formula; Matching; Essay; Fill in the Blank; Hot Spot; Multiple Answer; Multiple Choice; Numeric; Ordering; Stimulus; True or False; Dropdown	Yes (Formula question type)	No	No
Grasple	Multiple Choice (select one); Numeric: Enter Answer (Default error tolerance 5%) can include other correct answers by using multiple answers option; One-word open answer (ML algorithm for answer checking); Symbolic Math (which can check for equivalent statements)	Yes	Yes	No
LibreTexts ADAPT (iMathAS; WebWork)	Number; Calculated Number; Multiple-Choice; Multiple-Answer; Matching; Function; String; Essay; Drawing; N-Tuple; Calculated N-Tuple; Numerical Matrix; Calculated Matrix; Interval; Calculated Interval; Complex; Calculated Complex; Chemical Equation; File Upload; Multipart; Conditional; WebWork; H5P	Yes	Yes	Yes
MyOpenMath (iMathAS)	Number; Calculated Number; Multiple-Choice; Multiple-Answer; Matching; Function; String; Essay; Drawing; N-Tuple; Calculated N-Tuple; Numerical Matrix; Calculated Matrix; Interval; Calculated Interval; Complex; Calculated Complex; Chemical Equation; File Upload; Multipart; Conditional	Yes	Yes	Yes
Realizeit	Enter Answer; Multiple choice; True or False; Ordering; Matching; Grouping; Point and Click; Drag and drop;	Yes	Yes	Yes

	Attachment; Dynamic attachment; Composite parts			
OLI Torus	Basic page: Multiple choice, multiple correct answer, OLI embed, hotspot, drag-and-drop, ordering, math input (with LaTeX + formula) Adaptive page: Multiple choice, text input, dropdown, number input, slider, multiline text input	Yes	Basic page: Yes Adaptive page: No	No

Functionality Comparison

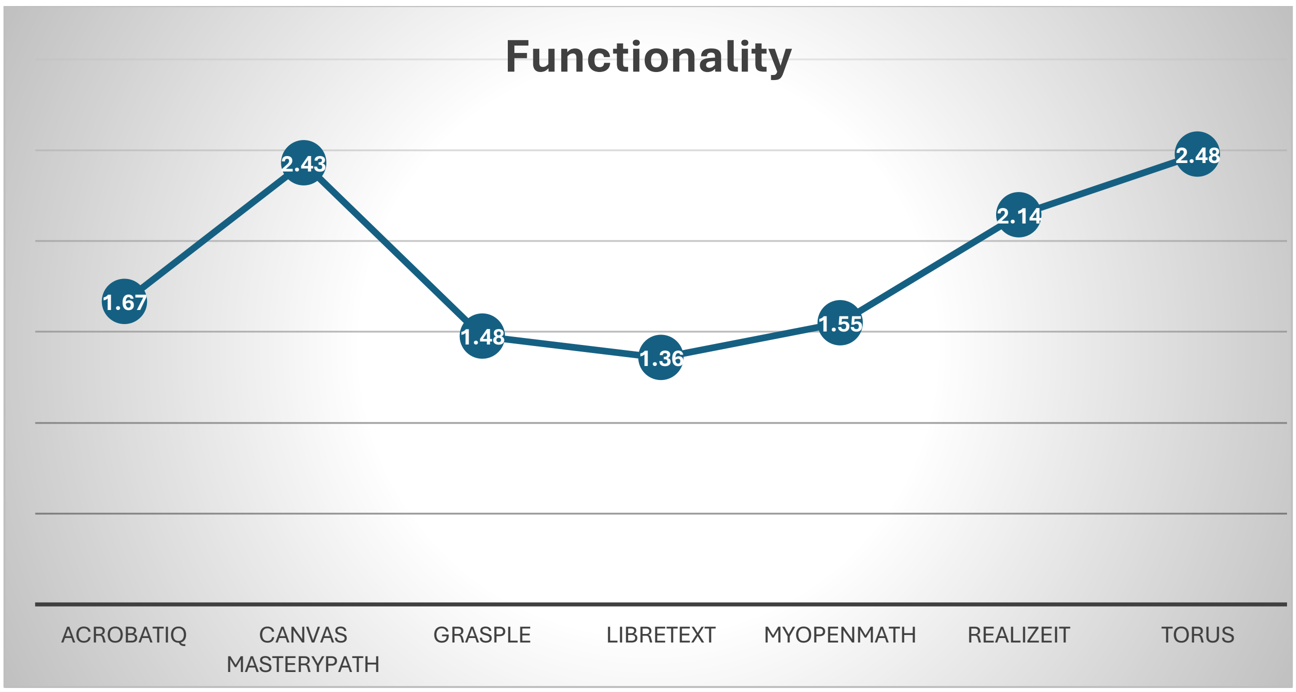

Figure 2. Platform Comparison in Functionality

The functionality criterion includes features such as adaptivity, communication and collaboration, customization, evidence-based teaching practices, learner guidance, measurement and structure, and usability. **OLI Torus** and Canvas **Mastery Paths** were rated the highest in terms of overall functionality.

System Capabilities Comparison

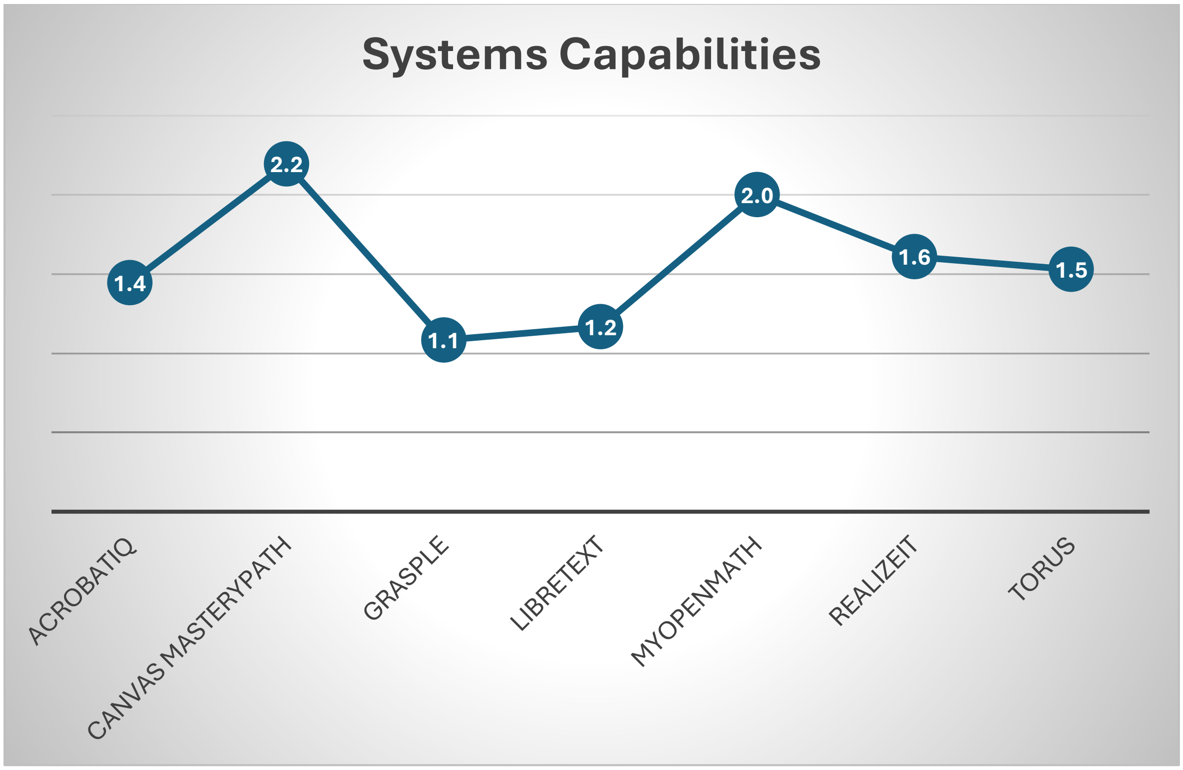

Figure 3. Platform Comparison in Systems Capabilities

Systems capabilities include functions such as content management, course administration, data access, data as support, data privacy and ownership, and third-party applications. Canvas **Mastery Paths** and **MyOpenMath** were rated the highest among all platforms.

Accessibility Comparison

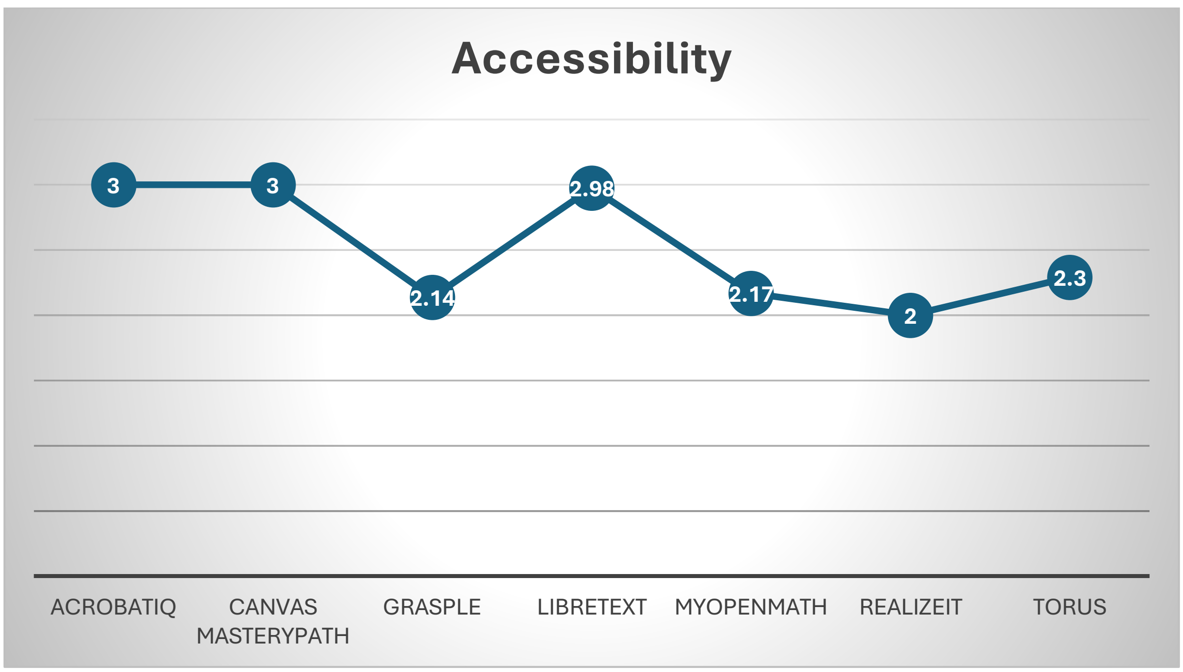

Figure 4. Platform Comparison in Accessibility

The accessibility criterion evaluates if the platform has robustly accessible functionality and documentations and follows best practices that align with technical (i.e. WCAG). This includes 19 sub-criteria and not all listed accessible functions were able to be tested by the evaluators due to technical limitations. All seven evaluated platforms were rated above 2 and provide clear accessibility statements.

Efficacy Comparison

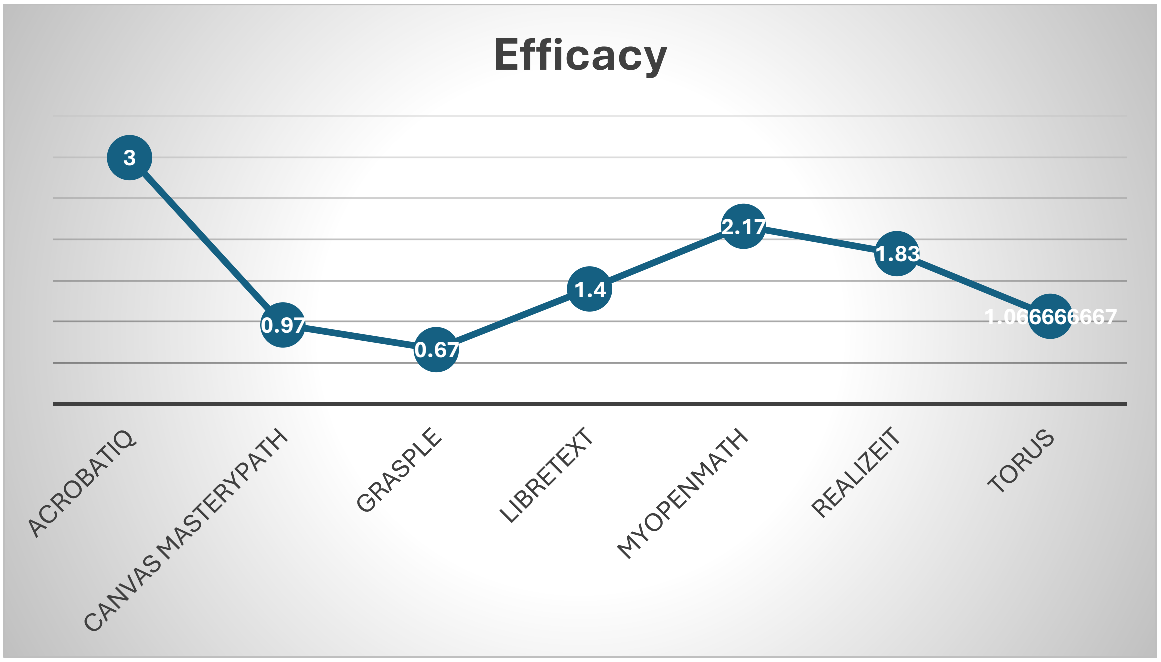

Figure 5. Platform Comparison in Efficacy

The efficacy criterion evaluates if the vendor or users have published case studies and research across a variety of use cases and contexts. This category includes 11 sub-criteria. In general, commercial vendors outperformed the open platforms in terms of research and efficacy, except for **MyOpenMath** where broad users have published voluntarily.

Cost Comparison

Last but not least, Table 3 compares the cost and open elements among the seven platforms.

Table 3: Cost Comparison

Platform	Cost-Associated	Open Content Repositories	Open-Source Code
Acrobatiq	Yes	No	No
Canvas Mastery Paths	None beyond Canvas LMS (at institutional level)	Yes (Canvas Commons)	No
Grasple	Yes	Yes	No
LibreTexts ADAPT	Yes	Yes	No
MyOpenMath	Free	Yes	Yes

Realizeit	Yes	No	No
OLI Torus	Logistical costs-associated	No (Note: 3 legacy OLI courses viewable)	Yes

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Appendices

Appendix A CourseGateway Rubric Criteria

1 Accessibility
1.1 Accessible Functionality
1.2 Documenting Product Accessibility
1.3 Supplier Accessibility Maturity
2 Efficacy
2.1 Case Studies
2.2 Evidence Across Institution Types
2.3 Research Design Support
2.4 Rigorous Methodologies
2.5 Third-Party Participation in Efficacy Research
3 Equity
3.1 Design and Product Development
3.2 Language
3.3 Learning Activities
3.4 Learning Outcomes
3.5 Student Representation
3.6 Student Supports
4 Functionality
4.1 Adaptivity
4.2 Communication and Collaboration
4.3 Customization
4.4 Evidence-Based Teaching Practices
4.5 Learner Guidance
4.6 Measurement and Structure
4.7 Usability
5 Systems Capabilities
5.1 Content Management
5.2 Course Administration
5.3 Data Access
5.4 Data as Support
5.5 Data Privacy and Ownership
5.6 Third-Party Applications

Appendix B Topics of MyOpenMath Question Repository

The MyOpenMath platform offers a comprehensive open library across various subjects, including Arithmetic, Algebra, Trigonometry, Calculus, and more. Each subject is divided into multiple subtopics. For instance, the Arithmetic section alone contains around 5,400 questions, while the Algebra section boasts over 15,000 questions. The library includes various question types such as numeric, multiple choice, matching, and more. Most questions are ready to use, and you can modify any question to suit your needs.

Subjects/topics list:

- Arithmetic
  Whole Numbers; Integers; Fractions; Decimals; Ratios and Percents; Measurement; Coordinate Plane; Basic Statistics; Basic Geometry; Real Numbers; Sequences

- Algebra
  Basics; Evaluate expressions/formulas; Geometry; Linear equations in 1 variable; Linear inequalities in 1 variable; Exponents ;Polynomials; Factoring; Quadratics; Linear equations in 2 variables; Systems of linear equations; Linear inequalities in 2 variables; Rationals; Radicals; Exponential functions; Logarithms; Algebra of functions; Functions; Conics; Direct and Inverse Variation; Graphs general; Interval Notation; Regression; Absolute Value

- Trignometry
  Angles; Trig on circles; Triangle trig; Law of sines and cosines; Inverse trig functions; Graphing trig functions; Identities; Solving trig equations; Polar curves; Parametric curves; Complex numbers (including polar form); Vectors; Trig Models; periodic functions; Arc Length Linear and Angular Velocity

- Calculus
  Differential Limits; Differential Derivative rules; Differential Applications; Integration rules; Applications of Integration; Differential Equations; Sequences and Series; Multivariable 3D space; Multivariable Vector functions; Multivariable Partial Derivatives; Multivariable Multiple Integrals; Multivariable Vector Calculus; multivariable; Business Calculus; Calculus I Video Lesson Questions

- Differential Equations
  Intro; First Order; Second Order; Higher Order; Series Solutions; Laplace Transform; First Order Systems; Nonlinear Systems; Numerical Methods; Fourier Series (Trench chap 11); PDE's (Trench Chap 12)

- Linear Algebra
  matrices; Eigenvalues and Eigenvectors; Applications of Linear Algebra

- History of Math
  Mayans; Egyptians; Babylonians;Number Systems; Pythagoreans; Greeks; Cubics and Logs

- Math for Liberal Arts
  Social Choice; Networks/Graph Theory; Growth models; Consumer math; Logic; Sets; Basic Stats; Spiral Growth / Golden Ratio; Sequences; Proportional Reasoning; Cryptography; Number Theory

- Statistics
  Vocab and Sampling; Descriptive Stats; Probability; Discrete Probability Distributions; Continuous / Normal Distribution; Confidence Intervals; Hypothesis Testing, one population; Hypothesis Testing, two populations; Correlation and Regression; Chi-Square; ANOVA; Software Specific; Real Data Problems

- Textbook Specific
  Wallace: Beginning and Intermediate Algebra; Hoffman Calculus; Redwoods Prealgebra; - CK12 Trig - Sousa Edit; Lippman Rasmussen Precalculus; Lippman Math in Society; StitzZeager;

Calaway/Hoffman Bus Calc; Scottsdale Arithmetic; OLI supp; Scottsdale Intermediate; OpenIntro Stats; onlinestatbook; Big Bend Emporium; Scottsdale Intro Alg; Algebra - Yakima CC; Mayo: Pre-Algebra; Mayo: Arithmetic; OLI Statistics; Stats using Tech; Intro and Intermediate Algebra (Yakima Valley); Pierce Math 96; Scottsdale College Alg; Business Precalc - Lippman; SCC: Arithmetic for College Readiness; Scottsdale Math in Society; College Algebra using Excel sheets; Statistics using Excel sheets; OpenStax University Physics Volume 1; OpenStax University Physics Volume 3; Introduction to Physics; OpenStax University Physics Volume 2; VaristyLearning Geometry; SCC: Mathematical Concepts and Applications; OpenStax Astronomy; EnsleyDiscreteMath; Openstax Intermediate (Valencia); A First Course in Linear Algebra - Lyryx/Kuttler; Calculus Early Transcendentals 8e (Stewart); Active Calculus (Boelkins); Understanding Linear Algebra by D. Austin; Prob, Stats, Data: A Fresh Approach Using R (Speegle, Clair); Yoshiwara Elementary Algebra; Yoshiwara Intermediate Algebra: Functions and Graphs

- Chemistry
  Acids and Bases; Atoms, Molecules, and Ions; Composition of Substances and Solutions; Electronic Structure; Equilibrium; Essential Ideas; Gases; Kinetics; Laboratory; Liquids and Solids; Mass Relationships; Nuclear Chemistry; Organic Chemistry; Periodicity; Solutions and Colloids; Stoichiometry of Chemical Reactions; Thermochemistry

- Accounting
  Intro and Financial Statements; Acct cycle: Journal entries - posting; Acct cycle: adjusting and closing; Accounting for Merchandising Operations; Inventory and Cost of Sales; Cash and Internal Controls; Receivables; Long Term Assets; Liabilities; Payroll transactions; Corporate Reporting; Statement of Cash Flows; Financial Statement Analysis; Cost Concepts and Classifications; Job Costing; Process Costing; Service Costing; CVP Analysis; ABC Costing; Variable Costing; Budgeting and Profit Planning; Flexible Budgets; Standard Costs and Variance Analysis; Capital Budgeting; Performance Measurements and Responsibility Accounting; Product Planning; Special Journals

- Discrete / Finite Math
  Consumer Math; Systems / Matrices; Linear Programming; Business and Economics; Mathematical Induction

- Contributed Libraries
  BioCalc PEA; ECTC; Hasselberg Steve; High School Math (Lipscomb); Julies Library; Maricopa Discrete Math; Math for Elem Teachers 1 - Phoenix College; Math for Elem Teachers 2 - Phoenix College; Medical Math; OpenStax Calc 1; Phoenix College (most with videos); Santa Ana Business Calculus temp; Santa Ana Statistics Temporary; Study Skills; Transition to Quant Lit and Stat; Yakima Business Math and Business Calculus

- Physics Library
  Introduction: The Nature of Science and Physics; One-Dimensional Kinematics; Two-Dimensional Kinematics; Dynamics: Force and Newtons Laws of Motion; Uniform Circular Motion and Gravitation; Work, Energy, and Energy Resources; Linear Momentum and Collisions; Statics and Torque; Rotational Motion and Angular Momentum; Fluid Statics; Fluid Dynamics; Temperature Kinetic Theory and the Gas Laws; Heat and Heat Transfer Methods; Thermodynamics; Oscillatory Motion and Waves; Physics of Sound; Electric Charge and Electric Field; Electric Potential and Electric Field; Electric Current Resistance and Ohms Law; Circuits and DC Instruments; Magnetism; Electromagnetic Induction and AC Circuits; Electromagnetic Waves; Geometric Optics; Wave Optics; Special Relativity; Introduction to Quantum Physics; Atomic Physics; Radioactivity and Nuclear Physics; Particle Physics;

Frontiers of Physics

- Flash Card Questions

- Finance
Time Value of Money; Bond Valuation; Stock Valuation; Capital Budgeting; Capital Structure; International; Financial Statements; Financial Ratios; General

- Integrations / Video Motivated
Geogebra; Construct2; JSXGraph; Other HTML5; Video Motivated

- Quantway
Module 3; Module 1; Module 2; Module 4; Module 1 Assessments; Module 2 Assessments; Module 3 Assessments; Module 4 Assessments; Virtual Manipulatives Library

- Astronomy
PRELIMINARIES; VELOCITIES; SOLAR SYSTEM; ASTROBIOLOGY; VOCABULARY; STARS; GALAXIES; SETI; COSMOLOGY; BLACK HOLES; Ally; Zach; Josh; OpenStaxAstronomy

- Math for Elementary School Teachers
Problem solving, patterns, logic; Sets and operations; Whole number addition; Whole number subtraction; Whole number multiplication; Whole number division; Integers; Number theory; Fun with Fractions; Decimals and operations; Probability and counting; Descriptive statistics; Geometry basics; Numeration systems; Math for Elem Ed with Praxis Review

- Geometry
Lines; Angles; Triangles; Quadrilaterals; Polygons; Circles; Solids; Transformations; Reasoning; Area and Perimeter; Similar and Congruent; Pythagorean Theorem

- Engineering Statics
Engineering : Prerequisite of STATICS; Vectors; Particle Equilibrium; Force System Resultants; Rigid Body Equilibrium; Structures; Internal Forces and Moments; Friction;Centroids; Moment of Intertia

- Engineering Dynamics
Kinematics of a Particle; Kinematics of a Rigid Body; Kinetics of a Particle - Equations of Motion; Kinetics of a Rigid Body; Impulse and Momentum; Work and Energy