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Faculty and Student Perspectives on Gateway Math Courses and Courseware

Tanner Higgin, Cathy Holl-Cross, Anita Moorjani, and Ann Edwards with Olivia Cornfield, Sierra Eisen, Lewis Hosie, Haley McNamara, Dan Ray, and Belin Tsinnajinnie

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Introduction: A Challenging Time for Gateway Mathematics

Postsecondary gateway mathematics education faces several interrelated challenges. Declining enrollment and budget cuts mean staff must do more with less. Departments struggle to navigate policy changes and place students in courses that match with their skills. Meanwhile, distance learning has accelerated a shift toward a wide variety of course formats, including fully online synchronous or asynchronous, hybrid/HyFlex (including optional in-person), and traditional in-person courses. Math departments and faculty must navigate this difficult environment while supporting a student population struggling with math anxiety and motivation issues. While the causes of these issues are myriad, an increasingly uncertain future and intense academic pressure weigh heavily on students.

So where does courseware fit into this challenging landscape for postsecondary gateway math education?

This study defines *courseware* as a digital tool that delivers most or all of a course's instructional content. It serves as a functional supplemental resource that provides students with practice and instant feedback. While courseware is popular and offers benefits, there is a clear disconnect between the challenges that gateway math faculty and students face and the aims and impacts of the courseware tools that they use.

To inform the design of courseware that better serves all students, a team of researchers at WestEd conducted a study documenting the experiences of faculty and students in three semester-long gateway math courses: College Algebra, Quantitative Reasoning, and Calculus I. Specifically, the study collected input from 76 faculty and 50 students from

69 colleges and universities across 30 states, including input on how their experiences and needs intersect with courseware. This report summarizes the high-level challenges and opportunities for effective gateway math education that this study surfaced, the data collection and analysis methods used and outputs generated, the math teaching and learning needs of faculty and students, and the courseware requirements to support those needs.

Summary of Key Challenges and Opportunities

Based on the analysis of student and faculty data collected for this study, the research team identified the following key themes—organized as challenges and opportunities—related to gateway math.

Key Challenges to Effective Gateway Math Education

- **Time and resource constraints:** Both faculty and students consistently felt like they lacked the time they needed to teach and learn in the ways they wanted. Many indicated that they work with limited financial or technological resources. They conveyed a pervasive sense of needing to get more organized and focus on what matters, including attending to work, family, and managing mental health. These circumstances had a significant impact on math teaching and learning.
- **Skill gaps:** Both faculty and students recognized that the COVID-19 pandemic, and distance learning, set students back and made it harder for them to succeed in math courses. Both faculty and students were also hungry for support, and struggled to identify and close skill gaps in areas ranging from algebra to note-taking to building healthy study habits.
- **Purpose beyond practice:** While courseware is useful for facilitating homework and math practice, it is less instrumentally involved in activities that students and faculty identified as essential for motivation, engagement, and persistence in math. These essential activities include creating a welcoming classroom, building relationships, and connecting math concepts to the real world.

Key Opportunities for Improving Gateway Math Education and Courseware

- **Math identity shifts:** Most students reported struggling with math anxiety or not having a positive math identity. However, students also talked about how these feelings changed over time (both positively and negatively) based on a particular course or instructor. Good teaching, backed by engaging curriculum and lively, supportive classrooms, can have a profound impact on students' confidence in math courses.
- **New approaches to grading and assessment:** Most faculty and students are hungry for fresh approaches to assessment, especially a focus on mastery and even "ungrading," or reducing the frequency of (or removing entirely) grades and points from courses. When mastery-based assessment is adopted and effectively employed, it can reduce the pressure of performance tasks and tests, focusing student and faculty energy more on feedback and growth than on grades and grading.
- **Appetite for productive struggle:** Students enjoyed tackling tough math problems and were highly motivated when given intellectually stimulating work that was within their zone of proximal development. Faculty also enjoyed supporting this kind of work and helping students think through solutions and see math as a way of thinking about and better understanding the world.

Study Methods and Tools Developed for Courseware Design

The insights in this report are derived from several data collection efforts conducted by the WestEd research team between August and December 2024. Data analysis occurred between August 2024 and May 2025.

Study Participants

The study collected data on 76 faculty and 50 students who participated in the study. These faculty and students were from 69 two-year and four-year postsecondary institutions across

30 states, including many Hispanic-serving institutions and several Tribal Colleges and Universities. The faculty sample included individuals in both tenure-track and non-tenure-track roles, as well as several in part-time positions. Twenty-five percent of faculty were teaching in rural or small-town locations. Student recruitment efforts focused specifically on surfacing perspectives from historically underserved students. To this end, 60 percent of students were eligible for Pell grants, 20 percent were age 25 or over, and 40 percent identified as Latino/a/x, Indigenous, or Pacific Islander.

Data Collection Activities

Interviews and debriefs: All of the study's participants participated in one-hour semi-structured interviews that focused on their backgrounds, experiences, motivations, and needs. After each interview, researchers debriefed to document novel insights or recurring themes.

Surveys: All participants were invited to complete a post-interview survey focused on their most pressing needs related to technology. Fifty-five faculty and 38 students completed the survey.

Diary study: The research team selected nine faculty members that represented unique combinations of course, courseware, institution, and course format (e.g. asynchronous online or in-person). These nine faculty members participated in a six-entry diary study that captured their interactions with, and perceptions of, courseware between September and December 2024.

Data Analysis Activities

Affinity mapping: The research team participated in two collaborative sorting activities—one for faculty and one for students. These sorting activities, in which researchers documented findings related to motivation, frustrations, and other qualities, helped to surface topline themes and insights.

Qualitative coding: All surveys and diary study logs and a subset of interviews were coded and analyzed to surface themes and patterns, including by specific participant demographics and contexts.

Descriptive analysis: After surveys were cleaned and coded, they underwent descriptive analysis to identify any novel insights.

Tools Developed for Courseware Design

The research team developed several user experience design tools that courseware designers and developers can use to create or improve products that serve postsecondary students and

faculty. These tools are freely available for anyone interested in using them. To request access, please contact Tanner Higgin (thiggin@wested.org).

Persona creation kit: The research team developed a modular, deck-based user persona creation kit (see Figure 1 for a representation of the Faculty Persona Creation Kit) that allows courseware designers and developers to better empathize with the students and faculty who might use their software or product. As opposed to typical personas, which are static representations of a few individuals (e.g., "Anna is a mid-40s student returning to college . . .") who are deemed "average" users, this kit lets designers and developers rapidly create and re-create dozens of potential users. This kit better surfaces the dataset to designers and developers, encourages playful design thinking and discussion, and more adequately models the diversity and interconnectedness of our participants.

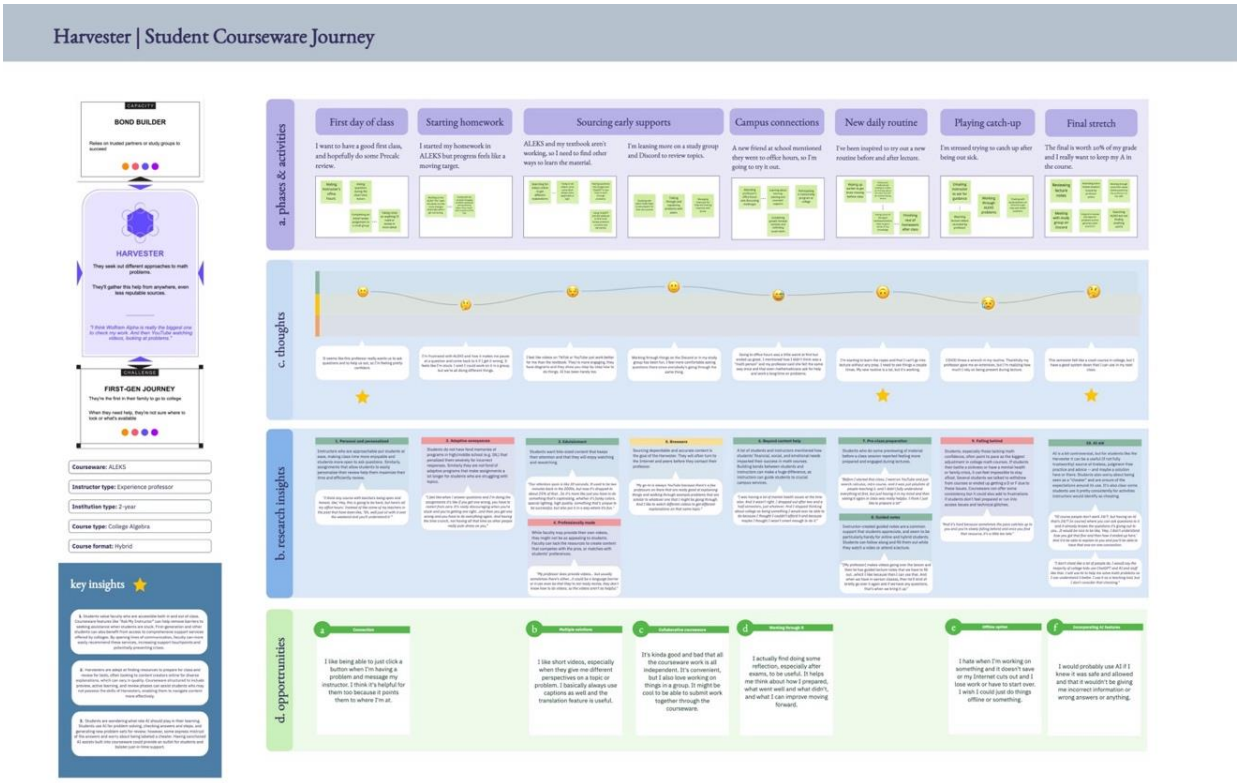
To create personas using the kit, courseware designers and developers first choose from eight archetypes, which are evenly split between student and faculty archetypes. These archetypes (e.g., a "Reformer" faculty member who is aiming to be more flexible and forgiving in their classroom) can then be paired) with capacity and challenge cards to turn the archetype into a fully built persona. Pairings require a match between the color of the archetype (e.g. the "Reformer" is blue) and the colored dots displayed on the bottom of the capacity and challenge cards. Capacity cards contextualize the resources—either enabling or limiting resources—that a user might have (e.g., teaching in a large lecture hall). Challenge cards describe timely obstacles that faculty or students face in their classrooms or with their learning (e.g., a faculty member struggling with students who do not speak up or provide feedback).

The final optional step, after a persona has been built, is to choose two design thought cards. Design thoughts are reflective questions meant to spark design thinking and discussion about the persona (e.g., a design thought for the "Reformer" archetype might be "What do you see that could hinder their efforts to be more open and forgiving?"). Importantly, all of the cards in the deck are rooted in participant data.

Figure 1. Faculty Persona Creation Kit

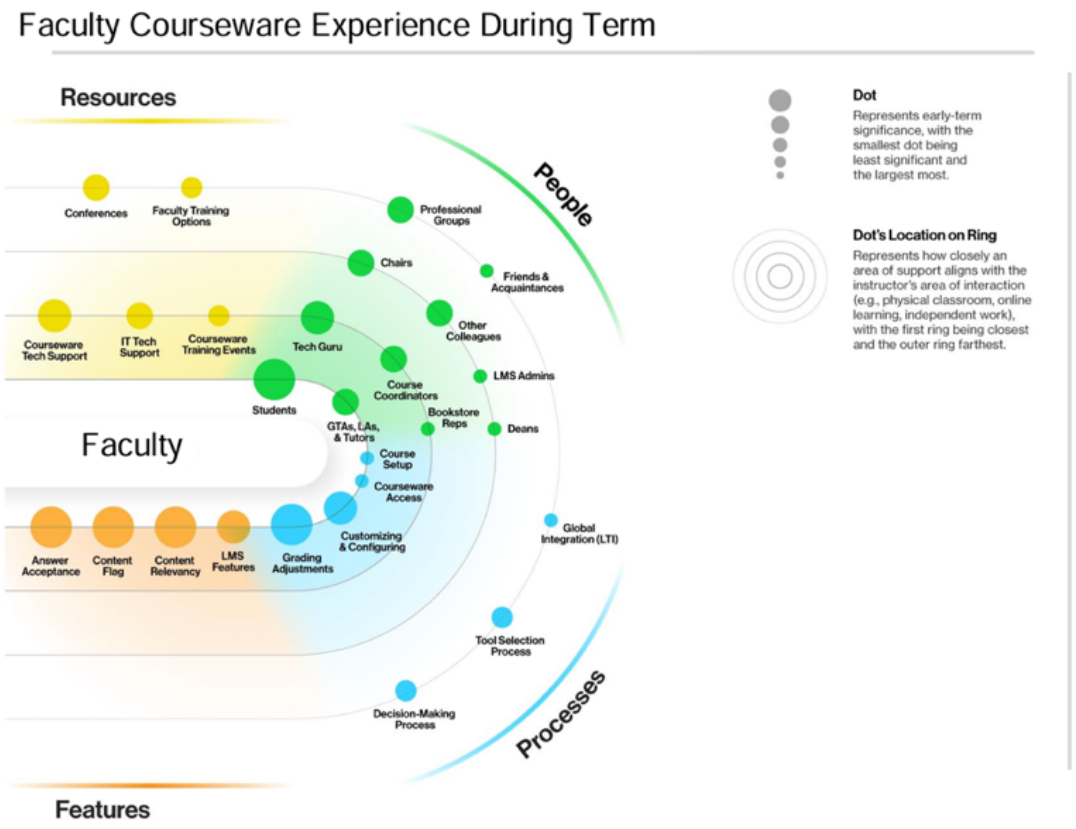
Journey maps: The research team produced eight journey maps—one for each archetype included in the persona creation kit—that each imagine a student's semester-long math course experience. The journey map visualizes, for designers and developers, what a particular kind of student might think, feel, and experience during a semester, including points of friction and frustration as well as courseware opportunities and solutions (see Figure 2 for high-level visual representation of what a journey map may look like).

Figure 2. Student Journey Map



Ecosystem maps: The research team developed two ecosystem maps: one for students and one for faculty. The maps illustrate the people, processes, courseware features, and resources that positively and negatively impact or condition success in math courses (see Figure 3 for a high-level visual representation of an ecosystem map).

Figure 3. Faculty Ecosystem Map



Findings and Recommendations: Improving Courseware to Meet Student and Faculty Needs

The research team asked participants about their experiences in gateway math courses, with specific interest in what factors impact their motivation, engagement, and persistence and how their experiences intersect with courseware. This section summarizes what the research team

found, grouping the results into primary and secondary findings. For each overarching finding, there is a writeup explaining it, followed by a blue text box that outlines how courseware could address student and faculty needs.

Primary Findings

The research team has identified the following findings as most significant, due to both the frequency with which they emerged in the data and their importance to math motivation and success.

Relationships and Collaboration

Social engagement in gateway math courses builds confidence and deepens understanding; this engagement is dependent on faculty fostering a supportive learning environment.

Students and faculty both recognize the benefits of collaboration in gateway math courses. Collaborative learning can foster deeper understanding by surfacing diverse approaches to and explanations of math problems and concepts. In classrooms that encourage group work and open discussion, students can be active participants, feel comfortable sharing ideas, and gain confidence in their abilities. When faculty create a safe space for students to ask questions and make mistakes, the supportive environment reduces pressure on the students, allowing them to engage more freely and refine their thinking. However, the rise of online and asynchronous learning can limit these interactions.

Courseware should include social and support features to enhance collaboration and engagement. These features can bridge the social engagement gaps between in-person and online courses and between synchronous and asynchronous courses.

Courseware Recommendations

- **Communication tools:** Live chats and breakout rooms to enable real-time communication, along with discussion boards and Q&A forums for asynchronous collaboration, bridging gaps across delivery modes
- **"Ask my instructor" functionality** to ensure that students can easily communicate with faculty about specific problems and that faculty can readily access students' work in courseware
- **Interactive collaboration tools**, such as screen sharing and online whiteboards, that students and faculty can use to engage with math problems

Efficiency and Usability

Thoughtfully designed courseware enhances efficiency, supports independent student navigation, and allows faculty to focus on teaching, rather than on technical challenges.

With declining institutional resources and growing administrative demands, faculty often face heavier course loads, expanded research responsibilities, and larger class sizes. At the same time, students have varied backgrounds and skillsets when it comes to technology and many grow up without much technology or relying mostly on smartphones. Supporting this range of skills requires tailored support. These evolving dynamics present significant challenges for faculty within and beyond the classroom.

Well-designed courseware simplifies grading, integrates with learning management systems, and provides students with instant access to relevant, high-quality resources without tedious searches. To achieve this, courseware must be user-friendly, intuitive for students, and easy for faculty to adapt without advanced technical skills. Faculty are then able to focus on instruction, rather than on troubleshooting technology issues.

Courseware Recommendations

- **Simplified and efficient grading tools**, such as the ability to adjust grades for multiple students at a time
- **Seamless integration** with learning management systems
- **Instant student access** to relevant, high-quality resources
- **Clear onboarding tools** to support user navigation
- **Intuitive, uncluttered, and mobile-friendly user interface** to ensure effective use, especially by students
- **Easy customization** for faculty, especially when modifying assignments and problems

Secondary Findings

While these findings are important and appeared frequently in the data, the research team has identified them as dependent on the primary findings.

Learning Gaps

Courseware can bridge learning gaps and boost student success by streamlining support through tailored tutorials, study tools, and targeted practice.

Students in gateway math courses often struggle with foundational skills and with adapting to college expectations. Accordingly, faculty spend significant time creating supplemental materials. However, integrated features such as tutorials, study-planning tools, and targeted practice can streamline learning.

Courseware can play a crucial role in supporting students by enabling independent practice and addressing gaps in math proficiency, technology use, and general readiness. Beyond problem-solving, it should offer personalized support, identify individual needs, and provide accessible resources such as videos and tutorials. Thoughtfully designed courseware can ensure that students receive the necessary guidance for success.

Courseware Recommendations

- **Independent practice tools** to address gaps in proficiency and readiness
- **Diagnostics that identify students' needs** and offer tailored study plans and support
- **Accessible onboarding resources**, such as videos and tutorials, that provide effective guidance when users need help the most
- **Interactive, conversational tutoring support** that delivers trustworthy, personalized, and curriculum-tailored guidance, as opposed to static, one-size-fits-all, non-interactive tips, tutorials, and feedback

Representations and Explanations

Providing students with different representations and explanations of math concepts aids their understanding, but faculty often lack the time to source or develop a wide range of high-quality explanatory resources.

Using visuals, video, and text to represent concepts helps students establish understanding. This conceptual understanding can be increased by providing students with explanations for foundational ideas and skills using a variety of mathematical representations. However, while students benefit from multiple representationally rich explanations, faculty often lack the time to create or source these resources.

Courseware can enhance conceptual understanding by using different modalities to represent concepts, while also offering students several approaches to each problem. Instructors may also benefit from having a library of ready-made resources and visual aids to support their teaching.

Courseware Recommendations

- **Multiple delivery formats**, such as text, video, or interactive multimedia, to attend to learner variability
- **Multiple explanations** that make use of different mathematical approaches and representations, to deepen understanding
- **Curated resources** that aid student learning and minimize the time faculty spend searching for and sharing materials
- **Tools that improve student engagement** while reducing burdens on instructors

Relevance

Students and faculty recognize the importance of real-world examples in gateway math, but limited resources and training for faculty often lead to procedural instruction instead of instruction focused on practical applications.

Students in gateway math courses want to understand how mathematical concepts apply to their lives, fields of study, and future careers. They seek relevance beyond learning and practicing abstract procedures. Faculty also value practical applications, but constraints such as limited textbook examples, lack of industry experience, and time pressures often lead them to rely on standard procedural problems. Integrating meaningful, career-aligned examples into instruction requires intentional course design and accessible resources, ensuring that students develop not only computational skills but also deeper understanding of how math supports their professional goals.

Courseware can bridge gaps in instruction by providing faculty with tools to more easily and regularly incorporate these real-world examples into their courses.

Courseware Recommendations

- **Industry- and career-relevant examples** that show students how learning gets applied
- **Instructional resources** that help faculty incorporate real-world problems, examples, or data without needing deep expertise
- **Explanations or visualizations of the "why" behind concepts**, ensuring that students recognize the practical significance of mathematical content

Formative Feedback

Students want ongoing, targeted feedback that helps them understand mistakes and refine their thinking, but faculty often struggle to provide it, due to time constraints and large class sizes.

In math instruction, effective feedback is essential for helping students understand mistakes and refine their thinking. Faculty strive to provide meaningful feedback, which often takes the form of written feedback on students' thinking. However, large class sizes and tight grading deadlines can limit their ability to do so.

Courseware can automate grading, but dichotomous grading offers little insight into errors and saps student motivation. Automated grading must prioritize supportive and personalized formative feedback that helps students struggle productively and work toward a solution.

Courseware Recommendations

- **Instructor-generated, selectable feedback options** to enhance grading efficiency while maintaining the quality of handwritten feedback
- **Support for handwritten homework** so students can show their solutions rather than just inputting an answer in text box
- **Constructive and personalized feedback tools** that help students identify errors and push forward to solutions

Pedagogical Balance

Gateway math students seek both hands-on, social learning and on-demand practice, but faculty face constraints that limit active learning, especially in large or asynchronous courses.

Faculty at large four-year institutions face challenges in implementing active learning, due to large class sizes, standardized curricula, and limited pedagogical training. Smaller institutions

and two-year colleges offer more flexibility, but require faculty to balance multiple course formats, including asynchronous courses that make more interactive learning challenging. Across all environments, students benefit from a balance of social, active learning and independent practice. They also need to practice productive struggle, which is crucial for deepening their mathematical reasoning.

Courseware can help faculty tackle these challenges by making connections easier among students and between instructors and students, and by connecting at-home or independent work to in-class or group work.

Courseware Recommendations

- **Resources or features that connect lectures with students' independent work**, creating continuity between courseware and the classroom
- **Group work activities** that ensure that students are not only working independently at home or in asynchronous courses
- **Growth-mindset activities** that support psychosocial development, to enhance study habits, confidence, and motivation in math

Task, Time, and Course Management Tools

Students struggle to manage math assignments alongside busy schedules, while faculty need efficient tools for grading and managing assignment due dates and extensions.

Both students and faculty face significant challenges balancing their commitments inside and outside of their math courses. College students must juggle coursework, jobs, and personal responsibilities. They require structured support to manage due dates and occasional extensions in ways that reduce stress and support their overall success. Faculty also navigate demanding schedules, contending with logistical challenges such as grading, research, committee work, and administrative tasks. They want to be able to quickly respond to common student issues without a lot of effort.

Courseware can help students and faculty strike a balance between administrative and academic work by enhancing efficiency and flexibility. Time-saving features for task management can support students' time management and reduce faculty members' workloads.

Courseware Recommendations

- **Task lists and reminders** to help students stay on track with deadlines
- **Learning management system calendar synchronization** for increased visibility of due dates and exams
- **Customizable late passes and assignment extension requests** that faculty can easily set up and manage and that students can use or request when needed

Conclusion: Making More Meaningful Courseware

Although this study was aimed at informing courseware, it is important to note that the key elements needed to unlock motivation and learning are not technological but pedagogical. These elements include supporting productive struggle, creating engaging and challenging content that ignites thinking, and supporting math learning by building social, supportive classrooms and peer groups. In many ways, these key elements of learning are a rediscovery of what is already known about math education. However, due to existing systemic challenges, these elements have been persistently difficult to enact sustainably at scale.

Technology, including courseware, can play an instrumental role in bringing about change. However, the results of this study reveal that what faculty and students need will require more than just modifying existing courseware to support efficient independent practice and automated feedback. To truly meet the needs of educators and learners, math courseware must be reimagined. Courseware needs to be welcoming, social, and accessible. It needs to facilitate collaboration and active learning. The content needs to invite students into math's intellectual playground, showcase real-world application, and build conceptual understanding. This is the vision for gateway math that faculty and students crave and that courseware, if designers and developers are bold enough, can help realize.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