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How to Support and Lead the Urgent Transition to Quality Online Learning in Intro Math

A Resource Guide

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ITHAKA S+R
TPSEMath
Transforming Post-Secondary Education in Mathematics

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Introduction

The COVID-19 pandemic and subsequent shelter-in-place orders enforced throughout the country prompted a rush to emergency remote learning in spring 2020.[1] As institutions enter the next phase of planning with a substantial share of their courses expected to be delivered in hybrid or fully online formats, there is an urgent need to move emergency remote instruction toward more sustainable and intentional models that incorporate evidence-based standards and practices for online learning. It is imperative that higher education institutions capitalize on this pivotal moment—when more people than ever before are talking about teaching and learning—to bring their communities of stakeholders together to lead a meaningful change that will have a lasting impact on student learning while navigating these unprecedented times.

One area worthy of immediate attention is college-level introductory math, which has an outsized impact on the likelihood of students continuing their postsecondary education and earning a degree.[2] As a core part of undergraduate general education requirements, introductory math courses serve as important pathways for students to enter a wide range of study fields, including those that lead to high-wage and high-growth careers.[3] Given the prevailing racial, ethnic, and gender inequities in the world of work, particularly those in STEM fields, math is a critical area of focus to promote greater access and social mobility for all students.[4] The pandemic-induced economic downturn and anticipated budget cuts throughout higher education make this focus more dire. Without a strategy and coordinated action, the current outlook threatens to substantially reduce students' success in these introductory math courses and consequently their success in today's increasingly dynamic knowledge economy.

To that end, this report aims to be a resource for department chairs, academic administrators, and senior leaders involved in decisions about the structure, delivery, and modality of introductory math courses. Although specific strategies around pedagogy and technology are

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[1] For a detailed account of student and faculty experiences with emergency remote learning in spring 2020 at a large public institutional system, see Christy McDaniel, Catherine Suffern, Jenna Joo, and Rayane Alamuddin, "Student and Faculty Experiences with Emergency Remote Learning in Spring 2020: Insights from an Exploratory Qualitative Study," *Ithaka S+R*, forthcoming; also see Melissa Blankstein, Jennifer K. Frederick, and Christine Wolff-Eisenberg, "Student Experiences During the Pandemic Pivot," *Ithaka S+R,* June 25, 2020, https://sr.ithaka.org/publications/student-experiences-during-the-pandemic-pivot/; also see Doug Lederman, "How College Students Viewed This Spring Remote Learning," *Inside Higher ED*, May 20, 2020, https://www.insidehighered.com/digital-learning/article/2020/05/20/student-view-springs-shift-remote-learning.

[2] Colleen Moore and Nancy Shulock, "Student Progress Toward Degree Completion: Lessons from the Research Literature," *Institute for Higher Education Leadership & Policy,* 2009, https://www.csuchico.edu/gradinitiative/_assets/documents/ihelp-student-progress-toward-degree-completion.pdf.

[3] Stella Fayer, Alan Lacey, and Audrey Watson, "STEM Occupations: Past, Present, and Future," *U.S. Bureau of Labor Statistics,* 2017, https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf.

[4] Anthony Martinez and Asiah Gayfield, "The Intersectionality of Sex, Race, and Hispanic Origin in the STEM Workforce," *US Census Bureau,* 2019, https://www.census.gov/content/dam/Census/library/working-papers/2019/demo/sehsd-wp2018-27.pdf.

inevitable in the transition to online learning, this report targets the institutional decision-making process to move introductory math courses online and explores possibilities for doing so at scale. Resource suggestions are provided that may be useful once the decision to transition online is made, but this report is *not* intended as a "how to" guide for teaching online and will not address specific pedagogies, technologies, or the individual decisions of instructors and their courses.

Why Intro Math? And Why Online Now?

Introductory math courses (e.g. pre-calculus, calculus, college algebra, introductory statistics) often form a cornerstone of undergraduate general education requirements and serve as gateway courses for many STEM majors. At the same time, introductory math courses are frequently an academic chokepoint, an unfortunate off-ramp from a student's path to a degree. Introductory math as an academic obstacle is a particularly acute problem for the least academically prepared students, representing an outsized proportion of first generation, racial minority, and lower socioeconomic-status students. As such, attending to introductory math and improving outcomes for students is perennially appropriate.

As the COVID-19 pandemic continues to impact individuals and communities, the disruption has dramatically impacted students as well as colleges and universities. For students, economic uncertainties make obtaining a college degree all the more necessary in order to be competitive in a shrinking job market. For institutions, the financial impacts of the pandemic make maintaining and increasing student enrollment and persistence an existential priority. This urgency is greatest for institutions with large populations of underserved students who are disproportionately impacted by the pandemic.[5]

Amid the trauma and tragedy of the pandemic, colleges and universities made an almost instantaneous switch from their traditional modes of learning to remote instruction in the middle of the spring 2020 term. This move by stereotypically slow-moving institutions required a herculean effort by faculty and staff, coupled with incredible patience and resilience from students. Since the end of that term, what was once thought to be a temporary response to an emergency situation is morphing into an uncertain future and online and hybrid learning will be part of the status quo for the foreseeable future. Although remote teaching and learning have been used and well-understood in some corners of the academic world, its implementation on this scale, by academic leaders and faculty with little or no experience in remote teaching, is unprecedented, requiring new investments and strategies to make this approach to instruction valuable and accessible to all. It is critical that that include introductory courses in math as well.

[5] As the fall semester gets underway in the midst of the pandemic, schools are starting to notice an alarming trend that lower-income and students and students of color are most likely to drop or not enroll at all, raising concerns that they might never get a college degree. See Heather Long and Danielle Douglas-Gabriel, "The Latest Crisis: Low-Income Students are Dropping Out of College this Fall in Alarming Numbers," *The Washington Post,* September 16, 2020, https://www.washingtonpost.com/business/2020/09/16/college-enrollment-down/.

Designing (or re-designing) a course for different teaching modality is a key moment to consider (or re-consider) the quality of the predominant pedagogical approaches and instructional design. Increasing effort and expense can often be accompanied by increased quality; however, this relationship is not inevitable, especially not in the short term when faculty development and technology implementation will require additional time and resources, and faculty and students learn to operate in an environment that is new to many of them. The move to quality online learning for introductory math can also bring increased quality and efficiency for the institution, and more importantly, for students on their academic journeys.

This guide is intended to help institutions navigate the process of bringing their introductory math courses online while attending to both quality and efficiency. The resource constraints introduced by the pandemic and its health, social, financial, and economic impacts require a fresh examination of resource priorities. The guide can help department chairs, academic administrators, and senior leaders allocate increasingly scarce resources to have the most positive impact for multiple institutional stakeholders.

About the Resource Guide

This resource guide provides a conceptual framework and promising strategies that departments and institutions can employ to achieve the twin goals of quality and efficiency in online introductory math instruction. In support of those goals, the guide also provides a curated digital repository of resources to support the transition to hybrid or online learning in introductory math once decisions about the structure, delivery, and modality are made (see Appendix A for details about the resource curation process).

The guide is positioned within the broader paradigm shift spreading throughout higher education from being teaching-focused to learning-focused and from individualistic models to systems models.[6] In the new paradigm, course design is conceptualized as a collaborative endeavor that is integrated within a larger system, with a shared focus on equity in access, opportunity, and outcomes for all students. The institutional focus also becomes more student-centered, changing the conversation on readiness from whether *students are ready for college* to whether *colleges and universities are ready for students*.[7] Departments and institutions will need to navigate this paradigm shift at a time when resources are continually more difficult to

[6] For example, see Robert B. Barr & John Tagg, "A New Paradigm for Undergraduate Education," *Change Magazine,* 1995, https://www.colorado.edu/ftep/sites/default/files/attached-files/barrandtaggfromteachingtolearning.pdf; Jodi Rust, "Working Smarter Not Harder: Using a Pedagogical-Based Model in the Rapid Development of Quality Hybrid Courses, *Doctoral Dissertation,* 2010, Retrieved from ProQuest, AAT 3419236; and Julia Kampov-Polevoi, "Considerations for Supporting Faculty in Transitioning a Course to Online Format," *Online Journal of Distance Learning Administration,* Volume XIII, Number II, 2010, https://www.westga.edu/~distance/ojdla/summer132/kampov_polevoi132.html.

[7] Tia Brown McNair, Susan Albertine, Michelle Asha Cooper, Nicole McDonald, and Thomas Major Jr., *Becoming a Student-Ready College: A New Culture of Leadership for Student Success*, John Wiley & Sons, 2016.

generate.[8] To ensure financial stability while meeting the evolving needs of students and the labor market, they will need to strategically adapt their models to offer high-quality learning opportunities while simultaneously controlling costs.

Cultural and operational changes of this scale require much more than just an individual faculty effort. Campus leaders and other stakeholders must provide the leadership, organizational, and financial support, including sharing costs, resources, and knowledge to avoid duplication of effort, building on research-based experience and knowledge about remote teaching that leads to student success, while building system-wide coordination and success. Students also have a role to play in informing and adapting to this new model. As such, the guide targets broad audiences who can work as teams at various stages of implementation. These audiences may include academic leaders, department heads, faculty leaders, and instructional support staff, as well as others involved in decisions and subsequent actions around introductory math curricula, online instruction, academic resource allocation, and inter-institutional relationships.

Several general principles informed the development of this guide and the educational approaches it describes:

- **Incorporate evidence-based practice.** Over the past several decades, the scholarship of teaching and learning has developed substantially. Despite these advances, the wide-spread adoption of evidence-based instructional practices has been limited. Students will ultimately benefit from instructor's growing awareness of the existence of these practices in general and of specific practices that relate to introductory math instruction and online teaching and learning in particular. Although not elaborated on specifically in this guide, all courses transitioning online should follow evidence-based instructional practices.
- **Collectively be responsible for enabling student success.** No single unit or individual at an institution can truly support student success on its own, given the incredible complexity of student experiences and needs in today's higher education landscape. Participatory leadership that leverages extensive stakeholder engagement and participation at all levels and roles, based on trust and reciprocity, will be key to success in collective adaptation to new models of teaching and learning.
- **Think outside the box**. As digitization, automation, and artificial intelligence continue to reshape industries and transform people's lives in profound ways, it's important to think beyond the status quo to develop strategies that truly prepare students for the remainder of their education. This may involve identifying innovative ways of imparting knowledge to students through problem-based, experiential, and constructional learning experiences, involving students directly in the knowledge construction process as active participants (not as passive recipients of knowledge), and restructuring how institutions operate and function in support of evolving needs of students and the society. It may also involve identifying

[8] Lucie Lapovsky, "The Changing Business Model for Colleges and Universities," *Forbes,* February 6, 2018, https://www.forbes.com/sites/lucielapovsky/2018/02/06/the-changing-business-model-for-colleges-and-universities/#bc6da535ed59.

creative technologies, possibly in collaboration with the students themselves, that support more innovative pedagogies.

- **Build a culture of continuous learning.** It is important to integrate a continuous quality assurance process at the outset to continually refine strategies to support the collective endeavor of online teaching and learning, while regulating the workload and pace of development. The community of stakeholders must embrace a culture of learning for themselves, and strive to improve their practices through ongoing reflection and application of lessons learned.

Defining Quality and Efficiency in Online Math Instruction

The Importance of Quality and Efficiency

The aim of this resource guide is to help institutions accomplish two things at once: increase quality *and* increase efficiency for introductory math courses. These two aspects of introductory math courses are often seen as having an inverse relationship based on the assumption that increases in quality require a decrease in efficiency and vice versa. Fortunately, this relationship is not absolute and the dual priorities of quality and efficiency can be accomplished, even in the context of a rapidly changing instructional environment.

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In order to fully evaluate the possibilities and opportunities for providing a higher quality and more efficient introductory math experience for students online, it is important to establish the criteria on which to make that kind of evaluation. Articulating the specific indicators of both quality and efficiency can help ensure that changes to current practice are made with those elements in mind as well as provide guidance as to whether new practices are indeed meeting the dual goals of quality and efficiency. These dimensions reflect the principles described above.

It is worth noting that this paper does not address affordability, the perceived or actual cost to students for attending college or taking classes. While an important element of student success, issues of affordability are usually outside the direct control, or even general influence, of the academic administrators and faculty leaders for whom this report is primarily intended. In addition, the diverse nature of institutional funding patterns, budget formulae, and public vs. private control decouple affordability and the elements of quality and efficiency described here.

The following sections will define quality and efficiency for the purposes of this resource guide, including indicators and other criteria for evaluation. Dimensions of quality for introductory math courses and online/hybrid learning environments will be explored, with a particular emphasis on where previous literature has identified an intersection between the two. Efficiency can often be a loaded concept in higher education, with implications around workload,

compensation, cost, class size, etc. This guide will describe multiple dimensions of efficiency for administrative, academic, and student stakeholders.

Defining Quality

The variety, diversity, and incongruity among available course evaluation instruments speak to the disagreement in higher education about elements fundamental to course quality.[9] Given that lack of consensus, it was necessary to assemble a series of quality dimensions in a novel way with a specific focus on introductory math instruction in online instructional modalities.

Using existing frameworks and input from experienced math faculty from TPSE Math, the following constellation of quality dimensions and indicators were identified as being the foundation of quality instruction for any introductory math courses offered online. These dimensions include equity, quantitative reasoning, alignment of learning outcomes, and intellectual challenge.

Equity

Not all students come to higher education with the same academic and life experiences, making it incumbent on their colleges and universities, as well as individual instructors to design learning experiences that minimize or mitigate these differences. When learning moves to an online environment, these considerations are thrown into higher relief; the inequities that are part of higher education more broadly continue to influence education online. The rapid shift to online learning during the COVID-19 pandemic highlighted many of the structural and infrastructural inequalities that may remain hidden during in-person instruction, including access to high speed internet and the hardware to use it and access to quiet places to learn and study online.[10]

These inequities constitute one of the many dimensions to consider in the development of equitable online learning environments. Every Learner Everywhere (ELE), a consortium of higher education and technology organizations, also suggest attending to the following dimensions:[11]

- **Academic:** students' preparation for online learning
- **Pedagogical:** course design and quality of instruction
- **Psychological:** students' perceptions about the course and instructor
- **Social:** students' connectedness with peers

[9] Goutam Kumar Kundu, "Quality in Higher Education from Different Perspectives: A Literature Review," *International Journal for Quality Research*, 11(1), p. 17-34, 2017, DOI: 10.18421/IJQR11.01-02.

[10] Daniel Rossman and Emily Schwartz, "Online Learning During COVID-19: Digital and Educational Divides Have Similar Boundaries," *Ithaka S+R*, April 27, 2020, https://sr.ithaka.org/blog/online-learning-during-covid-19/.

[11] L. O'Keefe, J. Rafferty, A. Gunder, and K. Vignare, "Delivering High-Quality Instruction Online in Response to COVID-19: Faculty Playbook," *Every Learner Everywhere*, May 18, 2020, https://www.everylearnereverywhere.org/resources/.

There are a variety of frameworks, including validation theory, culturally responsive teaching, social presence, and universal design in learning, that can ameliorate the challenges that can arise within each of these dimensions.[12] When embodied in the learning environment, they can increase equity in the learning environment.

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There is not a one-to-one relationship between any given aspect of inequality and an instructional solution. However asymptotic, making progress towards more equitable learning environments is possible when instructional *and* institutional choices are aligned and made from a place of equity-mindedness, meaning that the academic and administrative decision-makers "reflect on their own and their colleagues' role in and responsibility for student success" rather than attributing inequitable outcomes to students' unpreparedness.[13]

Indicators of Equity

Issues of equity, or more pointedly inequity, abound in all aspects of higher education. It is incumbent on instructors and institutions moving introductory math courses online to acutely attend to how such a change may impact different student communities differently and working diligently to mitigate those differences.[14] Presumed in this imperative is that student success outcomes, such as the rates at which students are earning a D or F, or Withdrawing (DFW rates), are actively being monitored and acted upon when differences emerge.

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[12] Michelle Pacansky-Brock, Michael Smedshammer, and Kim Vincent-Layton, "Humanizing Online Teaching to Equitize Higher Education." Current Issues in Education, 21 (2), June 18, 2020, https://cie.asu.edu/ojs/index.php/cieatasu/article/view/1905/870.

[13] Estela Mara Bensimon, "The Underestimated Significance of Practitioner Knowledge in the Scholarship of Student Success," *The Review of Higher Education*, Volume 30, No. 4, p. 446, 2007, https://cue.usc.edu/files/2016/01/Bensimon_The-Underestimated-Significance-of-Practitioner-Knowledge-in-the-Scholarship-on-Student-Success.pdf.

[14] "Position Statement: Distance Education in College Mathematics in the First Two Years," *American Mathematical Association of Two-Year Colleges (AMATYC)*, 2019, https://amatyc.org/page/PositionDistanceEd.

monitored in real-time to provide the opportunity to intervene individually or comprehensively before the end of the course. Such elements could include frequent, low-stakes assessments as well as tracking usage and consumption of online course resources. These early indicators can alert instructors to the potential for inequitable outcomes before the end of the course when there is still the opportunity to take corrective action.

Conceptual Understanding & Quantitative Reasoning

The goal of any introductory math course must be, to some degree, the development of conceptual understanding and quantitative reasoning. Conceptual understanding is "the ability to explain why something happens mathematically, using logical reasoning as opposed to empirical evidence"[15] while quantitative reasoning is the constellation of skills, competencies, and habits of mind that add up to the "ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations."[16] Although higher education organizations and associations posit somewhat different specifications of which knowledge, skills, and abilities constitute conceptual understanding and quantitative reasoning, they all involve the recognition of, communication about, and application of numeric data to some specific purpose.[17]

Centering conceptual understanding and quantitative reasoning in introductory math courses, as opposed to only procedural fluency, is essential because of the foundational role these courses play in so many academic disciplines beyond majoring in math.[18] The numeracy embodied in conceptual understanding and quantitative reasoning is essential throughout a traditional undergraduate curriculum as well as in supporting success after college. This emphasis is in contrast to how many introductory math courses are delivered, with a focus on mechanistic problem solving, time-based mental calculations, or rote memorization of formulas and procedures.[19]

Indicators of Quantitative Reasoning

Evidence of an emphasis on quantitative reasoning can be found in the activities, assignments, and assessments used in the course. These course elements should focus on the real-world application and utility of the underlying quantitative skills, not simply mechanistic or algorithmic problem solving. The complexity and sophistication of the tasks asked of students

[15] Martha L. Abell, Linda Braddy, Doug Ensley, Lewis Ludwig, and Hortensia Soto, "Instructional Practices Guide," *Mathematical Association of America*, 2018, https://www.maa.org/sites/default/files/InstructPracGuide_web.pdf.

[16] Association of American Colleges and Universities, "Quantitative Literacy VALUE Rubric," https://oia.arizona.edu/sites/default/files/2019-01/Quantitative%20Literacy%20VALUE%20Rubric.pdf.

[17] See, for example AAC&U, 2014; Mathematical Association of America, 1994; Roohr et al., 2014.

[18] Ed Aboufadel, Linda Braddy, Jenna Carpenter, Lloyd Douglas, and Rick Gillman, "The Importance of Mathematical Sciences at Colleges and Universities in the 21st Century." *Mathematical Association of America*, October 2018, https://www.maa.org/programs-and-communities/curriculum-resources/survey-and-reports/task-force-reports.

[19] Martha L. Abell, Linda Braddy, Doug Ensley, Lewis Ludwig, and Hortensia Soto, "Instructional Practices Guide," *Mathematical Association of America*, 2018, https://www.maa.org/sites/default/files/InstructPracGuide_web.pdf.

can be an indicator of this emphasis, such as more narrative activities that call on students to articulate their problem solving process.

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As a general education requirement and prerequisite for courses in other disciplines, introductory math courses contribute directly to the success of students in their later studies, making that success an essential metric. Institutions should develop the student data infrastructure to track student progress in the courses to which introductory math gateways provide access. Tracking back student success metrics (grades, persistence, etc.) and institutional measures (DFW rates) can demonstrate which introductory math courses, pedagogies, and/or instructors are best preparing students for the later application of their conceptual understanding of mathematics in diverse academic settings.

Alignment of Learning Goals and Outcomes

Well-articulated, appropriately calibrated, and clearly communicated learning goals and outcomes are the foundation of most effective course design initiatives.[20] For introductory math courses, these principles are further enhanced when the course in question aligns with other aspects of students' mathematical instruction. Students' prior knowledge has an outsized influence on their learning experiences, so it is essential that the learning outcomes for introductory math courses are a fluid connection between the mathematics preparation that students already have and the mathematics they will need in the future.[21]

Knowing what students know coming in can help instructors and course designers ensure that 'baton' of student learning is successfully handed off during the transition from high school to college. Ensuring this smooth transition into introductory math courses keeps students making progress in the academic career without unnecessarily predicating course activities on mistaken assumptions about what students know and can do. Formative assessments early in introductory courses can help students and instructors better understand what foundational content is already well understood and what content should be reinforced.

It is also important to note that introductory math courses do not exist as discrete entities, separate from the remainder of the students' education. The entire undergraduate experience, or at least the general education portion of which introductory math is a part, should exist within a coherent framework of learning goals and outcomes. The specifics of this academic super-structure will look different for each institution, but introductory math courses should advance

[20] See, for example: Cornell University Center for Teaching Innovation, https://teaching.cornell.edu/teaching-resources/designing-your-course/setting-learning-outcomes.

[21] Susan A. Ambrose, Michael W. Bridges, Michele DiPietro, Marsha C. Lovett, and Marie K. Norman, "How Learning Works: Seven Research-Based Principles for Smart Teaching." John Wiley & Sons, 2010.

students toward some cohesive learning goal that aligns with other requirements and transcends any individual course. These alignments can be made manifest in programs like Math Pathways, wherein specific introductory math courses are tailored to the mathematical knowledge and skills required for particular paths through the curriculum.[22]

Indicators of Alignment

There are two places in the curriculum to look for evidence that the learning goals and outcomes for an online introductory math course are well-aligned to the general education or institutional learning goals and outcomes. Each of these necessary, but not sufficient, components must clearly describe the knowledge, skills, and abilities students should be able to demonstrate at the end of the learning experience. Ultimately it is the interlocking relationship between the two sets of goals and outcomes that ensure proper alignment between any required introductory math course and the 'bigger picture' of student learning.

One way to ensure the appropriate alignment of courses is to engage in curriculum mapping, or the process of visualizing the connections between elements of the curriculum and the outcomes those elements support. A change in the curriculum as impactful as moving introductory math online is an important opportunity to establish - or reestablish - the explicit and direct connection between the introductory math courses and the learning required for success in later courses.

Intellectual Challenge

Related to the theme of purposeful learning that runs through the quantitative reasoning dimension of quality, providing introductory math students with intellectual challenge is an essential aspect of quality in any learning experience, but especially introductory math courses. Embodying an intellectual challenge is not about calibrating the difficulty of course assignments or exam questions. It is about both designing course tasks "just past students' current achievement level, but well within their reach" as well as connecting those activities to "authentic, real-world tasks relevant to students' academic life."[23] This approach builds on Sanford's classic model of challenge and support, in which the learning experiences provide the necessary scaffolding and content for students to successfully *and safely* take intellectual risks thereby building their own understanding.[24]

An important part of providing appropriate intellectual challenge is maintaining student motivation for the learning. The DNR (duality, necessity, and repeated reasoning) framework for math instruction posits that "[f]or students to learn what we intend to teach them, they must

[22] Pamela Burdman, Kathy Booth, Chris Thorn, Peter Riley Bahr, Jon McNaughtan, and Grant Jackson, "Multiple Paths Forward: Diversifying Mathematics as a Strategy for College Success," 2018, https://www.wested.org/resources/multiple-paths-forward/.

[23] IDEA Teaching Methods, 2012, p. 1, https://ideacontent.blob.core.windows.net/content/sites/2/2020/02/Stimulated-students-to-intellectual-effort-beyond-that.pdf.

[24] Nevitt Stanford, "Self and Society," New York: Atherton Press, 1966.

have a need for it, where 'need' means intellectual need, not social or economic need."[25] This approach suggests several different strategies for cultivating intellectual need, in which questions raised in the students mind naturally compel them to pursue the answer in order to satisfy that need.

Indicators of Intellectual Challenge

One of the key elements of challenge and support is the reciprocal relationship between the two. For every challenge presented to students, there should be appropriate support built into the course and the online learning environment. One effective way to provide such support is to ensure timely feedback on student work, a task made easier and faster with adaptive learning technologies. Prompt responses to student work keep students from moving too far forward armed with misunderstandings or insufficient skills.

In order to maintain intellectual challenge in a course, the majority of the activities and assignments should require students to engage in more cognitively complex tasks, as defined by Bloom's Taxonomy of Learning.[26] These higher level categories are creating, evaluating, and analyzing, as opposed to remembering or applying course concepts. An indicator that a course will provide motivating and meaningful intellectual challenge is the specific nature of the experiences students will have and the degree to which those experiences are cognitively complex.

Quality in Online Learning Environments

While online learning environments are certainly different from face-to-face, on ground classrooms, the differences in modalities do not change the fundamental elements of quality for introductory math courses. The basic aim of involving students in the experiences that will best prepare them to achieve the course's learning outcomes does not change, regardless of the teaching modality. It is only the nature of those learning experiences that may be different, and in many cases, should be. Simply replicating the traditional classroom experience in an online environment is not sufficient.

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There are innumerable 'best practices,' how-to guides, and assorted frameworks for the design and delivery of effective online learning.[27] One of the most widely adopted sets of standards are

[25] Quoted in Evan Fuller, Jeffrey M. Rabin, and Guershon Harel, *Intellectual need and problem-free activity in the mathematics classroom*, International Journal for Studies in Mathematics Education 4(1) 80-114, 2011.

[26] David R. Krathwohl, "A Revision of Bloom's Taxonomy: An Overview." *Theory into Practice*, 41, no. 4, 2002.

[27] See TPSE Math's top ten list of recommended practices for every online instructor developed over the summer 2020 in collaboration with American Mathematical Association of Two-Year Colleges, American Mathematical Society, Mathematical Association of America, Society for Industrial and Applied Mathematics, and Charles A. Dana Center at the University of Texas at Austin: http://www.ams.org/education/tpse-top-10-online-teaching-practices_v2.pdf.

those from Quality Matters (QM), a non-profit organization supporting online learning in multiple educational sectors. In addition to a general purpose set of standards for online courses, QM developed an *Emergency Remote Instruction Checklist* for higher education to support instructors during the sudden shift to online learning resulting from the COVID-19 pandemic.[28] While that emergency modality shift is different from a more deliberate and thought-out move to online learning, the general guidance on transitions remains sound.

QM suggests starting by orienting students to the new learning environment and teaching them first how to learn online before attending to course content. The suggestions also remind instructors to attend to social presence, or the relational, human component of the teaching and learning process. In traditional classrooms, social presence usually results from physical proximity, but must be specifically cultivated in an online learning environment. Students in online classes want to develop a rapport with their instructors, to feel that a person is teaching them and not a screen.[29]

It is also essential to orient students to the online learning environment, especially if they have limited experience learning in a virtual classroom. Educational experts note that prior knowledge can help *or hinder* learning, a truism that applies equally to content as it does to teaching modality.[30] Most faculty assume, rightly or wrongly, that students come into their traditional classrooms knowing how to successfully navigate that environment and use the artifacts of learning, such as the syllabus, office hours, and the learning management system (LMS). Following the transition to online learning, faculty must forgo all assumptions about what students may already know about the learning environment and teach them how to access learning materials, the norms and venues for communication, and how to self-assess their own learning.

> The quality of the online "classroom" and students' experience of online learning is predicated on the successful implementation of evidence-based course design and teaching practices...

The quality of the online "classroom" and students' experience of online learning is predicated on the successful implementation of evidence-based course design and teaching practices by those designing and teaching the course. As online learning is a new modality for many introductory math instructors, institutions undertaking a transition to online learning for these courses should provide substantial faculty development and course design support.

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[28] To learn more about Quality Matters' rubric standards for online courses, visit https://www.qualitymatters.org/qa-resources/rubric-standards. QM's Emergency Remote Instruction Checklist can be found here, https://docs.google.com/document/d/e/2PACX-1vRzSgvQZDAbu9iG3Cxnq3D2hlxiUZrzwVRj94MGPVDvY9exqxiSgOkuhKxkexPSxb12cb3QNqDTWSIc/pub.

[29] Rebecca A. Glazier, "A Shift to Online Classes this Fall Could Lead to a Retention Crisis," EdSurge, 2020, https://www.edsurge.com/news/2020-07-06-a-shift-to-online-classes-this-fall-could-lead-to-a-retention-crisis.

[30] Susan A. Ambrose et. al., 2010.

Institutional faculty development staff and resource centers should be leveraged to this purpose, if available. If such opportunities are not available, the acquisition and integration of such resources from external sources, through paid consultants or additional training for existing instructional staff, should be part of the transition planning process.

Defining Efficiency

Colleges and universities are not factories, but they are institutions made up of a web of policy, practice, and procedure. These systems regulate almost every facet of institutional life, including the ways in which students move through their academic programs, movement which has substantial implications not only for the students themselves, but also for the faculty providing instruction, the physical and technological resources used in instruction, and the expenses and revenues associated with that instruction. Increasing efficiency, then, is about reducing the time, effort, and cost of providing instruction so that more students are able to progress more quickly through their academic programs. One corollary of this approach to efficiency is that increasing rates of student success is an essential part of the paradigm.

Shortening Time

Time to degree is an important indicator of overall institutional efficiency and also an essential factor for individual students - and their families - making decisions about their academic careers. One of the main drags on student degree advancement can be a lack of progress through or success in required introductory courses.[31] This problem is most notable in introductory math, which has often been criticized for slowing or stopping students' academic progress, particularly for those students least prepared for college success.[32]

There is a wealth of research as to why introductory math courses have become the obstacle they are in students' timely academic progress, as well as a number of suggestions for how to ameliorate the problem. The local institutional context, such as the nature of the student body, the composition of the faculty, and the specific academic programs all must be considered when attempting to leverage introductory math courses as means of shortening time to degree. However, increasing the quality of instruction in line with the dimensions delineated above can go a long way towards keeping students enrolled and on track towards graduation.

In addition to students enrolling only to fail or drop out, the prerequisite nature of many introductory math courses can create an academic choke point if there are not enough seats available in classes to meet the demand from students. Increasing the number of seats available in any given course is one possible solution, but may be difficult or impossible with the

[31] Elli J. Theobald et. al., "Active Learning Narrows Achievement Gaps for Underrepresented Students in Undergraduate Science, Technology, Engineering, and Math," *Proceedings of the National Academy of Sciences*, 117 (12), 2020, https://www.pnas.org/content/117/12/6476.

[32] Elizabeth Zachry Rutschow et. al., "Gaining Ground: Findings from the Dana Center Mathematics Pathways Impact Study," *Center for the Analysis of Postsecondary Readiness (CAPR)*, November 2019, https://postsecondaryreadiness.org/wp-content/uploads/2019/11/gaining-ground-dana-center-mathematics-pathways.pdf.

constraints of the physical classroom spaces available. Online courses, however, are more flexible in this regard and can be an effective way to increase access to introductory math courses, thereby eliminating a potential obstacle to students' academic progress.

Another structural way that the curriculum can reduce time to degree is to move what might have otherwise been prerequisite courses to co-requisite courses. In this model, students in need of additional introduction or reinforcement of foundational concepts and skills take a course aimed at providing that content in tandem with the routine introductory math course. Co-requisite courses have already proven successful in helping students successfully complete gateway math courses[33] and there are emerging examples of this model working in online environments as well.[34]

Reducing Effort

Of course, suggestions of accommodating more students may cause the eyebrows of faculty *and* administrators to arch suspiciously. Instructors will naturally begin calculating increased time for correcting homework assignments or answering student questions while the academic administrators will inevitably think of rising faculty loads as course sections multiply. The strategic introduction of technology into the learning environment, however, can mitigate the proliferation of grading time and course sections, among other common consequences of increasing student enrollment.

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These technologies can accommodate or automate many of the routine, mundane, and time-consuming elements of the teaching and learning process, enabling faculty to attend to the most important, impactful interactions with students. The essential balance is to leave to technology what it is best equipped to handle to ensure that faculty time is always well spent.

For example, the automated grading tools embedded in most learning management systems or even available through Google Forms are able to provide almost instantaneous 'right or wrong' to students on their responses to some kinds of quizzes or tests. Even newer technologies are now available that can build on that system of automated grading and supplement it with specific, "just in time" learning resources and feedback to correct the misunderstanding. These

[33] Florence Xiaotao Ran and Yuxin Lin, "The Effects of Corequisite Remediation: Evidence from a Statewide Reform in Tennessee," CCRC Working Paper No. 115, *Community College Research Center, Teachers College, Columbia University*, 2019, https://ccrc.tc.columbia.edu/media/k2/attachments/effects-corequisite-remediation-tennessee.pdf.

[34] Dana Center's Webinar on "Transitioning Corequisite Math Courses to the Online Environment," https://www.utdanacenter.org/blog/free-webinar-transitioning-co-requisite-math-courses-online-environment.

new capabilities can speed up the provision of corrective feedback to students with no greater effort on the part of the instructor.

Lowering Cost

Whether or not it is formally calculated or used in curricular decision-making, there is a cost-per-student amount for the offering of every course. By increasing the number of students being taught using the same human and institutional resources, the effective cost-per-student will be reduced. However, it is not simply a matter of adding more students to existing courses, the level of instructional quality must be maintained - or even increased. As more students enroll in any given course, an ever-increasing number will need resource-consuming additional support or will simply drop, fail, or withdraw, meaning they will need to return the course in future terms.

Similarly, increasing instructional quality for the same number of students will lower the overall cost-per-student because fewer students will need assistance from instructors, teaching assistants, or tutors, and fewer will drop, fail, or withdraw from required courses, removing the need to re-enroll. The academic progress these students can make is certainly a boon for them, if costs can be controlled, but also for the institution as a whole as retention and graduation rates eventually rise, bolstered by students whose academic paths have not been disrupted by lack of success in introductory math courses.[35]

Institutions may find a synergy for lowering costs by both reducing effort and shortening time through the transition of introductory math courses from face-to-face and on ground to fully online learning. The automations, scalability, and vast array of digital learning tools available in an intentionally designed online learning environment can free up faculty time and attention to focus on student interaction and relationship-building, key elements of effective instruction and long-associated with student success.[36]

Departments and institutions should ensure that the benefits accrued by these efficiencies are shared with the faculty doing the instructional work. Rather than eliminating or limiting faculty lines, it will be important to engender faculty buy-in for there to be demonstrable efforts at reducing teaching loads, carving out additional time for research, or adjusting service expectations for tenured and tenure-track faculty. Non-monetary benefits for adjunct instructors may be less obvious, but should also be pursued. For example, greater predictability in contracting or a certification to teach certain courses or content could be offered.

[35] In their recent white paper, Jessie Brown and Martin Kurzweil make a case that improvement in instruction can lead to improvement in student outcomes which in turn lead to increases in marginal institutional revenue that are larger than the marginal costs of improving instruction and of serving a large student population. See Jessie Brown & Martin Kurzweil, “Instructional Quality, Student Outcomes, and Institutional Finances, *American Council of Education*, 2018, https://www.acenet.edu/Documents/Instructional-Quality-Student-Outcomes-and-Institutional-Finances.pdf; Also see https://www.acenet.edu/Documents/Estimating-ROI-Instructional-Improvement-Ithaka-Step-by-Step.pdf.

[36] For example, see Every Learner Everywhere, https://www.everylearnereverywhere.org/resources/.

Promising Strategies

In response to the growing concerns about the quality, cost, and price of higher education, institutional leaders have been actively experimenting with a variety of strategies over the past decade to achieve both quality and efficiency in core academic functions of their institutions. These efforts vary by focus, size, and scope, but the common threads include collaborative activities within and outside of institutions with an emphasis on de-siloing of institutions and functional areas to support innovative approaches to teaching and learning.

Examples of such efforts include supporting system-wide curation and adoption of Open Educational Resources (OERs) in programs and courses to increase access, affordability, and achievement for students;[37] expanding the scope of consortial activities to engage in deeper collaborations focused on developing shared digital educational systems and learning materials to reduce overall institutional development costs and promote student access and success;[38] partnering with businesses to leverage private capital to make infrastructure, program additions, and improvements to offer programs to students at an affordable rate;[39] and reconfiguring curricular approaches and faculty roles to improve student learning, reduce tuition, and shorten students' time to degree.[40] While these efforts have potential both on the quality and efficiency side, they also require a high level of coordination and a significant shift in structures and models in which institutions have long been operating. Successfully implementing any of these strategies will require trust among the participants and the recognition that going it alone may not be a sustainable approach going forward. As the higher education industry remains under stress, it's imperative that institutions develop capacities to continually develop and implement these strategies to provide quality education at an affordable rate to students.

In the following section, we highlight three promising strategies for achieving quality and efficiency in online introductory math instruction at the department or institutional level. It's important to note that these strategies, though presented separately, are not mutually exclusive; there are various ways in which these strategies can intersect and interact in the real world. Each institution must find and tailor its own approach in line with its broader integrated strategy that best meets their visions and goals. Making smart decisions will depend on strong leadership and collaborations at all levels that are adaptive to the evolving circumstances of their idiosyncratic institutional context and the equally evolving higher education landscape.

[37] For example, see Maryland Open Source Textbook Initiative, http://www.oer-maryland.org/.

[38] For example, see Unizin, https://unizin.org/.

[39] For example, see Georgia Tech's Online Master's Program in Computer Science, https://omscs.gatech.edu/.

[40] For example, see Western Governors University's competency-based educational model, https://www.wgu.edu/about/competency-based-education.html.

Master Course Shells to Reduce Variability in Course Quality and Delivery

The master course shell approach, sometimes referred to as one-to-many or curated content model, relies on a central team of subject matter experts and instructional design and support staff to develop a course shell with all of the materials for an online course that are aligned with an institution's learning objectives and meet major quality standards. The developed course shell is then used by all instructors teaching different sections of the same course, with some flexibility to incorporate customized content to reflect individual instructors' expertise or meet specific learner needs.

This approach has the potential to reduce variability in course quality often attributed to individual faculty members' varying levels of experience with online teaching modality, and contribute to greater coherence and rigor in critical foundational courses that students must successfully complete before moving onto higher-level study.[41] It can free up valuable faculty time so they can focus their attention on scaffolding student learning and providing personalized instruction, not on developing, organizing, and maintaining course content on an online platform which can be a very time-consuming and labor-intensive process. The consistency in student experience can, in turn, lead to more accurate assessment of the efficacy of the curriculum and enable departments to figure out better ways to design and deliver their courses. The use of a master course shell can also lower the overall course development cost through centralized management and maintenance.

Examples in the Field

- **Arizona State University (ASU)** uses a master course shell approach to manage the content, quality, and integrity of their online courses.[42] The content and the design of a master course shell are reviewed and approved by stakeholders at multiple levels and roles at the university. The course shell stores all the materials required for an online course as designed by a team of subject matter experts and instructional designers. The course shell not only stores the materials in the learning management system, but also presents the materials in a way that aligns with ASU's course design, accessibility, and branding standards, with the goal of maximizing student access to the materials, and ultimately their learning outcomes. Another key element of the ASU model is the iterative design process which aims to further increase instructor presence and improve student learning. There is a

[41] Benefits of this approach are well documented in a study looking at calculus coordination systems at five public research universities, which found that such systems can make instructors' lives easier by providing instructional resources and taking care of logistical issues, opening a space for faculty collaboration and community, and informal, in-house professional development. See Chris Rasmussen and Jessica Ellis, "Calculus Coordination at PhD-granting Universities: More than Just Using the Same Syllabus, Textbook, and Final Exam," in "Insights and Recommendations from the MAA National Study of College Calculus," ed. David Bressoud, Vilma Mesa, and Chris Rasmussen (MAA Press, 2015), p. 107-115. https://www.maa.org/sites/default/files/pdf/cspcc/InsightsandRecommendations.pdf.

[42] Kent Darr, "Why Use Master Shells to Manage Online Courses," *Arizona State University,* February 23, 2018, https://teachonline.asu.edu/2018/02/use-master-shells-manage-online-courses/.

process in place to evaluate new and existing courses to assess whether the materials, activities, and assessments are appropriately supporting student learning or are misaligned with the identified learning outcomes. Course revisions occur over time and in small phases and encourage regular scrutiny of instructional materials and strategies to identify any overlooked errors, weaknesses, and irrelevance. By preserving the valuable time and cognitive resources of the instructors, master courses allow them to focus their attention on facilitating student learning. The increased instructor presence, in turn, can have positive immediate and long-term impacts on students, promoting their retention and success. This approach is also valuable in ensuring continuity of quality learning in times of instructor or support staff turnover. If course content and management processes are all up to date and documented in a secured location for access, new instructors or designers joining the team can rely on those resources to easily set up a course and support their smooth transition. This approach provides continuity during times of transition and offers a practical and sustainable method of online course management.

- **Southern New Hampshire University (SNHU)** has a formal project management team for its course development.[43] The internal team composed of instructional designers and subject matter experts designs the full course, from its target outcome to the critical path for summative assessment, as well as formative assessments and other learning resources. All of this content is designed in-house and built into the learning management system (LMS) by the project which then becomes a master course shell. The course shell is then copied out to different sections that are needed for a select term. Instructors receive fully developed courses a few weeks before the courses begin, so they can get acquainted with what they will be teaching. This approach enables consistency across sections even when the majority of SNHU's online faculty are contingent faculty, many of whom are also experts in their respective fields outside of academia. SNHU ensures that their faculty deeply understand their approach to teaching and their own roles throughout the hiring and onboarding process. The institution-wide recommendations around the curated content model are transparent to faculty, and there is standard onboarding training for all faculty, including course-specific and tool-specific training for faculty teaching specific courses.
  There is also a streamlined process to decide which courses will get re-developed or refreshed every term. For each new program that needs to be built out, SNHU holds a multi-day workshop in which subject-matter experts, academic stakeholders, and a launch team collaboratively figure out the curriculum, including the number and type of courses, for that particular program. Once the program is approved by the university's governing body, a designed project management team begins scheduling course development work. While curriculum development work begins, course titles and descriptions are established and used to recruit instructors who are academically qualified and interested in teaching the sections. At the same time, outcomes and assessment specialists work with the subject-matter experts to write outcomes for the end of the course and critical tasks leading up to

[43] David Raths, "How Southern New Hampshire U Develops 650-Plus Online Courses Per Year," *Campus Technology,* October 15, 2014, https://campustechnology.com/articles/2014/10/15/how-southern-new-hampshire-u-develops-650-online-courses-per-year.aspx.

the final assessments. A design phase begins in parallel where the instructional design team works closely with subject-matter experts to build the courses and identify any third-party resources, such as videos, textbooks, and e-books. The fully designed and approved courses are then loaded onto the LMS for instructors to use.

Implementation Considerations

One of the biggest barriers to implementing this strategy is a long-held belief that course development is a solitary endeavor of an individual faculty. Some faculty members may view the effort as degrading their role to graders and discussion facilitators, not as subject-matter experts. Therefore, it is important for administrators to clearly communicate at the outset why the department is considering this approach and how this effort will benefit everyone involved including faculty, students, and the department. Teaming up with faculty leaders who can lead constructive discussions with other faculty members in the department to get their endorsement will be critical in collectively figuring out ways to move the idea forward. Also, faculty members' dedication to supporting student learning in their interactive work with students in introductory math must be acknowledged at the department level, and formally recognized in their future employment and promotional considerations. The president and provost can also prioritize teaching and learning as essential part of the institution-wide vision for student success, and help academic leaders, faculty, and other staff members reinforce that focus in their everyday work.

> Successful implementation rests on the ability to cultivate and sustain a high degree of coordination and collaboration among faculty, administrators, and instructional support staff.

Successful implementation rests on the ability to cultivate and sustain a high degree of coordination and collaboration among faculty, administrators, and instructional support staff. It is important to bring the relevant stakeholders together in the early stages to devise a plan, decide on roles and responsibilities, and the workflow. A designated project management team can help streamline communication and decision-making activities to enable the cross-functional team to work together throughout the iterative course development and continuous improvement processes. The team can also ensure that the fundamental basics around the course model, including weekly structures, participation guidelines, assessment rubrics, course expectations, and user experience basics are all in place to help students successfully navigate their courses. Institutions with limited expertise in online teaching modality or limited resources could benefit from partnering with other experienced institutions or third-party vendors to gain access to tools and resources that will help augment their pedagogy and delivery strategies.

It is important to ensure that the standardized approach itself doesn't limit the breadth and range of learning for students. The course design team should build the course shells with an eye toward helping students continually develop a strong foundational understanding as well as essential skills that will be valued and serve them well in their future academic and professional

endeavors, such as critical thinking, communication, teamwork, and creative problem-solving.[44] Faculty leaders should also collaborate with the design team to develop a set of resources and professional development opportunities to onboard and train newly joined faculty on best practices and pedagogical strategies to provide high-quality formative feedback to help students learn how to analyze, reflect, and accurately apply learned concepts to new situations.

Recommended Readings

- Macarena Aspillaga, "Standardized Templates Help Improve Accessibility and Usability Enhancing Transfer of Knowledge," 2016, https://www.qualitymatters.org/sites/default/files/presentations/standardized_templates_help_improve_accessibility_aspillaga.pdf**.**
- Allison Bailey, Nithya Vaduganathan, Tyce Henry, Renee Laverdiere, and Lou Pugliese, "Making Digital Learning Work: Success Strategies From Six Leading Universities and Community Colleges," *The Boston Consulting Group & Arizona State University*, March 2018, https://edplus.asu.edu/sites/default/files/BCG-Making-Digital-Learning-Work-Apr-2018%20.pdf.
- Mary Bart, "Teaching Standardized Courses: Advantages and Disadvantages," *Faculty Focus*, July 12, 2010, https://www.facultyfocus.com/articles/online-education/teaching-standardized-courses-advantages-and-disadvantages/.
- Kent Darr, "Why Use Master Shells to Manage Online Courses," *Arizona State University*, February 23, 2018, https://teachonline.asu.edu/2018/02/use-master-shells-manage-online-courses/.
- Phil Hill, "The Master Course: A Key Difference in Educational Delivery Methods," *eLiterate*, 2012, https://eliterate.us/the-master-course-a-key-difference-in-educational-delivery-methods/.
- B. Jean Mandernach, "Multi-Faculty Collaboration to Design Online General Studies Courses," *Faculty Focus*, September 10, 2019, https://www.facultyfocus.com/articles/online-education/online-course-design/.
- Beth McMurtrie, "Fixing the Courses Everyone Loves to Hate," *The Chronicle of Higher Education*, December 6, 2019, https://www.chronicle.com/interactives/20191206-GatewayCourses.
- David Raths, "How Southern New Hampshire U Develops 650-Plus Online Courses Per Year," *Campus Technology*, October 15, 2014, https://campustechnology.com/articles/2014/10/15/how-southern-new-hampshire-u-develops-650-online-courses-per-year.aspx.
- Laura Widener, "Institutional Support for Assessment: Southern New Hampshire University," *Personal Blog*, 2016, https://incessantpen.wordpress.com/2016/09/14/institutional-support-for-assessment-southern-new-hampshire-university/.

[44] "The Soft Skills Gap," *The Chronicle of Higher Education*, 2020, https://connect.chronicle.com/rs/931-EKA-218/images/Softskills_adobe_KeyTakeaways.pdf.

Jointly Designed Courses to Leverage Collective Faculty Expertise and Enhance Instructional Quality

This strategy relies on collaboration among multiple faculty members either within a single institution or across a network of institutions to jointly design and deliver courses by drawing on each faculty member's expertise and skill set. The jointly developed courses can be shared with other instructors and institutions to achieve economies of scale, and can be delivered by a single faculty or a team of faculty. This approach emphasizes innovation and collaboration, with a coordinated support system for a team of faculty.

This collaborative approach to online course development and delivery has a number of benefits. It can spark intellectual and pedagogical growth for participating faculty, and produce richer learning experiences for students. By working together in identifying learning outcomes, producing content, and designing appropriate assessments, faculty can consider different perspectives, learn new ways of thinking, reflect on their own teaching philosophies, and discover new teaching methods and technologies. In addition to being intellectually stimulating for those involved, this type of collaboration can reinvigorate faculty's investment in curriculum development and nurture a sense of community. Moreover, faculty collaboration can potentially reduce the overall burden on each participant by dividing tasks in ways that maximize their individual and collective expertise.

Examples in the Field

- **Liberal Arts Collaborative Digital Innovation (LACOL)**[45] is a consortium of ten selective, private liberal arts colleges. The leadership team is composed of presidents, chief academic officers, and faculty representatives from each campus, as well as the consortium director who serves all campuses. As the backbone entity of the consortium, LACOL leverages consortial relationships and activities across the colleges to promote excellent and innovative teaching and learning in the liberal arts, with a special emphasis on using and adopting emerging technologies. The consortium prioritizes collaboration among consortium institutions, creating projects that can be accomplished jointly and would be less effective for any of them to undertake alone. Teams of faculty, librarians, technologists, and academic support specialists are engaged across the consortium network to develop, share, and assess the most effective modes of digital teaching and learning. For example, an online data science course was offered in summer 2020 through the consortium by a team of faculty from five institutions, supported by an overall course coordinator, teaching assistants, learner experience specialists, and course designers and technologists from multiple consortium institutions.

[45] Founded in 2014, LACOL is a consortial partnership between Amherst College, Bryn Mawr College, Carleton College, Davidson College, Hamilton College, Haverford College, Swarthmore College, Vassar College, Washington and Lee University, and Williams College. For more information, visit the consortium website, https://lacol.net/.

- **Western Governors University (WGU)[46]** uses a competency-based learning model as opposed to the traditional, cohort-based class model used at most colleges and universities. Educational programs that incorporate competency-based learning measure acquired skills and learning rather than time on task, which means that students can progress through courses as soon as they've mastered the material, rather than advancing only when the semester or term ends. As an integral part of their learning model, WGU also uses an unbundled faculty model where a team of faculty, each with a specialized role, work together to provide personalized instruction and support for students in their individual courses and the overall degree program. In a nutshell, there are three types of student-facing faculty (i.e. program mentors, course instructors, and evaluators) who interface with students regularly on the phone or online to provide tailored instruction and support, and provide constructive feedback on their assessments. While students interact with faculty who specialize in instruction, support, and evaluation, there's another group of faculty who work behind the scenes to develop curriculum and assessments, ensuring the quality of what students are learning and the value of their degrees. This separation of roles and clear division of roles and responsibilities enable WGU to provide on-demand, personalized faculty support to students without sacrificing their ability to continually align and make improvements to their courses and programs.[47] Since the team of student-faculty faculty know their students well, they are able to make instruction better by providing learning experiences that are attuned to students' interests and major field of study. At the same time, the use of common curriculum and assessment tools developed collaboratively support faculty imparting knowledge to students that are aligned with industry-endorsed competencies.

Implementation Considerations

It is important to recognize that collaboration almost always requires more effort and time than going it alone, so there must be a clear reason and incentive for taking a collaborative approach to course design and delivery. The reason for collaboration should not focus solely on cost savings, but rather on removing any duplication of efforts or inefficiencies that may exist in traditional, individualistic approaches to course design, and creating innovative learning experiences for students by strategically tapping into diverse expertise and knowledge of faculty members. This kind of collaboration could be especially beneficial for introductory or gateway courses that almost all students with different academic and career interests have to go through. Institutions can recruit faculty from different disciplinary backgrounds that use foundational math to contribute to content development to expose students to applications of math in a variety of contexts. Institutions can also differentiate their faculty roles by key areas of course

[46] Western Governors University, Our Faculty, https://www.wgu.edu/about/faculty.html.

[47] Western Governors University Instructional Design Model, https://wgu.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=b496c370-a645-4d95-b9c6-a886014cf40c; Mark Lieberman, "Team Players in Teaching," *Inside Higher Ed,* April 24, 2019, https://www.insidehighered.com/digital-learning/article/2019/04/24/instructional-teams-challenge-tradition-dividing-teaching-roles.

design and delivery (e.g. curriculum, assessment, pedagogy, mentoring) to enable faculty members to play to their strengths and further enrich students' engagement and learning.[48]

One of the big challenges is determining the amount of credit each of the faculty members receives for teaching the course. Sometimes an instructor receives only a fraction of the credit that they would receive for teaching a course independently, while in reality team teaching usually requires each instructor engage in more work than being the only instructor. Collaboration must be prioritized by departments and institutions, and faculty members' individual and collective efforts must be visible and recognized in order to sustain and promote continuous maintenance and improvement of jointly developed courses.

While this strategy has the advantage of potentially engaging students in deep learning by leveraging the diverse and broader expertise of a multi-faculty teaching team, misfortunes could occur if the team is not well organized and connected. Because successful implementation of this strategy rests on close collaboration between faculty and other support staff across departments and institutions, it requires a central team to provide leadership, project management, and coordination support throughout the development processes. Participating institutions must be willing and able to invest resources to support the central team's operation as well as the collaborative course design workflows.

Recommended Readings

- Jenna Joo and Richard Spies, "Aligning Many Campuses and Instructors Around a Common Adaptive Learning Courseware in Introductory Statistics: Lessons from a Multi-Year Pilot in Maryland," *Ithaka S+R*, November 9, 2019, https://sr.ithaka.org/publications/adaptive-learning-courseware-introductory-statistics/.
- Martin Kurzweil and Daniel Rossman, "Faculty Collaboration and Technology in the Liberal Arts: Lessons from a Teagle Grant Program," *Ithaka S+R*, January 29, 2018, https://sr.ithaka.org/publications/faculty-collaboration-and-technology-in-the-liberal-arts/.
- Jessica N. Lester & Katherine R. Evans, "Instructors' Experiences Collaboratively Teaching: Building Something Bigger," *International Journal of Teaching and Learning in Higher Education*, 2009, https://files.eric.ed.gov/fulltext/EJ869322.pdf.
- Mark Lieberman, "Team Players in Teaching," *Inside Higher Ed*, April 24, 2019, https://www.insidehighered.com/digital-learning/article/2019/04/24/instructional-teams-challenge-tradition-dividing-teaching-roles.
- Mark Lieberman, "The Future of Digital Learning Collaboration," *Inside Higher Ed*, September 5, 2018, https://www.insidehighered.com/digital-learning/article/2018/09/05/digital-learning-consortia-diversify-priorities-amid-shifting.

[48] "Unbundling Versus Designing Faculty Roles," *American Council on Education & Center for Education Attainment and Innovation,* https://www.acenet.edu/Documents/Unbundling-Versus-Designing-Faculty-Roles.pdf.

- Penelope A. Moon, "Building Online Courses Communally," *Inside Higher Education*, March 27, 2019, https://www.insidehighered.com/digital-learning/views/2019/03/27/we-can-do-better-master-model-online-course-development-lets-build.
- Michael T. Nietzel, "Scaling Higher Ed Collaboration: An Interview with University Innovation Alliance Executive Director Bridget Burns," *Forbes*, June 1, 2020, https://www.forbes.com/sites/michaeltnietzel/2020/06/01/an-interview-with-university-innovation-alliance-executive-director-bridget-burns/.
- Tanya Roscorla, "Collaborative Course Design Helps Colleges Scale Online Learning," *Center for Digital Education*, January 14, 2016, https://www.govtech.com/education/higher-ed/Collaborative-Course-Design-Helps-Colleges-Scale-Online-Learning.html.
- "Team/Collaborative Teaching," *Vanderbilt University Center for Teaching*, https://cft.vanderbilt.edu/guides-sub-pages/teamcollaborative-teaching/.
- John Villasenor, "Why Colleges Should Pool Teaching Resources," *The Chronicle of Higher Education*, June 4, 2020, https://www.chronicle.com/article/Why-Colleges-Should-Pool/248927.

Outsourcing Instruction to Address Internal Capacity Issues and Quickly Meet Student Needs

In this strategy, institutions outsource instruction of individual courses to other credible partner institutions or third-party providers to help meet their internal capacity issues while also helping students progress more efficiently by tapping into a broad set of vetted courses. The "teaching" institutions or third-party providers administer the entire instructional package on an online platform. Faculty at the "home" institutions are not responsible for course design or teaching, but rather agree to offer credit to students for successfully completing a course elsewhere.

> The ability to cater to student needs effectively and efficiently also enables an institution to retain students and support their academic progress while also maintaining the institution's own financial viability.

This approach affords institutions with limited resources and in-house expertise to offer online courses a means to respond to students' academic needs with the help of the external partners in a timely and cost-effective way. The ability to cater to student needs effectively and efficiently also enables an institution to retain students and support their academic progress while also maintaining the institution's own financial viability. This practice has been very common among various consortial relationships in higher education, though historically, it tended to be limited in small groups of neighboring colleges with similar missions and curricular goals, and focused primarily on sharing in-person courses. Newer initiatives take advantage of technology to broaden their partnership scope and allow students to take online courses from schools all over

the country.[49] More recently, third-party organizations have stepped in to help find greater synergies between these inter-institutional relationships by providing a central platform and the necessary administrative support to bring together a much larger network of institutions and students to access a broader range of course options. We highlight two such examples below.

Examples in the Field

- **Acadeum (formerly College Consortium)[50]** provides a platform for a network of over 200 institutions to share courses across over a dozen existing higher education consortia. It focuses on enabling student progress by providing them expanded course offerings from a broad set of institutional partners while creating new opportunities for participating institutions to increase their revenue. Acadeum's platform enables easy vetting and approval of shared courses for individual institutions, makes it easy for students to explore course offerings and electronically request registration, and provides an automated inter-college payments system. Designated staff at Acadeum also conduct an initial review of teaching institutions ahead of loading their courses onto the platform using widely used quality metrics to ensure that basic elements of online courses are in place. The platform stores and displays syllabi, faculty credentials and learning assessments to help institutions vet the courses they use, which is often a primary responsibility of regional accreditors.
- **Straighterline[51]** offers an affordable and convenient way to earn college credit for general education courses with a nominal monthly membership fee and flat fees for individual courses. All courses go through a quality review process by ACE Credit prior to being available to students, and earned credits can transfer to more than 130 partner colleges and universities. The platform allows immediate access to courses, free one-on-one tutoring, and offers free transcript processing and easy credit transfer, with live support (technical, membership, course support from dedicated student advisors). Many of the courses come from third-party vendors (e.g. McGraw-Hill, eScience Labs) and are self-paced, while some courses have options where students can benefit from increased engagement and direct communication with professors with access to additional resources, tips, and supplemental instruction.

Implementation Considerations

Because institutions are outsourcing a limited number of general education courses in many cases, it still gives the institutions' faculty the ability to maintain control of their degree programs and teach the majority of courses in their major field of study. However, concerns over quality of courses, equity in student outcomes, and diminished faculty roles still exist and will need to be carefully considered when making decisions.

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[49] Alia Wong, "The Shift Online Has Colleges Looking to Share Courses," *Education Dive*, October 2, 2020, https://www.educationdive.com/news/the-shift-online-has-colleges-looking-to-share-courses/586346/.

[50] For more information, visit Acadeum's website: https://acadeum.com/.

[51] For more information, visit Straighterline's website: https://www.straighterline.com/.

Some questions institutions may want to ask include[52]:

- Is outsourcing the best option available? What institutional and student needs will be addressed by outsourcing? What alternatives are there, if any? Will outsourcing place the institution's public missions in jeopardy in any way?
- What is the anticipated impact on faculty jobs and morale? How will faculty be involved in decision-making about outsourcing and its execution?
- How will the quality of courses and instruction be evaluated? Will students continue to have access to and/or personal contact with regular faculty?
- How will the equity goal of student access and success be met through outsourcing? Can outsourcing be used to reduce students' time to degree and promote their learning? Will those courses be offered to students at an affordable cost?
- What mechanisms will be established to measure student outcomes and ensure accountability?

Depending on the size and nature of the institution, there is a high likelihood that the face-to-face math courses are already being outsourced to some degree through the use of adjunct faculty or graduate teaching assistants. While these types of contingent instructors allow for flexibility in staffing and some control over course content and pedagogy, it is important to recognize the financial non-monetary institutional resources of time and effort that go into maintaining this non-employee instructional workforce when considering the relative risks and benefits of pursuing wholly outsourced online instruction.

Recommended Readings

- Alene Russell, "Outsourcing Instruction: Issues for Public Colleges and Universities," *American Association of State Colleges and Universities - A Higher Education Policy Brief*, July, 2010, https://www.aascu.org/policy/publications/policy-matters/2010/outsourcing.pdf.
- Goldie Blumenstyk, "College Leaders Are Getting Serious About Outsourcing. They Still Have Plenty of Concerns, Too," *The Chronicle of Higher Education*, March 26, 2019, https://www.chronicle.com/article/College-Leaders-Are-Getting/245978.
- Scott Carlson, "The Outsourced College," *The Chronicle of Higher Education*, February 29, 2016, https://www.chronicle.com/article/The-Outsourced-College/235445.
- Jenna Joo, Deanna Marcum, and Daniel Rossman, "CIC Consortium for Online Humanities Instruction II: Evaluation Report for the Second Course Iteration," *Ithaka S+R*, September 19, 2018, https://sr.ithaka.org/publications/cic-consortium-for-online-humanities-instruction-ii-2/.

[52] Questions adopted from Alene Russell, "Outsourcing Instruction: Issues for Public Colleges and Universities," *American Association of State Colleges and Universities - A higher Education Policy Brief*, July 2010, https://www.aascu.org/policy/publications/policy-matters/2010/outsourcing.pdf.

- Kristina Powers, "Examining Current Institutional Outsourcing Practices and the IPEDS Human Resources Survey Component," *National Postsecondary Education Cooperative,* December 3, 2019, https://nces.ed.gov/ipeds/pdf/NPEC/data/NPEC_Paper_Examining_Institutional_Outsourcing_Practices_and_IPEDS_Human_Resources_Survey_Component.pdf.
- Matthew Lynch, "Why Your College Shouldn't Outsource Its Online Programs," *The Tech Edvocate,* July 23, 2019, https://www.thetechedvocate.org/why-your-college-shouldnt-outsource-its-online-programs/.
- Scott Jaschik, "Revolt Against Outsourced Courses," *Inside Higher Education*, March 31, 2009, https://www.insidehighered.com/news/2009/03/31/revolt-against-outsourced-courses.

Concluding Thoughts

The COVID-19 pandemic has brought unprecedented disruption, uncertainty, and tragedy to students, instructors, administrators. Despite these challenges, this crisis can be transformational for the institutions all three groups share.[53] Institutions can demonstrate the adaptability required of the moment by finding ways to both improve quality and increase efficiency in all of their academic offerings through remote instruction. Introductory math courses, a cornerstone of so many academic paths, is an obvious place to focus these efforts due to the number of students involved and the potential to reap the benefits of increased persistence.

This guide suggests three approaches to making introductory math more available to more students by building efficiency and quality into the nature of the change. Collaboration and coordination within and between institutions can lighten the load for all involved. Involving third parties into the process leverages their scale experience as well. As with any curricular change, specific dimensions of quality must be ensured as well so that greater institutional efficiency is not gained at the expense of the students being served.

[53] Kenneth Matos, "Five Stages of a Transformational Crisis," August 5, 2020, https://www.linkedin.com/pulse/five-stages-transformational-crisis-kenneth-matos.

Appendix A. Resource Collection Process

Ithaka S+R and TPSE Math set out to develop a repository of resources that may be useful once the decision to transition online is made by departments and institutions in line with the quality and efficiency goals outlined in the resource guide. Throughout summer and early fall 2020 resources were solicited from several higher education and math instruction professional associations. One of them was MAA Connect, an online community for members of the Mathematics Association of America where members composed of mathematicians, students, and enthusiasts in educational settings can connect, communicate, and collaborate. The second venue was POD Network Google Group, a public discussion forum provided by POD Network, which is one of the largest postsecondary educational development communities in North America. The third organization was TPSE Math, the co-sponsoring organization for this report.

These efforts generated specific technology resource recommendations in four categories: (1) Adaptive Learning Systems, (2) Online Collaboration Platforms, (3) Proctoring Solutions, and (4) Scribing/Mathematical Annotation Systems. These resources have been reviewed, copyedited, and are available online at https://airtable.com/shr606i8GcZwqDc7J/tblodYelAcGb0HR5B. Additional supportive materials, such as practice guides, technology reviews, and other math and online instruction resources assembled by the authors during research are also available online at https://airtable.com/shr5h99hdiJP6FkM0/tblodYelAcGb0HR5B.