Modularization in Developmental Mathematics in Two States: Implementation and Early Outcomes

Susan Bickerstaff
Maggie P. Fay
Madeline Joy Trimble

May 2016

CCRC Working Paper No. 87

Address correspondence to:

Susan Bickerstaff
Senior Research Associate, Community College Research Center
Teachers College, Columbia University
525 West 120th Street, Box 174
New York, NY 10027
212-678-3091
Email: bickerstaff@tc.edu

Funding for this research was provided by the Bill & Melinda Gates Foundation. The authors wish to thank the Virginia Community College System (VCCS) and the North Carolina Community College System (NCCCS) for their ongoing partnership in the study of their developmental education redesigns. We are appreciative of the students, faculty, staff members, and administrators at colleges in both states who shared their experiences with the research team. Nikki Edgecombe provided valuable guidance throughout the project. In addition, the authors would like to thank Thomas Bailey, Elisabeth Barnett, Lisa Chapman, Maria Scott Cormier, Catherine Finnegan, Shanna Smith Jaggars, and Julia Raufman and for their helpful feedback on earlier drafts of this paper. We are grateful to Amy Mazzariello for her editorial assistance.

Abstract

Developmental (i.e., remedial) mathematics is often a barrier to student progress and success in community colleges. In response, many colleges and states have modularized the curriculum and course structure of their developmental mathematics sequence in an effort to decrease the amount of time it takes for students to complete their developmental requirements and increase the number of students who successfully move on to college-level math. Drawing on data collected in a mixed-method study of modularized developmental mathematics reforms in North Carolina and Virginia, this paper describes how the reforms have been implemented, with particular attention to the choices colleges must make when designing course offerings and instructional delivery. Student outcomes—including placement patterns, module pass rates, and progression through the developmental math sequence—are presented for two distinct course structures. Analysis of qualitative data provides insights into how the modularized curricula and course structures present opportunities and challenges for student progression and learning.

Two overarching themes emerged from this analysis. First, "modularization," as a reform to developmental mathematics, cannot be disentangled from the implementation choices colleges make. Second, the theorized benefits of modularization, which include student-centered and personalized learning as well as enhanced mastery of content, appear to be in tension with the effort to accelerate student progress through developmental math requirements. The paper provides examples of how colleges have balanced these tensions and found solutions to drawbacks inherent to each course structure. The final section includes recommendations for colleges.

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1. Introduction

Over the past decade, developmental education has become a focus of reform efforts in community colleges as research has demonstrated that for a large number of students, the traditional system is not working as intended. Student outcomes in math are of particular concern. In mathematics, approximately 59 percent of community college students are placed into developmental courses, but only 33 percent of those students complete their developmental requirements and move on to college-level math (Bailey, Jeong, & Cho, 2010). Research points to a number of reasons for these poor success rates, including underplacement into developmental education among students who could have been successful in college-level courses (Scott-Clayton, 2012), lengthy developmental sequences that invite stop-out and dropout at each "exit point" (Hern, 2010), and curricula and pedagogy that are neither relevant nor rigorous (Grubb, 2012).

To address these issues, colleges, districts, and entire state systems have begun to redesign their assessment systems and policies that place students into developmental math, as well as the course structures, curricula, and pedagogy used in their developmental programs. Modularization is an increasingly popular reform approach. In a modularized system, traditional multicredit math courses are broken into smaller modules (often offered at one credit each). In many cases, colleges use a diagnostic assessment to determine which modules a student must take. Under this system, it is assumed that students will study only the math topics they need and bypass modules where they have shown proficiency. This allows them to focus on their areas of weakness and ideally results in a shorter sequence of developmental coursework and accelerated progress to college-level math. Despite this robust theory of action, little research has investigated how this type of reform plays out in practice. Few studies have examined student performance in modularized courses, their enrollment and progression through the sequence, the administrative changes needed to offer modularized courses, and the teaching and learning practices used in modularized classrooms.

This paper explores these issues using qualitative and quantitative data collected over two years in North Carolina and Virginia. First, in Section 2, we present a historical perspective on modularization in mathematics and other subjects in higher education, placing the current reforms in context. In Section 3, we describe the modularized curricula and the two available course structures used in both states. In Section 4, we present the findings from our mixed-method analysis, including placement patterns for Virginia's new diagnostic assessment, perspectives on the modularized curricula, and student progression in each course structure. In particular, we explore the extent to which the reforms appear to be achieving their stated goal of accelerating student progress through developmental math requirements. We describe opportunities and drawbacks of the curricula and course structures and provide examples of ways in which colleges have mitigated implementation challenges. In Section 5, we summarize our key findings; describe the tensions between efforts to accelerate student progress, increase mastery of content, and provide more personalized instruction; and offer recommendations for colleges.

2. Literature

Over the past decade, growing numbers of community colleges, college districts, and state systems have moved to modularized curricula and course structures in developmental mathematics (Edgecombe, Cormier, Bickerstaff, & Barragan, 2013; Rutschow & Schneider, 2011). While this reform movement is a relatively recent phenomenon, the notion of curricular modularization in higher education has a lengthy history. Viewed in the context of international higher education systems, the contemporary U.S. system of credit-hour courses and electives is already relatively modularized in comparison to systems that prescribe a program of study. The U.S. credit-hour system emerged in the late 1800s with the introduction of elective courses in postsecondary institutions and the establishment of the Carnegie Unit for tracking progress toward a high school diploma (Harris, 2002). Dochy, Wagemans, and de Wolf (1989) argued that these reforms were partially driven by emerging educational theories highlighting student-centered learning, freedom of student choice, and the value of student self-knowledge and self-interest.

Today, most collegiate programs of study are composed of a series of courses (such as Biology 101 and Biology 102) in which larger fields of content are divided into smaller building blocks. Curricula at all levels are divided into discrete components in the form of textbook chapters or course topics. Many courses are organized around a series of unit tests that cover different competencies. This organization is driven by the assumption that students learn best by mastering or fully acquiring skills or knowledge in one area before moving on to the next (Block, Efthim & Burns, 1989; Morrison, 1926). On the other hand, some educational theorists have argued that learning is nonlinear and that students are best served by a "spiraling" approach, in which they are repeatedly reexposed to the same content in more complex forms (Bruner, 1960). To address the concern that students may not retain information across chapters or topics, some courses or programs feature cumulative assignments or assessments, and courses in a sequence may feature repetition of key concepts.

Beginning in the 1960s, education scholars documented the move to further compartmentalize course content into what they called modules (e.g., Allen, 1967; Creager & Murray, 1971). In their review of this literature, Goldschmid and Goldschmid (1973) defined a module as "a self-contained, independent unit of a planned series of learning activities" (p. 16). Modules were more limited in scope than traditional courses, intended for self-study and designed to promote student self-pacing, student choice of topic and learning mode, and increased institutional flexibility and responsiveness (van Eijl, 1986). Additionally, Klingstedt (1971) argued that because modules typically include frequent opportunities for assessment, modularization would allow students to identify strengths and weaknesses relatively quickly and to "recycle" through content areas, repeating them as needed. As defined in this literature, the self-directed, personalized nature of student selection of and progression through modules was seen as an antidote to the teacher-centered instruction and student passivity observed in traditional longer courses. Students were expected to select the instructional materials of greatest value to them and actively work though the content until the module's learning objectives were achieved. Research during that period suggested that a student-directed mastery approach had positive impacts on learning and student attitudes but had negative impacts on course completion (Kulik, Kulik, & Bangert-Drowns, 1990).

In the intervening years, experiments with modularization have occurred in several European systems (see, e.g., Howieson, 1992; Välijärvi, 2003; Veugelers, 1989), but there was little documentation of this approach in American higher education until the late 1990s, when the Pew Charitable Trust funded course-redesign efforts intended to increase educational quality and lower costs in high-enrollment postsecondary courses. Much of this work was led by the National Center for Academic Transformation (NCAT), which created models and provided technical assistance for modularizing courses in two-year and four-year colleges. The goals of modularization, as described by NCAT and adopting states, include personalizing the learning experience for students so that they would take only the content needed to address their identified weaknesses and support their academic goals (Twigg, 1999). Other recent adopters of modularized developmental math have described its advantages in terms of enhanced opportunities to repeat content as needed for enhanced learning and mastery (Wong, 2013).

The move by states and systems to modularize their math curricula and course structure coincides with a number of other national reforms to developmental mathematics with similar aims. For example, some reforms rationalize curricula and eliminate course levels to help students progress to college-level math more quickly. Others customize curricula according to academic program of study—for example, allowing liberal arts majors to take a developmental course preparing them for statistics rather than precalculus (Edgecombe et al., 2013). Recent scholarship on community colleges has called for a broader rethinking of developmental education, positioning it as a highly contextualized on-ramp to a specific college-level program of study (Bailey, Jaggars, & Jenkins, 2015). Colleges employing this approach may offer developmental education as a corequisite with a relevant college-level course so that students may see the connection between math skills and their academic and career interests.

Computer software is seen as an important facilitator of the personalization implied by a modularized mathematics curriculum. Software can identify when students need opportunities to review or recycle through material, provide customized activities based on their performance, and aid instructors in managing unique trajectories for each student. Instructional software also readily provides students with varied and targeted problem sets and worked examples in focused topic areas. Prior research has identified the effectiveness of viewing worked examples for mathematical learning (Cooper & Sweller, 1987; Sweller & Cooper, 1985). Based on her experience leading NCAT, Twigg (1999) suggested that these advantages may be particularly beneficial at the developmental level:

> Introductory level mathematics, for example, typically involves a modest conceptual core, underpinning a great deal of numerical and symbolic calculation. Interactive computer instruction is a natural way to provide examples and practice in implementing the ideas, especially where practice efforts and repetition count toward mastery of content. (p. 15)

Courses that utilize instructional software may also give students greater control over the pace of instruction, as they can spend more or less time on concepts depending on their need. This self-paced approach is also thought to allow for greater personalization in instruction (Goldschmid & Goldschmid, 1973).

Despite the promise of modularization, research raises questions about the efficacy of this approach in developmental education. For example, research on students referred to developmental mathematics has demonstrated student reliance on memorization of procedures, which is associated with fundamental misunderstandings about basic mathematical concepts (Givvin, Stigler & Thompson, 2011; Stigler, Givvin & Thompson, 2010). Richland, Stigler, and Holyoak (2012) argued that this suggests the need for instruction that helps students understand "that mathematics is a sensible system" (p. 195) rather than a collection of rules. More specifically, they and others have argued for teaching that helps students draw connections between problems, concepts, and procedures (Hiebert & Grouws, 2007; Richland et al., 2012). This type of teaching involves attending to the relationships among concepts "in an explicit and public way" (Hiebert & Grouws, 2007, p. 384). These findings suggest that an approach focused primarily on practice and examples facilitated by interactive computer instruction, or one that compartmentalizes basic math topics into discrete modules, may not meet the learning needs of students referred to developmental education.

Similarly, previous research suggests that online education, an approach that also grants students enhanced autonomy and responsibility over their learning, may be less effective for low-performing students. Specifically, Xu and Jaggars (2014) found that while all community college students performed more poorly in online courses, the negative impact of online courses on course persistence and course grades was larger for students with lower grade point averages. Further research is needed to determine whether these trends hold for students with developmental needs in self-paced modularized models.

3. Modularized Developmental Math Redesigns

In 2012 and 2013, Virginia and North Carolina independently rolled out redesigns of their developmental math placement systems, course structures, and curricula. Prior to the redesigns, incoming students in both states took a commercially developed placement test, which determined their assignment to college-level math or to one of several sequentially ordered developmental mathematics courses. Across individual colleges, there were significant variations in policy, course design, and even course offerings, but most colleges offered arithmetic, beginning algebra, and intermediate algebra as three-, four-, or five-credit-hour[1] developmental courses in a semester-long format. Thus, a typical student referred to arithmetic would be required to take three semesters of developmental math, for a total of nine to 15 credit hours, before progressing to college-level courses.

The redesigns have now been implemented in all community colleges in both states.[2] The broad goals of the redesigns were similar in North Carolina and Virginia. The states implemented policies and practices that sought to decrease the number of developmental referrals and the need for developmental education, and they endeavored to reduce the amount of time students were spending completing their developmental requirements, stating that most students should be able to complete their developmental requirements within one year. The redesigns made developmental requirements consistent across colleges and revised developmental curricula to align with the curricula of introductory college-level math courses (Asera, 2011; North Carolina Community College System, 2011; Virginia Community College System, 2010).

To facilitate these goals, the reforms are composed of several key components. First, the developmental math content was revised to reflect prerequisite needs for college-level math courses. Both states standardized their prerequisite policies so that students pursuing technical math or liberal arts math are required to take less developmental content (fewer modules) than students pursuing precalculus, which is required for science, technology, engineering, and math (STEM) majors. Second, the math content was organized into one-credit modules. In Virginia, there are nine modules, and in North

[1] Developmental courses are usually non-credit bearing, meaning they do not count toward a student's program or credential. Credit hours here refer to contact hours and the cost of the course.
[2] For more information about the redesigns, see Kalamkarian, Raufman, and Edgecombe (2015).

Carolina there are eight.[3] Third, both states worked with testing companies to design their own customized diagnostic assessments that place students into individual modules. And finally, in both states, colleges were given discretion over instructional delivery.

3.1 Modularized Curricula

The new modularized curricula contain eight or nine modules. Faculty teams in both states developed curriculum guides that identified the content areas and learning outcomes for each module. Table 1 lists the topics covered by each module by state.

Table 1
Modularized Developmental Math Curricula

Virginia		North Carolina	
Module	**Topics Covered**	**Module**	**Topics Covered**
MTE 010	Operations with Positive Fractions	DMA 010	Operations with Integers
MTE 020	Operations with Positive Decimals and Percents	DMA 020	Fractions and Decimals
MTE 030	Algebra Basics	DMA 030	Proportions, Ratios, Rates, Percents
MTE 040	First Degree Equations and Inequalities in One Variable	DMA 040	Expressions, Linear Equations, Linear Inequalities
MTE 050	Linear Equations, Inequalities, and Systems of Linear Equations in Two Variables	DMA 050	Graphs and Equations of Lines
MTE 060	Exponents, Factoring, and Polynomial Equations	DMA 060	Polynomials and Quadratic Applications
MTE 070	Rational Expressions and Equations	DMA 070	Rational Expressions and Equations
MTE 080	Rational Exponents and Radicals	DMA 080	Radical Expressions and Equations
MTE 090	Functions, Quadratic Equations, and Parabolas		

Each state published a curriculum guide that describes each module; outlines learning outcomes and course competencies; and includes a suggested four-week timeline, sample assessment items, and teaching tips (North Carolina Community College System, 2011; Virginia Community College System, Developmental Math Curriculum Team, 2011; see Table 2 for excerpts). In addition to the curricular materials for each module, the guides outline a number of policies and recommendations related to

[3] In 2014, some colleges in North Carolina began offering a two-credit module for upper level developmental students that covers the content of the final three modules in the sequence.

assessment, use of calculators, and grading. In North Carolina, the mathematics curriculum places an explicit emphasis on conceptual and contextual learning. The curriculum guide states:

> A module should begin, whenever possible, with a rich application with which students can connect and from which skills will emerge. . . . Deep understanding of mathematical concepts is as much the goal as is the ability of students to perform the required skills.

Table 2
Excerpts from the North Carolina Community College System Curriculum Guide: Module 2—Fractions and Decimals

Type of Content	Excerpt
Course competencies	• Solve contextual application problems involving operations with fractions and decimals. • Visually represent fractions and their decimal equivalents. • Simplify fractions.
Conceptual learning outcomes	• 2.1 – Solve conceptual problems involving fractions and decimals. • 2.8 – Visually represent the sum and difference of two fractions with unlike denominators. • 2.13 – Estimate sums, differences, products, and quotients with decimals.
Conceptual question	Mike and three friends stopped at a pizza parlor Saturday night and shared a large pizza equally. The next day Mike and seven friends stopped at the same pizza parlor for a snack. This time the eight friends shared a large pizza equally among them and then ordered a second large pizza and shared it equally. Did Mike eat more pizza on Saturday or Sunday? Or did he eat the same amount each day? Draw a diagram of the problem events before trying to solve the problem.
Teaching tips	• The key concept from this module is the relationship between fractions and decimal representations of numbers. The concept of fraction as division leads into this discussion of the decimal form of a rational number. • It is recommended that rounding not exceed the ten-thousandths place.

The curriculum guides set benchmarks for proficiency, which must be met before the student can move on to the next module or course. North Carolina's states that students must pass the module's "rigorous final assessment" with a grade of 80 percent or better. Virginia set the passing benchmark as a score of 75 percent on the module's final assessment. In the curriculum guides, these performance requirements are described in terms of student "mastery" of module content.

Colleges developed their own end-of-module assessments, and in practice, how students demonstrate their mastery varies across colleges. Some colleges allow students to bypass the module if they performed well (usually over 80 percent) on a module pretest; others do not offer this option. Colleges differ in their approach to administering the final assessment. Some allow students to attempt the assessment multiple times, often with tutoring required after an unsuccessful attempt. Others allow students to take the test only once, in effect creating a high-stakes final assessment. At most colleges, students can only attempt the final test after passing all homework and quizzes with a designated score. These variations stem in part from the variance in course delivery structures, as multimodule shell courses (described below) allow for more flexibility with retesting.

3.2 Course Delivery Structures

Both states made two course prefixes (i.e., new course names for the catalog) available to colleges, designating two distinct options for course structure (see Table 3). In the first, each module is offered as a stand-alone, one-credit course, in which the course number indicates the module. For example, a student enrolled in MTE 020 in Virginia is enrolled in module 2. These courses are primarily offered in four-week terms. Other than the shortened timeframe, stand-alone courses function like other transcripted courses: Students who pass the module are awarded a "Satisfactory" on their transcript; students who fail receive a nonpassing designation and must reenroll to attempt the course again. Stand-alone courses can be taught using a traditional, lecture-based instructional delivery approach, but some colleges also employ a computer-mediated instructional delivery approach, described more fully below.

The second course prefix designates a multimodule shell course. Shell courses are variable-credit, depending on the number of modules a student is expected to complete in the course. For example, in North Carolina, DMS3 is a three-credit course open to students in need of *any* three modules. Shell courses range from one to four credits, allowing students to sign up for up to four modules in one semester.[4] A grade of "Satisfactory" in a shell course denotes that the student has passed the number of modules in which he or she enrolled; it does not convey which specific modules were

[4] Some colleges offer three-credit-maximum shell courses that span the full semester; others offer four-credit shell courses to be completed in the same timeframe.

completed. Even if students do not complete all of the modules they enroll in, and thus do not pass the course, they do not need to repeat modules they successfully complete.

Table 3
Course Structure Comparison

	One-Credit Stand-alone	Multicredit Shell
Prefix		
Virginia	MTE	MTT
North Carolina	DMA	DMS
Course numbering	Course numbers 1–8 or 1–9 correspond with the modules in the curriculum guides.	Course numbers 1–4 correspond with the number of modules to be completed in the semester.
Semester structure	There are three or four terms in a semester, each about four weeks long.	Four-credit shell courses are usually offered in a semester-length course. One-credit, two-credit, or three-credit shell courses may be offered in shortened terms.
Grading	Students receive a "Satisfactory" for each module they complete.	Students receive a "Satisfactory" for completing all of the modules in which they enroll.
Instructional approach	Instructional delivery can be traditional, teacher-led lecture format; computer-mediated; or a hybrid.	Instructional delivery is computer-mediated in almost all cases.

Because most shell course sections enroll students working on varied modules, instructors cannot lecture or lead whole-class activities. Instead, these classes employ a computer-mediated instructional delivery approach. In a shell course, students work individually through a series of assignments and assessments at computer workstations using an instructional software package that is customized to the learning objectives of the module.[5] Faculty members oversee their progress and provide instruction and one-on-one assistance when necessary. This approach is sometimes referred to as "self-paced" because even though students are expected to follow a general pacing guide laid out by the instructor, in practice they can spend more or less time on each module. For example, a student enrolled in a four-credit shell course could spend five weeks on one module, then accelerate his or her pace in the others and still successfully complete the four required modules in 16 weeks. At most colleges, a student who works quickly could complete more modules than he or she enrolled in without paying for any additional course credits.

[5] Examples include Pearson's MyMathLab, Hawkes, ALEKS, and Carnegie's Cognitive Tutor.

4. Findings on Implementation and Outcomes

One of the stated goals of the modularized developmental math reforms in both states is to accelerate student progress through developmental requirements—ideally, allowing students to complete all developmental math requirements in one year or less. In this section, we draw on statewide administrative data from Virginia[6] and qualitative data collected in North Carolina and Virginia to explore the extent to which the modularized curricula and course structures facilitate that goal. Using interview data, we examine instructor and student experiences with teaching and learning developmental math content in both course structures, with attention to other theorized goals of modularization: personalization and mastery. Importantly, we do not compare our findings to student outcomes in the pre-reform period, so this analysis does not speak to the effectiveness of modularization relative to the former multicredit course sequence.[7]

The administrative records are provided by the Virginia Community College System and include basic demographic information, placement test scores, course transcript records, and module completion records. The dataset comprised 20,572 first-time-in-college students[8] who began in one of the state's 23 community colleges in fall 2012. For many statistics below, we present data only for colleges primarily offering stand-alone courses or only for those primarily offering shell courses.[9] Qualitative data come from interviews and focus groups conducted between fall 2012 and fall 2014 in North Carolina and Virginia. Researchers interviewed 205 faculty, administrators, and staff members about changes to developmental math courses. Additionally, researchers interviewed or surveyed 177 math students.

In this section, we report on placement patterns for Virginia's new diagnostic assessment and explore perspectives from both states on the modularized curricula. We then examine student progression in each course structure in Virginia, identifying

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[6] Because North Carolina implemented its math reform 18 months later than Virginia did, we only present outcome data for Virginia.
[7] For a comparative analysis of developmental student performance in Virginia before and after the reform implementation, see Rodríguez, Bickerstaff, and Edgecombe (2016).
[8] This is the subset of the full sample of first-time-in-college students (29,566) who have placement test scores.
[9] We designate stand-alone colleges as those where at least 5 percent of students took a stand-alone course in their first year and shell colleges as those where at least 5 percent of students took a shell course in their first year. We omit from our analyses colleges where both course types enrolled at least 5 percent of students.

unique instructional and implementation issues across the states in the stand-alone and shell courses.

4.1 Diagnostic Placement Tests Allow Students to Skip Math Content

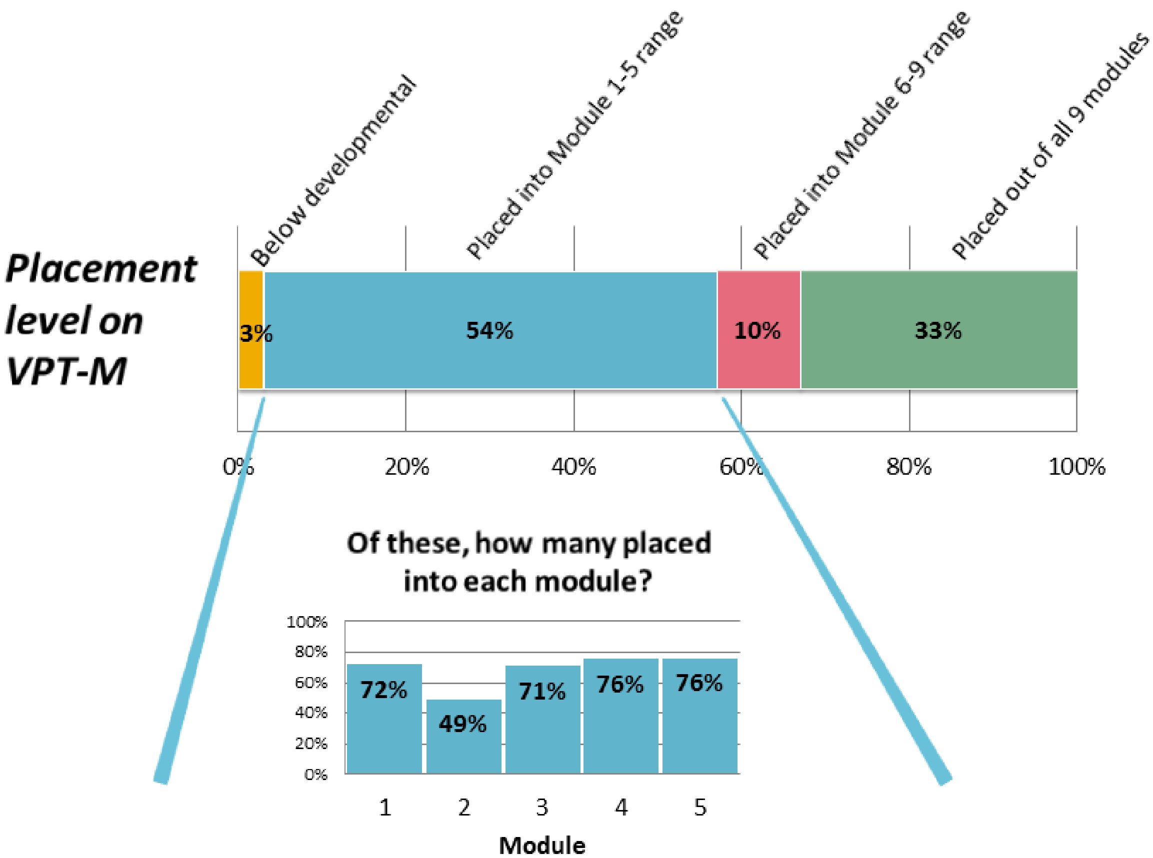
Before the launch of the reforms, community colleges in Virginia and North Carolina employed traditional placement tests (COMPASS/ASSET in Virginia, and a choice of ACCUPLACER or COMPASS/ASSET in North Carolina) to determine students' math placement. Under the new system, each state uses a diagnostic assessment, which has been designed around the specific learning objectives of each module. These assessments are intended to identify particular areas of weakness for students and to place students into modules that cover the content they need. They also identify content areas that students have already mastered, allowing students to skip those modules.

Diagnostic assessment is key to the goal of allowing students to take only the math content they need, and early analysis of the placement patterns of students taking the Virginia Placement Test in Math (VPT-M) demonstrates that the assessment does allow students to skip content areas as intended.[10] As shown in Figure 1, the test places students into one of four general placement levels: below developmental, into the module 1–5 range, into the module 6–9 range, or out of all nine modules. Students who place into one of the developmental ranges (1–5 or 6–9) then take diagnostic tests to determine their placement for each module within that range.[11]

The majority of test takers (54 percent) were placed into the module 1–5 range. Out of those students, more than three quarters placed out of at least some of those modules. Among developmentally placed students (n = 13,116), 59 percent placed into module 1 as their lowest level module. However, of these students, 67 percent placed out of at least one other module. This suggests that students are able to skip math content they have already mastered, as determined by the placement test, giving students opportunities for acceleration.

[10] For preliminary patterns from the North Carolina Diagnostic Assessment and Placement in mathematics, see Mbella (2014).
[11] The placement test in North Carolina works differently. For a full description of both placement test structures, see Kalamkarian et al. (2015).

Figure 1
Initial Placement Levels of Students Taking the Virginia Placement Test in Math



Math faculty expressed mixed opinions on allowing students to skip topics based on the new assessment. One faculty member appreciated this aspect of the design, explaining:

> Maybe they do well with algebra concepts, but maybe they were a little rusty on the ratios and percents. I like that because you're not having them go through an entire sequence that maybe they don't need everything in that sequence.

However, other math faculty expressed discomfort with the idea of students being able to place out of higher level modules if they had not mastered prerequisite concepts. A faculty member explained the reservations about the diagnostic assessment approach:

> Now [for example] you can test out of [modules] 2 and 3 but not test out of 1. [Module] 1 is where you get the negatives and the positives. If you can't test out of negatives

> and positives, how have you tested out of 2, which is negatives and positives with fractions and decimals?

This question about student placement out of particular modules reflects concerns about the placement instrument, but it is also related to a more fundamental question we heard voiced in interviews: Should developmental math content be modularized into smaller discrete chunks, or would students benefit from a more holistic approach to learning this material? Varied perspectives on this question are explored in the next section.

4.2 Splitting the Curriculum Into Modules Has Perceived Benefits and Drawbacks

Praise for the modularized curriculum was common in interviews with faculty, students, and administrators. They complimented the way that it allows students to take only the math they need. One student compared the modularized structure favorably with the old model:

> The way it was done before, there was a possibility that I would have had to sit through a whole semester, and the first half of it was stuff that I [already knew], and would have had to go through that to get to the part that I needed.

Students and faculty also reported that the ability to focus on fewer mathematical topics at one time had benefits. As one faculty member explained:

> I think what I like about the [modules] is that it seems like students are like, "Oh, good." Especially students that are a little bit more math-anxious are sort of like, "Oh, great. Okay, for these four weeks, I'm just going to focus on this." As opposed to trying to cram in one, two, or three things, they are just going to focus on this one thing.

Positive comments from faculty and students also related to students' ability to learn the content. It was perceived that a limited in-depth immersion in just a few topics would lead to a more in-depth understanding of the content. Similarly, prior literature has identified the ability to recycle through content that has not yet been mastered as a benefit of modularized instruction (Goldschmid & Goldschmid, 1973; Klingstedt, 1971). Thus, if a student is not able to master a topic in four weeks, the student can repeat only that module and spend additional time on his or her areas of weakness. One instructor described the student perspective:

> Maybe I'm not able to do it in four weeks, but [I'm] offered another opportunity then, so I still have an opportunity to be successful. And you don't have to repeat 16 weeks of classwork either. You just repeat four instead of a full semester.

The modularized structure enables students who require more time to master content to repeat or spend additional time working on a module, with less of a time penalty than in the previous developmental course structure.

Administrative data from Virginia supports these assertions about the value of repeating a failed module for some students. Among students who attempted a stand-alone course in the first 4-week term but failed to complete it, 44 percent attempted the course again in the second 4-week term, and 53 percent attempted it sometime within that same semester. Out of those students who made a second attempt within the same semester, 63 percent were successful in that attempt, and 56 percent moved on to the next module in their sequence within that same semester.

On the other hand, some faculty worried that the modularized curricula could discourage retention and application of knowledge by limiting the extent to which students learn to connect mathematical concepts across modules. For example, one instructor explained:

> I think students get very myopic. So for instance, once a student has finished [module 5], which is graphic linear equations, there's really no place in the remaining part of developmental where they might see graphing linear equations.

Another faculty member made a similar point, drawing on a different example:

> So we are in fractions: We didn't do anything else, no algebra. When we're in decimals, we do just decimals. And then, once we get to [module 3], it's all algebra. So really, you don't use module 1 or 2 really in [module 3]; you usually add whole numbers with variables.

Thus, while stakeholders perceived that splitting the curriculum into discrete modules helps to personalize the curriculum, as students can recycle through troublesome content with fewer penalties, instructors expressed mixed opinions on whether it resulted in greater mastery of content. Some argued that it did, as students benefit from focusing on one topic at a time. But others expressed concerns that the modularized curriculum detracts from students' ability to see connections between topics and understand the mathematical concepts that underpin content across modules. To counter this issue, one college offered cumulative exams covering content from three modules to encourage retention and connections. Another college created three-module courses taught by a single instructor over the course of a semester. While these courses were not available to students who needed only one or two of the modules, they were perceived to be beneficial for students who needed all three.

4.3 Modules Vary in Both the Amount and Difficulty of Content They Cover

The process of organizing the prerequisite knowledge and skills that students need for college-level mathematics into a series of one-credit modules involved difficult decisions. These decisions were made at two levels: First, the states' curriculum committees set out specific learning objectives for each module, and second, mathematics faculty and department heads at colleges determined which assignments and what level of performance was required to complete each module.

One outcome of these processes was a perceived unevenness across the modules. As one curriculum team member described:

> We ended up with what the team thought was as good of a job as we could to fit them into these one-credit chunks. But there was still—we knew when we started that there was some content that would be heavier, some units would be heavier than others.

A review of the states' curriculum guides shows this variation. For example, the number of learning objectives per module ranges from a low of three to a high of 10. The same is true for the number of assignments, as determined by individual colleges. For example, at one college, the number of assignments ranged from 13 for several "lighter" modules to 22 for module 6. As a faculty member at that college explained, "Module 6 is a bear; there is just no other way to say it. It's just hard to get through, but we warn them."

This variation is not unexpected, and most faculty reported overall satisfaction with the curriculum; however, the question of calibration of volume and difficulty of content across modules emerged in interviews as an instructional challenge in both states. Moreover, it was unclear what the implications of variation in amount and difficulty of content would mean for student outcomes. To shed light on this issue, we used administrative data from Virginia to explore whether there appear to be systematic differences in course success across modules. The analysis showed that in stand-alone courses, system-wide pass rates ranged from 59 to 76 percent. Table 4 summarizes pass rates conditional on attempting each module. Because higher level modules tend to be taken by fewer students—not all students need or are able to reach those modules—higher pass rates for those modules may signal higher average student ability in those courses rather than an easier course. Modules 5 (systems of equations, including graphing) and 6 (exponents, factoring, and polynomials) appear to have the lowest conditional pass rates among all nine modules. These modules were frequently cited in interviews as being more difficult and as containing more content than other modules.

Table 4
Conditional Pass Rates by Stand-alone Course Module

Module	Topic	Conditional Pass Rate (%)	*n* (Course Attempts)
1	Operations with Positive Fractions	62	4,578
2	Operations with Positive Decimals and Percents	68	2,616
3	Algebra Basics	74	3,069
4	First Degree Equations and Inequalities in One Variable	64	2,651
5	Linear Equations, Inequalities, and Systems of Linear Equations in Two Variables	59	1,965
6	Exponents, Factoring, and Polynomial Equations	59	1,570
7	Rational Expressions and Equations	60	999
8	Rational Exponents and Radicals	75	611
9	Functions, Quadratic Equations, and Parabolas	76	476
Total		65	18,535

To address this concern, at some colleges, faculty undertook reviews of module outcomes and requirements after the first or second semester of implementation. For example, one instructor explained:

> One of the things we did in module 5 is we actually took a hard look at that over the summer because we noticed that was where a large part of our failure rate was. And that's actually the exit point for our liberal arts students. And we noticed that there was one whole area that we were including that's not in the curriculum guide for VCCS [Virginia Community College System]. So we're just like, "This isn't even a requirement; how did this even get in here?" We have had more success now that we've removed that.

Despite refinements, faculty and administrators reported that variation in content volume and difficulty was a persistent challenge for instruction and student progression. As we discuss in subsequent sections, the solutions devised by colleges to address these issues varied according to course structure.

4.4 Stand-alone Courses Create Exit Points but Allow for Instructional Flexibility

Stand-alone courses, which operate like regular transcripted courses and enroll students working on the same module, present benefits and challenges that have implications for student performance, progression, and learning. In particular, this course structure is associated with a large number of "exit points" and unique administrative considerations.

Exit points. Stand-alone courses typically are structured so that students can enroll in and complete four modules per semester, or as many as eight modules in one academic year.[12] However, an analysis of student enrollment patterns in these courses demonstrates that students are likely to take breaks between modules or to fail to reenroll in modules, particularly after a module failure.

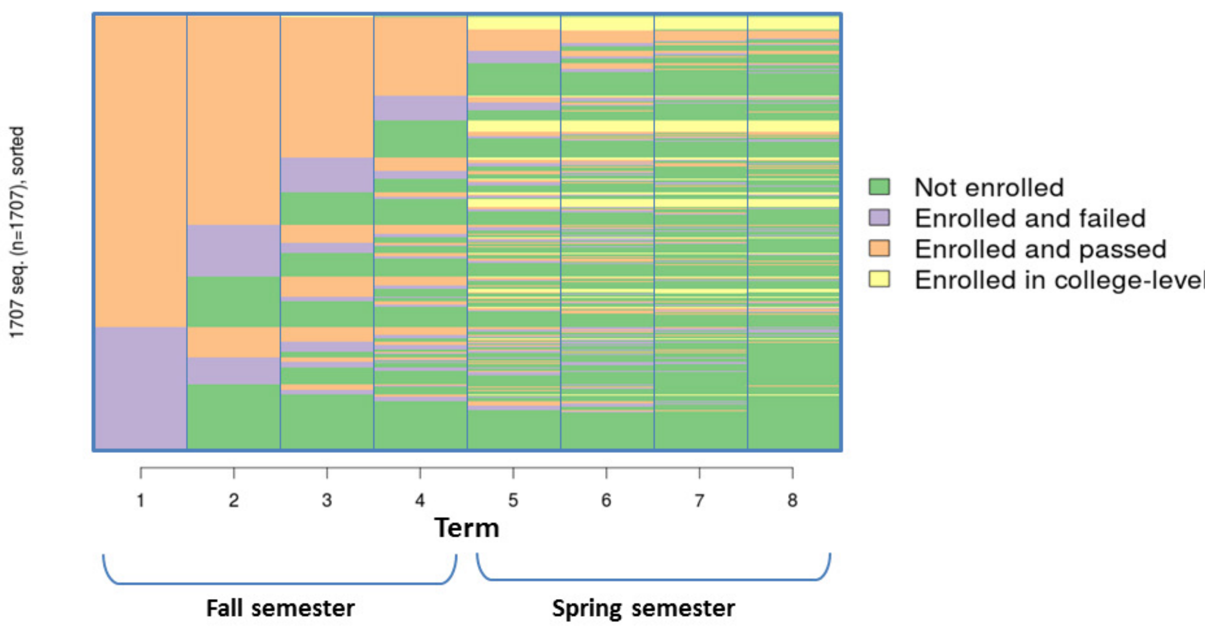
Less than a quarter of students attempt four stand-alone courses in a semester at colleges that offer the option.[13] Figure 2 illustrates the enrollment patterns for the subset of 1,707 developmentally placed first-time students at those institutions who attempted module 1 in the first four-week term of the fall semester. In this figure, each column represents a four-week term. Reading from left to right, one can see how a student enrolls

[12] A minority of colleges offering stand-alone courses offer three terms per semester rather than four. For clarity in analyses involving course sequences, we limit the sample of colleges offering primarily stand-alone courses to colleges that offer four terms per semester.
[13] Given the variation in program requirements, the dataset does not allow us to determine how many modules a student needs to exit remediation. The most accurate way to understand whether students are progressing through their developmental requirements is to look at college-level math enrollment.

over the course of the academic year. Orange shading represents attempting and passing a stand-alone module in a given term, blue shading represents attempting a module and failing, and green shading represents not enrolling in mathematics.

Compared with a traditional developmental sequence, the stand-alone course structure introduces additional exit points; students may exit the sequence not only between semesters but also within a semester. The large amounts of green space in Figure 2 suggest this is in fact happening. Some students may have completed their required modules after one or two terms, in which case some green space would be expected. Because we do not have a reliable indicator of student developmental needs, we cannot observe the extent to which this is occurring. However, the visualization also shows that a small proportion of students who start in the first module (12 percent) are enrolling in college-level math during the spring semester.

Figure 2
Enrollment Patterns in Stand-alone Courses in Fall and Spring Semesters for Students Who Began in Module 1



Overall, 40 percent of the students in this subsample who enrolled in at least two stand-alone courses during their first academic year took a break in between modules at some point. The same general patterns hold for students who began in other modules.

Furthermore, the reenrollment rate is lower in a four-week term following a failed module attempt than in a four-week term following a passed module attempt. Among students who enrolled in any stand-alone course in the first four-week term, 82 percent of those who passed enrolled in another module in the second four-week term, compared with only 49 percent of those who failed. This finding suggests discouragement may be negatively impacting students' enrollment decisions.

Interviews with students provide more insight into what may be contributing to the discouragement, beyond course failure. Specifically, students described a feeling of burnout that derived from the volume of work, the pace of instruction, and/or a lack of engagement with the content. As one student reported:

> In module 1, we can't use a calculator, so I was finding it difficult to try to figure out the problems. 'Cause I have to relearn the multiplication times table all over again, and the instructor, he was moving fast-paced. I don't like how the [modules] causes you to cram all that in like four weeks. . . . It's a little tough. A little too fast for my pace.

Another student described how the amount of work required in the modules discouraged immediate reenrollment. This student passed module 1 on her second attempt in the fall semester and decided not to take the additional two modules she needed until the next academic year:

> I just felt like I needed a break after taking it two times last semester. But I'm going to take it in the fall, when I'm ready. It's a lot more than the other classes, 'cause it's only four weeks, and you have so much to get done in four weeks.

Students cited other reasons for taking breaks between modules, including wanting to enroll with the same teacher: "I took it with Mrs. P., and I've pretty much been sticking with her. I took a break when I found out I couldn't take 9 with her."

The issue of exit points as a challenge to student progression in developmental course sequences is well documented (Bailey et al., 2010; Hern, 2010). Yet the stand-alone modules exacerbate this issue, increasing the number of exit points before college-level math from three (in the old system of three courses) to as many as nine. Additionally, the pace of instruction and volume of content to cover in the stand-alone modules may lead to higher levels of student burnout than one would find in traditional semester-long courses. One of the overarching goals of the modularized redesign is to facilitate student acceleration through developmental requirements. The realization of this goal is imperiled if a large proportion of students take breaks between modules.

Administrative considerations. Another unique consideration of the stand-alone courses is the scheduling and registration burden for colleges and for students. Because students might skip modules via the placement test or might need to repeat modules they have already attempted, there is no single pathway that students will follow over a semester. An analysis of 6,067 developmentally placed student transcripts at colleges offering four stand-alone courses per semester in Virginia shows 500 unique course-taking patterns in the four terms in the fall semester. In addition to the pattern of *1*, *2*, *3*, *4*, which would be expected, other common course-taking patterns included *1*, *3*, *4*, *5*; no module in the first four-week term followed by *1*, *2*, *3*; and *1*, *1* followed by no modules in the third and fourth sessions. These variations make predicting enrollments for the purpose of planning course offerings and staffing more difficult.

At the conclusion of each four-week term, staff, faculty, and students must execute what stakeholders at many colleges call the "add/drop/swap" process for students who do not successfully complete their course. For example, a student enrolled in module 2 in the first four-week term may be enrolled in modules 3, 4, and 5 in the subsequent terms. If the student does not satisfactorily complete module 2, he or she must drop modules 3, 4, and 5, then reenroll in module 2 in the second four-week term, and swap into modules 3 and 4 for the subsequent terms.

To address what one department chair called the "scheduling nightmare" presented when students do not successfully complete stand-alone courses, some colleges hired additional personnel to manage enrollment and registration in stand-alone courses. These individuals assisted with monitoring and assessing enrollment, which facilitated offering the right number of sections of each module during each four-week term. At many colleges, these individuals were also responsible for working with students on their enrollment and encouraging continuous enrollment. These activities might involve calling or emailing students who failed a module to ensure they are enrolled in the correct course for the subsequent four-week term.

Instructional benefits and challenges. A major perceived instructional benefit to stand-alone courses is the opportunity for instructional flexibility. Content in stand-alone courses can be offered via teacher-led instruction, including lecture, teacher-directed small-group activities, whole-class conversations, and/or computer-mediated or computer-supported instruction. In shell courses, teacher-led approaches are largely not possible because students enrolled in a given class are working on a variety of modules. Some instructors viewed a teacher-led approach as key to helping students see connections across concepts. One instructor stated, "So in class, you make that kind of connection because you're able to lecture them, and you're able to show them the connection." Another instructor believed lecture fulfills the needs of many developmental students, saying "I don't think there's any time you can totally get rid of lecture. I mean, especially with nontraditional students. I think they need to hear something, need some visual examples to kind of follow through." These types of perspectives drove many colleges to offer stand-alone courses in order to preserve a traditional teacher-directed class format.

On the other hand, faculty described the challenge of teaching a course with so few instructional days. When accounting for the class periods when tests are administered, some colleges have as few as 6 days of instruction per module in stand-alone courses. Many faculty reported feeling constrained within this structure; for instance, one interviewee stated: "Four weeks is not very long. If it's a review, they're fine in there. If it is really basically new material, then that's pretty fast." In a full-semester class, instructors have more latitude to spend more time than anticipated on a topic in response to student needs. Additionally, some faculty wished for more time to draw connections across modules to ensure students were retaining and applying previously learned information. As one instructor explained:

> It makes it difficult to connect concepts all the way through, and it's always possible for someone to say, "When you're teaching this, you just show them where all of this stuff connects in." And ideally, you do that, but then in a four-and-a-half-week class when you've got to give two tests and a final exam, it can get difficult to cover all the new material.

Students confirmed that the pace of instruction presented challenges, one expressing that "for some it takes longer, some it doesn't. As you get into the units that are short, I don't like that. I just don't grasp that fast." Interestingly, while stand-alone courses allow for a wide range of instructional approaches (e.g., group activities, student-centered pedagogies), most instructors reported that they relied on lecture, in part because of pressure to cover a large volume of content in a short amount of time.

Relatedly, instructors described the lack of opportunity for relationship building in the shortened course timeframe. This was deemed important for efficacy of instruction, as described by a faculty member comparing teaching a 16-week course to teaching a 4-week course:

> This person is very timid, but really gets what's going on. This person is very vocal, has no clue what's going on. And so I am learning how to reach these people and reach them where they are and help them to learn. In four and a half weeks, that's pretty nearly impossible.

College administrators addressed this concern by using placement test and enrollment data to build course schedules that would allow groups of students to continue with the same instructor through multiple modules. Students at many colleges did report having the same instructor for more than one module, which might facilitate relationship building. However, such schedules typically do not accommodate students who need nonsequential modules (e.g., 1, 3, and 5) or students who do not successfully complete a module and must reenroll.

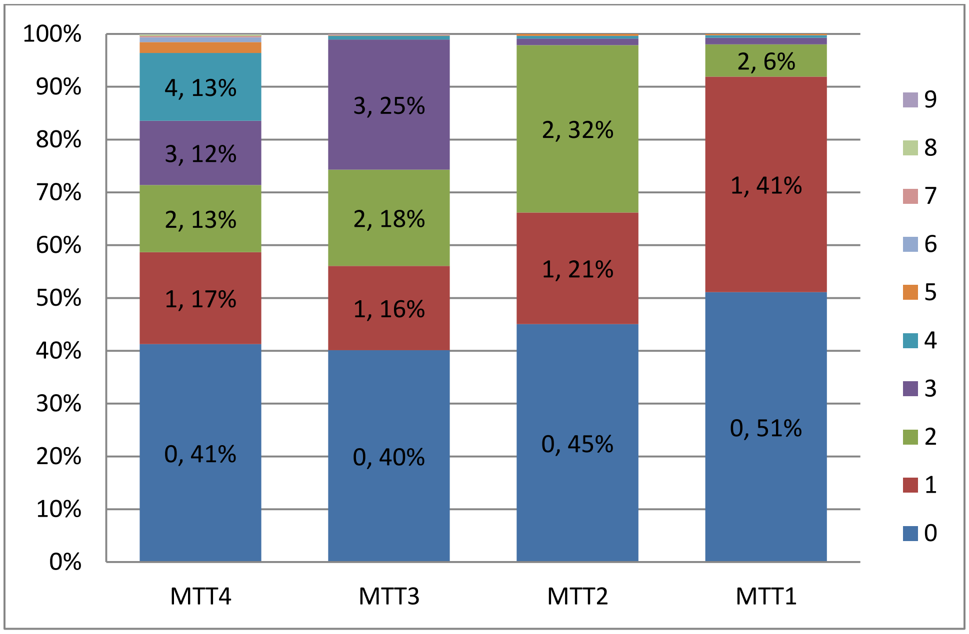
4.5 Computer-Mediated Shell Courses Allow for Personalization but Can Slow Student Progress

Like stand-alone courses, shell courses present unique benefits and challenges. Students in shell courses may be enrolled in any module. Thus, teacher-led, whole-class instruction is not feasible; students learn content primarily through instructional software. The course number designation indicates the number of credits in which the student is enrolled and the number of modules he or she is expected to complete. Multicredit shell courses (i.e., MTT2, 3, and 4 in Virginia) are longer than four weeks, alleviating concerns about within-semester exit points, relationship building between students and instructors, and scheduling and registration. However, as explored in this section, these courses present their own challenges related to student progress. In particular, the "self-pacing" enabled through computer-mediated instruction is a feature that students and faculty appreciate, but that also poses barriers to accelerated progress through the modules.

Student progress in shell courses. Analysis of transcript data suggests that most students in shell courses are making less progress than intended by the design of the course. Seventy-six percent of students who attempted one shell course of any length in the fall semester completed fewer modules than they needed to pass the course, while 3 percent of students completed more modules than required. Among students in Virginia who enrolled in a shell course in the fall, 55 percent enrolled in a four-credit shell (MTT4); 19 percent enrolled in a three-credit shell (MTT3); 14 percent enrolled in a two-credit shell (MTT2), and 13 percent enrolled in a one-credit shell (MTT1).

Figure 3 shows the rates of module completion broken down by the size of the shell course. The leftmost column represents module completion for students who attempted the four-credit course. Sixteen percent of MTT4 enrollees completed at least four modules; 41 percent completed zero modules over the 16-week semester. The rightmost column represents the one-credit shell course, which is intended for students who need only one module. Forty-nine percent of students who attempted this course completed at least one module. As the number of required modules per course increases, the percentage of students completing no modules mostly decreases, but the proportion of students passing the course also decreases. This suggests that with more modules to complete, students are more productive—that is, a larger proportion completes at least one module. However, with more modules to complete, fewer students are able to complete enough modules to pass the course.

Figure 3
Module Completion in Shell Courses by Number of Modules Required to Pass



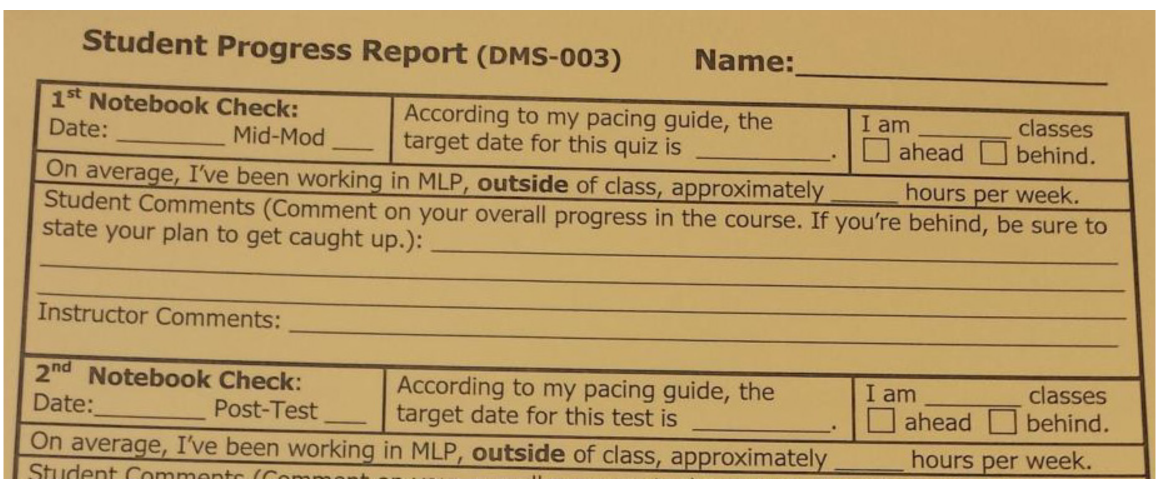
Shell courses are meant to create a student-centered, personalized learning experience in which the learner controls the pace at which the material is covered. However, as our descriptive findings suggest, allowing students greater control over their pace of learning does not always yield good outcomes. Interview respondents provided further insights into these trends. In traditional, teacher-led instruction, students are part of a class cohort progressing through material at the same pace, which is dictated by the instructor. In shell courses, without the traditional classroom's lecture-based structure and assignment due dates to help students remain on pace, many struggled to manage their time and make progress through the modules. This is the "dark side" of self-pacing: If courses are truly self-paced, depending on levels of student proficiency and motivation, some students may take a very long time to complete requirements.

One student described her own experience this way: "You definitely have to want to complete the units. It took me two semesters to finish four units. I kept putting it off. I'll do it tomorrow, I'll do it tomorrow." Faculty and administrators often wondered if this approach was appropriate for students referred to developmental mathematics, who may need additional support to direct their learning. One instructor reported:

> And the downside of it is that all of the motivation goes on the shoulders of the student. And so students who have a hard time motivating themselves, who have a hard time managing their time, simply don't get the work done.

Shell courses are described as self-paced, but this description belies the fact that the courses have an end date, after which students do not receive credit for modules that they have not completed. Most colleges attempted to address this issue by creating pacing guides and mechanisms for ensuring that students understand these pacing guides. For example, at one college, students must complete a pacing guide with a detailed class-by-class schedule of exactly which assignments they should have completed by which date to remain on target to meet the requirements to pass the shell course. In order to take a mid-module quiz or final module test, students must complete a graded progress report stating how many classes ahead or behind schedule they are (see Figure 4). This strategy ensures that students are aware of where they should be in the curriculum at any point if they want to complete the course on time.

Figure 4
Example of a Curricular Pacing Guide



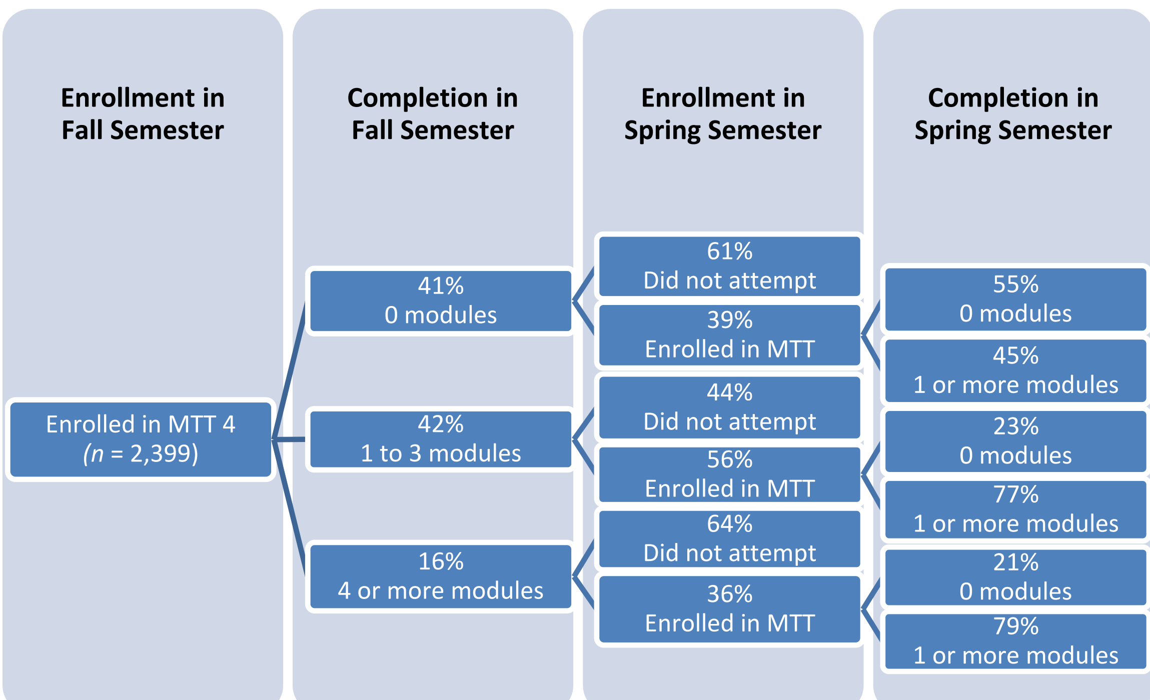
Student Progress Report (DMS-003) **Name:**__________

1st Notebook Check: Date: _____ Mid-Mod __	According to my pacing guide, the target date for this quiz is ______.	I am ____ classes ☐ ahead ☐ behind.
On average, I've been working in MLP, **outside** of class, approximately ___ hours per week.		
Student Comments (Comment on your overall progress in the course. If you're behind, be sure to state your plan to get caught up.):		
Instructor Comments:		
2nd Notebook Check: Date: _____ Post-Test __	According to my pacing guide, the target date for this test is ______.	I am ____ classes ☐ ahead ☐ behind.
On average, I've been working in MLP, **outside** of class, approximately ___ hours per week.		

Our analysis indicates students are completing four or more modules within a four-credit shell course at a low rate (i.e., 16 percent). Yet the ability for students to succeed slowly in self-paced courses might be considered a benefit rather than a drawback. "[T]he real surprise hasn't been the ones who've floored the accelerator," according to a 2014 blog post on the topic; "it's the ones who ordinarily would have given up and walked away, who are slowly plugging along" (Reed, 2014). Participants in our study affirmed this perspective to some degree, with some arguing that the flexibility afforded by shell courses is particularly appropriate for allowing developmental students to master content. As one faculty member explained, "The students who truly need more time to grasp a concept, they have that opportunity."

However, Figure 5 illustrates that, like in stand-alone courses, students who perform poorly in shell courses are less likely to reenroll in developmental math in the subsequent semester. The 42 percent of students in a four-credit shell course who completed one, two, or three modules in our analysis received a nonpassing grade on their transcript. Forty-three percent of these students went on to complete at least one module again the next semester (77 percent of the 56 percent who enrolled in a shell course in the following semester). However, failing to complete a shell course has clear implications for academic progress and may impact financial aid eligibility.

Figure 5
Enrollment and Completion Patterns for Students in Four-Credit Shell Courses



The shell course structure provides a substantial payoff for a small minority of students by accelerating their progress more quickly than the stand-alone course structure would have permitted. Four percent of students who enrolled in a four-credit shell course wound up completing five or more modules. These students saved time and money, as they fulfilled five or more credits of developmental requirements in a single semester, typically having only paid for four credits. Instructors often highlighted these students as success stories; for instance, one interviewee explained:

> She's got a chance of doing all eight units, in a semester. That's twice the work we expect from our students who pass. I mean, she has taken advantage of all of the flexibility that the system offers; it's a perfect match for her.

Instructional benefits and challenges. Stakeholders perceived both benefits and drawbacks to the instructional environment in shell courses. For example, students reported that the self-pacing of the shell courses provided greater flexibility, which if well utilized could lead to focused time to prepare for the final test. One student stated, "If you do keep up with it, you could get [the assignments] all done in two weeks and have the second two weeks to study, since you can go at your own pace." Some students also appreciated the independence; one commented, "It's pretty much you. So what you put in is what you're going to get out."

On the other hand, one challenge described by both faculty and students is the mix of students working on different modules enrolled in each course section. A single course section may have students in module 1 working alongside students working on the highest modules, which has implications for how faculty engage with and support students. For example, faculty may answer the same question posed by different students repeatedly throughout the semester as students work their way through content at different times. Students with questions during class oftentimes waited extended periods for one-on-one assistance from their instructor. According to one student, "We all are doing different stuff, and my teacher is running around in the classroom helping different people, and I get stuck, and he doesn't have time to just sit down and help me and explain it to me." These situations could lead faculty and students to view the computer-mediated shell courses as inefficient: Instructors felt they could not use whole-class instruction even when appropriate, and students perceived that their instructors were rushed in their one-on-one interactions.

The composition of students at varying levels in shell courses also made it more challenging for faculty to organize peer support as they might in a traditional class. A student described the experience this way:

> It's really discouraging when you are next to somebody that's [in a different module], and you are sitting there, and you are like, "Oh my God, I got to keep asking [the instructor] for help." If that person was on the same page, like you do in school, "Hey, can you help me?"

Some instructors addressed this challenge by grouping students working on the same modules in the same area of the classroom. This facilitated peer learning and also allowed students to listen when the instructor responded to questions from classmates working on similar content. Some colleges created restricted shell courses that were only open to students working on particular modules (e.g., modules 1–3). This practice introduced some scheduling and registration issues comparable to those of stand-alone courses, but it did allow for more small-group instruction and peer support within the class.

A second set of instructional issues emerged as a result of the computer-mediated mode of instruction that is standard in shell courses.[14] In addition to the flexibility of pacing described above, the computer software was perceived as offering students more choices in terms of instructional resources. Typically, students could access videos, e-textbooks, and several types of help features within problem sets. One student explained his preference for this mode of instruction over a traditional lecture course: "You pace yourself, and for me, I'm a visual learner, so it worked in my favor. . . . It had a lot of graphs and pictures and words. I like to learn like that." Some instructors also identified the multiple instructional resources as a benefit: "It gives students some choices they wouldn't otherwise have, in terms of how they learn and in terms of at what pace they learn."

Faculty in computer-mediated classrooms worked with students individually and, on occasion, in small groups, which some reported allowed for more individualized instruction than in a lecture-based model. On the other hand, many students remarked that they wished for more teacher-led instruction.

[14] At some colleges, stand-alone courses were delivered using computer-mediated instruction too.

> I was hoping to actually get taught. I mean, you can click through [the software] all day long; that doesn't mean you're going to be proficient at it when you put it down on paper.

Other students mentioned sentiments similar to those expressed by the student above—that they felt left on their own to muddle their way through material. For instance, one student stated:

> For thousands of years, people had to be taught by somebody to do something and now all of a sudden everybody is supposed to teach themselves. If that was the case, we wouldn't need college; everybody would educate themselves on the outside and then go make something of themselves.

These reflections demonstrate some students' beliefs that learning is best facilitated in a teacher-centered environment where students are positioned as receivers rather than producers of knowledge. The shell course structure disrupted student expectations, as it demanded that students play an active role in monitoring and deepening their own understanding of math. In addition to this shift in the role of the student in relationship to learning, the use of software as the mechanism for content delivery was further destabilizing for some students.

Some faculty felt that more teacher-led instruction could mitigate the challenges of fractured content in the modular curriculum, which they reported may be exacerbated when students learn primarily via software:

> This is what I mean: We have no glue holding this together; we have a bunch of isolated little blocks of facts. And frequently I find that I am lecturing on prior units at somebody's desk individually, because in my view, it's a lack of glue holding it together, which an instructor would have provided.

In this faculty member's view, teacher-led instruction would allow instructors to make stronger connections across modules than the connections drawn by the software. In this respondent's shell courses, she attempted to show individual students relationships between modules, but she wished for the opportunity to do so as part of whole-class instruction.

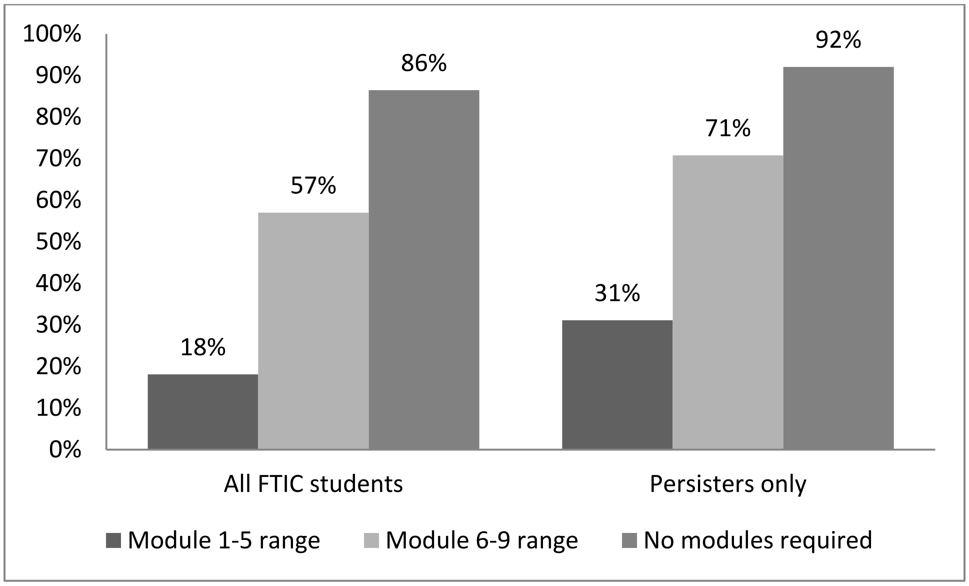
One way that colleges addressed these challenges related to computer-mediated instruction was by employing embedded tutors in their shell courses. At many colleges, enrollment in shell courses was capped at 20 or 25 students, with the intention of allowing for as much individual attention as possible.

4.6 Assignment to Remediation Still Proves a Stumbling Block to Enrollment in College-Level Math

Though modularization is viewed as a promising reform and has received positive reception from many of our interviewees, it is not a panacea to the nationwide problem of students getting "stuck" in developmental education. Across delivery formats, a large number of students in the study sample did not reach the intended redesign goal of completing all required remediation and progressing to college-level mathematics courses within one year of college entry.

Our administrative data from Virginia reveal that for students in the fall 2012 first-time-in-college cohort who placed into the module 1–5 range, only 18 percent attempted a college-level math course by the end of the fall 2013 semester; for students who placed into the module 6–9 range, that figure was 57 percent; and for students who placed out of all modules, it was 86 percent (see Figure 6). These rates may be partially attributable to general college attrition, particularly for the lowest placing students, who would have required two semesters to work through the modules required as prerequisites for most college-level mathematics courses. When the analysis is limited to only students who persist in the college through the following fall semester, the percentage of students attempting a college-level math course is higher. This suggests that strategies are needed to support students referred to developmental math (and particularly those placing into modules 1–5) in order for them to complete their requirements and enroll in college-math. Recommendations for colleges are presented in the section that follows.

Figure 6
Percentage of Students Enrolling in College-Level Math Within Three Semesters by Placement Level



Note. FTIC = first time in college.

5. Discussion and Conclusion

Findings from this analysis indicate that a modularized developmental math curriculum, coupled with a diagnostic placement test, can enable students to skip portions of the curriculum, creating opportunities for faster progress to college-level math than would have been possible pre-redesign. Yet large proportions of students testing into developmental math, particularly those testing into the module 1–5 range, are not enrolling in college-level math within one year. There are mixed opinions about the fracturing of mathematical content inherent to the modularized design. Modularization allows students to focus on fewer content areas at one time and allows them to recycle through smaller chunks of content until they demonstrate mastery. Yet the organization of content into smaller units may make it difficult for students to make connections across topics, retain information, and see the math covered in the modules as an integrated "sensible system." Both course delivery formats (stand-alone and shell) present advantages and drawbacks in terms of student progress, teaching and learning, and ease of implementation. These are summarized in Table 5.

Table 5
Comparative Summary of Course Delivery Structures

	Stand-alone	Shell
Benefits	• Teacher-led pacing supports students with weak time management skills. • Structure allows for a variety of instructional approaches (i.e., teacher-led or computer-mediated).	• Structure reduces exit points relative to stand-alone courses. • Student-led pacing allows students to spend more or less time on content according to their needs.
Drawbacks	• Structure increases exit points. • Short courses provide limited time for relationship building. • Scheduling and registration processes are burdensome.	• Students can stall or make very slow progress. • Mixed-enrollment classes limit instructional choices and necessitate computer-mediated delivery.

5.1 Tensions Between Student Autonomy, Mastery, and Acceleration

Findings from this analysis suggest that the theorized benefits of modularization, which include student-centered and personalized learning, enhanced mastery of content, and accelerated student progress through developmental math requirements, appear to be in tension with one another. The literature suggests that modularization can afford students greater control over their learning experience by allowing them to control the pace at which they move through material. In addition, a modularized curriculum is intended to give students enhanced opportunities for mastery, as students can recycle through challenging content or review discrete areas where they need more practice. The data from our study show that the diagnostic placement test allows students to skip modules, creating opportunities to accelerate their progress through developmental requirements. However, in practice, we find that the promises of greater autonomy, mastery, and acceleration are not always fully actualized, in part because of the ways in which the tensions among them play out in implementation.

For example, the states operationalized their stated goals for enhanced mastery by setting strict performance requirements for module completion; both North Carolina and Virginia set minimum passing scores for end-of-module assessments. In many colleges, students are not permitted to take the final test until all other assignments are completed with a satisfactory score (often 80 percent or above). In shell courses, students can stall in an effort to reach target scores on homework and quizzes, and they may find themselves retaking quizzes and the final test multiple times until the minimum score is reached. In stand-alone courses, which have few instructional days, faculty report that it is difficult to cover the material, make connections across modules, and tailor instruction to students' needs. In order to cover the material in depth and to provide more conceptual instruction, thus promoting mastery, faculty often reported that they needed more instructional time. The fixed time frame of stand-alone courses makes allowances for retesting more unlikely; thus, students who fail the final test typically must repeat the four-week course, slowing their progress through the sequence.

One of the perceived advantages of the shell course structure is the opportunity it provides for student autonomy. However, our findings for shell courses suggest that greater student control may not always yield positive outcomes in terms of completion of modules. Without strict deadlines, many students flounder and do not make substantial progress through the sequence. This challenge may be particularly acute for students with limited time management skills, negative perceptions of math, or weak foundational math knowledge. The enhanced teacher-directed structure of stand-alone courses alleviates concerns about greater student control leading to deceleration, but it allows for less personalization. Students lose the ability to work at their own pace and have fewer choices in terms of their learning when the instructor leads class activities. Similarly, colleges that set firmer deadlines or enhance the structure of their shell courses (a logical response to slow student progress) may not realize the theorized benefits accorded to a student-paced model of instruction.

Reformers should keep these tensions between student autonomy, mastery, and acceleration in mind when considering a modularized curriculum and course structure. Colleges will likely need to make trade-offs resulting in one or more of the following: slower student progress, less personalization of instruction, lower performance benchmarks, or fewer topics covered.

5.2 Recommendations for Colleges

As the findings presented in this paper indicate, modularization, as a reform to developmental mathematics, cannot be disentangled from the implementation choices colleges make. In addition to creating a curriculum, which involves decisions about which content belongs in which module, reformers must make significant choices regarding course structure and instructional design. Those decisions impact student and faculty experiences and have implications for student success. Yet despite the drawbacks of each delivery format, we find that colleges in North Carolina and Virginia are making refinements to their approaches that show promise for optimizing implementation. In closing, we summarize a few examples of these strategies.

Match students to the optimum delivery format. Numerous respondents noted that some students do better in shell courses and others do better in stand-alone courses. Thus, colleges may want to devise strategies to evaluate which format is better for which students when an option is available. However, determining which students will benefit from which course structure may not be straightforward. Notably, many participants in our student focus groups who reported feeling successful in computer-mediated shell courses acknowledged apprehension about the course structure going in, and thus may not have selected it if given a choice. Assumptions about which types of students thrive in each environment were inconsistent; some college stakeholders reported that older students struggle in shell courses, while others said they were more likely to succeed in them. Colleges looking to match students to the best format may consider internal analyses to understand comparative success rates (e.g., are repeaters more successful in stand-alone or shell courses?). A few colleges that offer both stand-alone and shell courses include questions related to students' ability to learn in a computer-mediated environment in advising sessions to determine a recommendation on the best course format. Surveys of this type could be useful and provide additional variables for analysis.

Identify and address instructional challenges in selected course formats. Stakeholders we spoke with mentioned a range of instructional challenges, which vary according to course structure. Colleges may survey faculty and students to identify the curricular and pedagogical issues most prevalent their context so that appropriate refinements can be devised. In stand-alone courses, relationship building and instructional time emerged as prominent issues. In shell courses, instructors reported challenges related to supporting students in multiple modules, facilitating peer-support networks, maintaining student motivation and engagement, and supplementing instruction provided by computer software. Professional development and/or faculty inquiry on these topics could generate approaches to address these challenges. Other resources, such as embedded tutors and instructional technology, may be deployed strategically to address specific gaps in student learning. Across both course structures, instructors reported challenges in supporting students in making connections across modules and developing their conceptual understanding. Revised curricular materials and varied instructional methods (e.g., student-centered strategies) may help students to see math as more than a sequence of unintegrated topics. Relatedly, a critical assessment of the volume of assignments and practice problems may reveal irrelevant and duplicative content, which when eliminated may allow for more in-depth exploration of content areas.

Support student acceleration through triage and incentives. To improve student progression in shell courses, colleges should consider ways to make pacing benchmarks clearer to students and to encourage efficient progress through a system of incentives and triage. For example, one college in our sample allows students who are on pace with assignments to miss class sessions without penalty. Thus, students who demonstrate an ability to manage their own progress are given greater autonomy, while students who struggle to keep up with the work are subject to more oversight. Specific and explicit instruction in time management and organizational skills, perhaps via a linked student success course, may address these issues as well. In stand-alone courses, interventions should be devised to encourage continuous enrollment to minimize exits from the sequence. Assigning college staff to monitor student enrollment and ensure rapid reregistration could facilitate this. Alternatively, automated systems in course-management software could default to enrollment or reenrollment, depending on course outcomes.

Target instructional support for students with the greatest needs. Finally, colleges should identify students in need of additional support, a group which likely includes students placing into the lowest level modules and students who fail modules (both groups are more likely to drop out of the developmental sequence). One college in our sample requires students who fail a stand-alone course to repeat the module in a computer-mediated classroom with other students who have failed a module. This format is designed to allow students to focus on the content areas within the module with which they struggled, and to receive more targeted support from the instructor. Some faculty perceived that students with greater math needs would benefit from deeper relationships with instructors and peers and from more teacher guidance on meeting course deadlines. Further analysis of outcomes in courses that group modules 1, 2, and 3, offered at a few colleges, may provide insight into whether a semester-long, teacher-led format serves these students more effectively. Other models mandate tutoring for students with the greatest needs. Some colleges employ dedicated staff to support developmental mathematics students; these individuals can monitor student progress and provide targeted early-alert counseling and support to students who are not making progress in the sequence.

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