# A Call To Action to Expand Access to Statistics

Statistics is increasingly regarded as the most relevant mathematics content for many students' academic and career goals, but, traditionally, many colleges have offered statistics only to a handful of students after they have completed College Algebra or Intermediate Algebra. This creates artificial barriers for students and decreases overall student success and completion.

The Charles A. Dana Center is compelled to release this call to action to encourage mathematics departments to expand access such that more students are allowed to enter directly into Introductory Statistics, and to eliminate or replace stand-alone prerequisite courses that do not adequately prepare students for statistics content.

*__The Charles A. Dana Center at The University of Texas at Austin__ is committed to promoting equity and access to quality math and science education for all students. Through the Dana Center Mathematics Pathways (DCMP), we promote course structures that support college students to: 1) learn mathematics content that is rigorous and meaningful to their lives; and 2) progress towards timely completion of a certificate or degree.*

## We Believe

- It is essential that colleges offer options that allow more students to enter into Introductory Statistics courses in a timely fashion.
- Prerequisites for Introductory Statistics should only include courses with a *primary* objective of teaching students essential skills for mastery of Introductory Statistics content. Allowances should only be made for minor additions of content based on programmatic or general quantitative literacy needs.

## We Recommend

Mathematics departments should:

1. Examine Introductory Statistics to identify the essential skills students will need to be prepared to master the content. Define those skills as prerequisite skills for Introductory Statistics.
2. Establish appropriate guidelines for placing students into Introductory Statistics based on the identified prerequisite skills.*
3. Identify and provide appropriate academic and nonacademic supports for underprepared students that best align with the prerequisite skills for Introductory Statistics.

* An analysis by leading statistics educators, "Mathematics Prerequisites for Success in Introductory Statistics," is available at www.dcmathpathways.org.

## Rationale

Our call to action is based on four points:

- An analysis of prerequisite skills for Introductory Statistics does not support the need for algebraic-intensive prerequisites such as College Algebra or Intermediate Algebra.

Therefore, courses and course sequences should be designed to achieve desired learning outcomes.

- Mathematics professional associations support removing College Algebra and Intermediate Algebra as prerequisites to Introductory Statistics. It is important, then, to review gateway courses and their prerequisites to ensure that students are adequately prepared for their programs of study.
- Colleges from across the country are providing empirical evidence that students can be successful in Introductory Statistics without algebraic-intensive preparation.
- The negative impact of long course sequences on student success outweighs the positive impact of increased preparation from traditional algebraic-intensive courses. Accelerated sequences improve long-term student outcomes.

We discuss these four points in more detail below.

## Courses and course sequences should be designed to achieve specified learning outcomes.

Effective course design is predicated on the concept of beginning with the end in mind. In other words, one designs a course and course sequences to achieve desired outcomes for students. The Dana Center recommends that faculty engage in a process of identifying appropriate prerequisite skills for statistics and that they use these findings to determine if there is a need for prerequisite course requirements (see Appendix A for an illustration of this process).

The criteria for the identification of a prerequisite skill are:

1) The skill will not be taught in the Introductory Statistics course, and
2) Students will need the skill in order to understand or do specific task(s) in statistics.

Many statistics educators have made the case that the learning outcomes for algebra-intensive courses are not necessary for Introductory Statistics. To clarify this issue, the Dana Center asked three leaders in statistics education to write an analysis on prerequisite skills that students need to be successful in a college-level statistics course. In *Mathematics Prerequisites for Success in Introductory Statistics*, which has been endorsed by the board of the American Mathematical Association of Two-Year Colleges, the authors identify prerequisite skills that include some algebra topics covered in Beginning and Intermediate Algebra courses. However, these skills are not well aligned with the full set of learning outcomes typical for Beginning and Intermediate Algebra courses. Thus, we conclude that underprepared students would be better served by a non-algebraic intensive course. In addition, we believe that the recommendations for prerequisites for Introductory Statistics do not preclude algebra, but rather identify the essential elements of algebra and other math topics that are necessary for student success.

**Note:** *We do recognize that there may be a few topics included in a prerequisite course that are necessary to meet program needs or to generally prepare students for the quantitative reasoning skills required of citizens and consumers in today's society. For example, an understanding of exponential growth is an important quantitative reasoning skill, but it is not necessary for statistics. Any topic added under this category should be supported by substantive evidence that it is essential. Be wary of arguments using vague terms, such as "mathematical maturity" or "logical thinking," to contend that certain topics are necessary. The types of skills that often fall under such labels can be developed through a rigorous treatment of any mathematical concept.*

## Mathematics associations support the review of gateway courses and their prerequisites.

The Mathematical Association of America (MAA) and the American Mathematical Association of Two-Year Colleges (AMATYC) both published recommendations that provide guidance on prerequisites for gateway or entry-level mathematics courses (see Appendix B for a glossary of terms).

The MAA's 2004 Committee on the Undergraduate Program in Mathematics (CUPM) curriculum guide lists Introductory Statistics as one of a suite of entry-level courses that should be offered as an alternative to College Algebra (p. 28). Thus, it follows that the MAA authors consider Introductory Statistics to be a gateway course that should be offered without a College Algebra prerequisite.

The AMATYC position is summarized more concisely in the association's *Position on The Appropriate Use of Intermediate Algebra as a Prerequisite Course* (2014): "Prerequisite courses other than intermediate algebra can adequately prepare students for courses of study that do not lead to calculus." It is logical to conclude that, if Intermediate Algebra is not a necessary prerequisite, then College Algebra is also not a prerequisite.

## Students can be successful in Introductory Statistics without algebraic-intensive preparation.

Empirical evidence supports the idea that students who do not place as college ready and have not taken College Algebra or Intermediate Algebra can be successful in Introductory Statistics courses. This evidence directly contradicts the assertion that students must be placed into prerequisite algebra courses in order to succeed in Introductory Statistics.

Three major initiatives have worked with colleges to offer accelerated year-long statistics pathways: the Carnegie Foundation for the Advancement of Teaching's Statway, the California Acceleration Project, and the Dana Center Mathematics Pathways.

Each of these initiatives promotes placing students who are not college ready into a first semester course designed to prepare them for statistics and/or that starts students directly in statistics content with just-in-time supports. The first semester is followed by a college-level, transferable course that meets state learning outcomes for Introductory Statistics. Across these three initiatives, over 40 colleges in multiple states have implemented accelerated statistics pathways. The results described below provide encouraging evidence of their success.

> *"We now have a compelling body of evidence, both from large quasi-experimental studies and a large randomized controlled experiment, that students labeled 'underprepared' in math can do well in a rigorous Introductory Statistics course without intensive algebra remediation. Streamlining remediation to align with college course requirements holds great promise for improving completion rates and helping more students realize education's promise."*
>
> *Professor Myra Snell*
> *Co-Founder, California Acceleration Project*

***Statway*** – *Fifty-one percent* of all Statway students successfully completed the full pathway (had a grade of C or higher in the final term) and *earned college credit for statistics* in 2011–2012. Data from Statway colleges revealed that only 5.9% of non-Statway developmental mathematics students received credit for college-level mathematics in one year (Yamada, 2014).

***California Acceleration Project (CAP)*** – In high-impact, accelerated statistics pathways in CAP colleges, *students' odds of completing statistics with a C or higher were 4.5 times higher than in traditional remediation*, in which they could complete any transfer-level math (Hayward & Willett, 2014).

***Dana Center Mathematics Pathways (DCMP)*** – In the first year of the DCMP, *student completion of college math more than tripled*, increasing from 8% for students in traditional remediation to 30% for students in the redesigned pathways. Completion rates were even higher in colleges that encouraged students to enroll in statistics as their second course—in these colleges, *49% of students received college credit in statistics in the first year* (Rutschow & Diamond, 2015).

It is important to note that these rates indicate success over the full pathway and not specifically in the statistics course. Success rates for students for the college-level course itself are much higher. While we do not have data for individual courses in Statway or CAP, in the DCMP, 70% of students who enroll in statistics pass the course. These initiatives provide evidence that, with carefully designed pathways, even students who place below college-level can be successful without extensive remediation in algebra.

## Acceleration improves students' long-term outcomes.

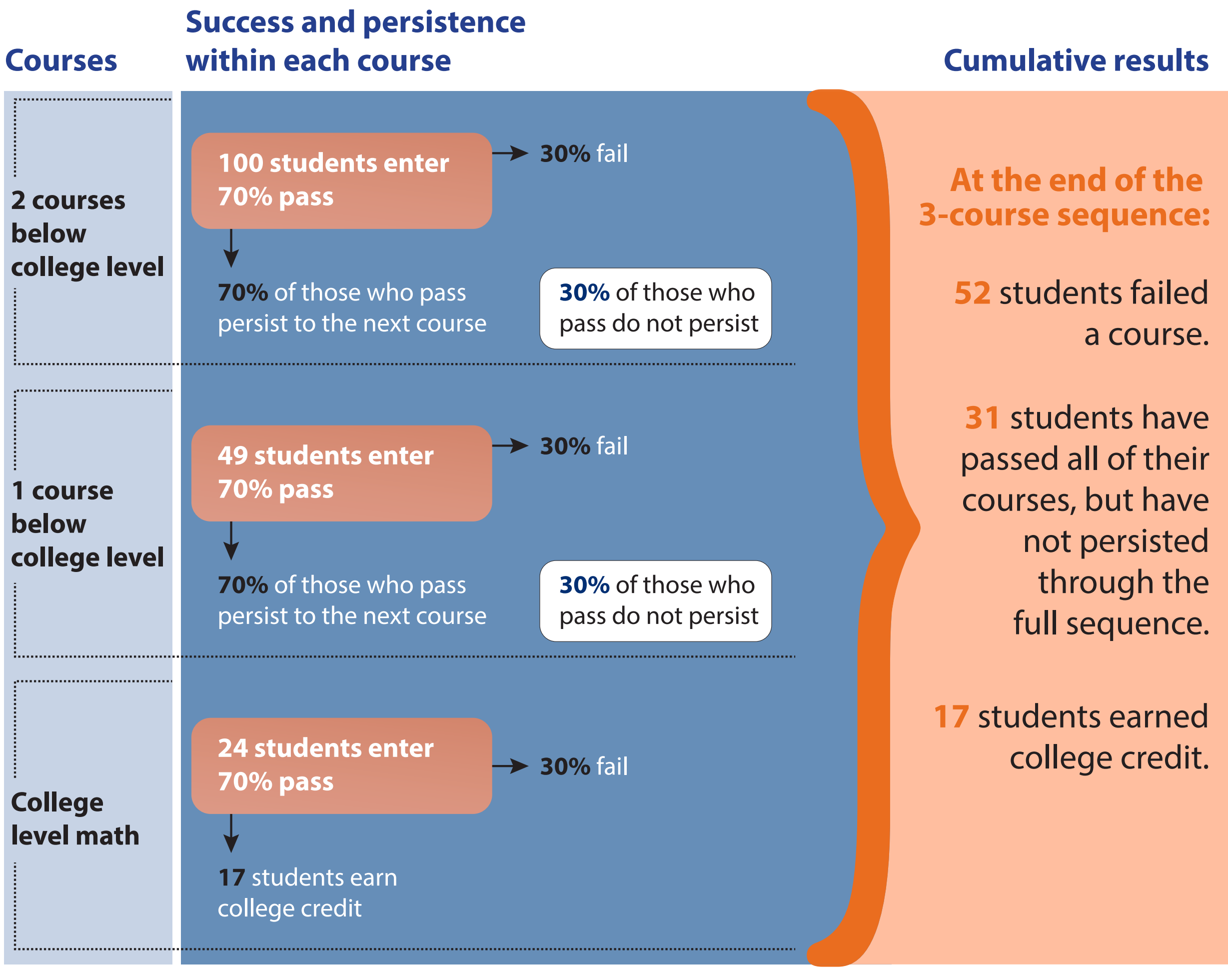
Individual Introductory Statistics courses with more prerequisite requirements may have higher success rates than accelerated programs such as those mentioned above. However, it is important to remember that meaningful student success is defined by the completion of a certificate or degree. It is imperative, then, that we examine student success in terms of long-term outcomes.

Adding requirements certainly ensures that a more prepared set of students will be in the course and should, therefore, increase success rates within that one course. However, a review of what happens to students over a sequence of courses demonstrates that longer sequences have a negative impact on student success.

Student completion rates in college-level math drop with each additional level of remedial coursework required. Researchers using large, national data sets have found that students placed three levels down from college math go on to pass the college-level course at a rate of just 10% (Bailey, 2009). As students fall away at each level, the pool of continuing students becomes smaller until only a fraction of the original group remains to complete the sequence (Hern, 2010).

In "Exponential Attrition and the Promise of Acceleration" (Hern, 2010), math faculty member and co-founder of the California Acceleration Project, Myra Snell, is described as coming to the realization that, "even if her department could raise course success and persistence rates to levels they had never seen, they would only see modest gains in that completion rate. The problem was the length of the sequence" (p. 2). Snell summarized this problem in the "multiplication principle" model, illustrated in Figure 1. The model shows the progression of students through a three-course sequence, assuming success and persistence rates of 70% in each course. Persistence rate refers to the percentage of students who pass and enroll in the next course.

**Figure 1. The effect of multi-course sequences as described in the "multiplication principle"**




As Figure 1 demonstrates, only 17% of students will successfully complete a three-course sequence even with relatively high success and persistence rates of 70%. Thirty-one percent pass every course but do not complete the sequence, and 52% fail a course. One might dismiss the 52% as those students who were unable to master the content, but most faculty members will point out that a significant proportion of students fail a course due to financial difficulties or family obligations such as loss of child care, family illness, or moving for a new job. Long course sequences compound these problems. It is likely that fewer students would fail if the course sequences were shorter.

Data from the California community college system (Hayward & Willett, 2014) and the national data referenced above have verified that the multiplication principle is an accurate portrayal of the negative impact of long course sequences on student success.

This is not to say that prerequisite requirements are inherently harmful to student success. Prerequisites are appropriate when they increase the overall rate of student success in completing a sequence. Gains made in student success due to greater preparation should outweigh the inevitable losses from attrition and failure in multiple courses. As data from Statway, CAP, and DCMP demonstrate, there is mounting evidence that more students successfully complete Introductory Statistics when they are placed into an accelerated sequence with content that directly prepares them for statistics. Not only do more students in these programs earn credit in statistics, but they also do so in less time. If students who are not college ready are able to accomplish this without algebraic-intensive coursework, college-ready students going directly into Introductory Statistics are also likely to be successful.

## Conclusion

Mathematics faculty care deeply about their students and are rightfully cautious about changing existing structures without strong evidence of a benefit to students. This call to action summarizes such evidence in terms of effective practices in course design, recommendations from mathematics professional associations, empirical evidence demonstrating student success in Introductory Statistics, and data on the consequences of long course sequences on student persistence and success.

Much of this evidence requires a shift in perspective on how we measure student success. It is natural for faculty to view student success only in terms of course outcomes—the students sitting in our classrooms are visible and real to us. However, this view ignores the many students who never get an opportunity to enter those classrooms. The full picture of student success comes from looking at the progression through a sequence of courses and on to completion of a degree or certificate and seeing the students who are lost along the way.

We hope this call to action will encourage mathematics departments to evaluate prerequisite and placement requirements for Introductory Statistics to ensure that each requirement is necessary and will increase the *overall* rate of student success. We believe that such an evaluation will lead to the conclusion that algebraic-intensive coursework or placement standards are unnecessary barriers to student success.

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## Appendix A. Process for backward-designing an Introductory Statistics course and course sequence

**Determine the expected learning outcomes** for students in Introductory Statistics courses.

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**Determine the content** (essential knowledge, skills, and concepts) that students need to learn in Introductory Statistics

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**Identify the essential prerequisite skills** necessary for students to succssfully master the content for Introductory Statistics.

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**Determine the learning outcomes for any prerequisite courses and the requirements for placement,** using the prerequisite skills for Introductory Statistics.

## Appendix B. Glossary of Terms

**Academic and non-academic supports** – A wide variety of instructional methods, educational services, or school resources provided to students in an effort to help them accelerate their learning progress, catch up with their peers, meet learning standards, or generally succeed in school.

**Acceleration** – Generally, this term can refer to any structure that accelerates the progress of students from developmental math through college-level math in comparison to the traditional sequence, which typically has at least three levels: Beginning Algebra, Intermediate Algebra, and College Algebra.

**Backward design** – A method of designing educational curriculum by setting goals before choosing instructional methods and forms of assessment.

**Developmental mathematics** – Mathematics courses designed for students who have been deemed underprepared for college-level mathematics content.

**Gateway course** – The first course that provides transferable, college-level credit allowing students to progress in their programs of study. College Algebra is currently the most common gateway course in mathematics. The Dana Center Mathematics Pathways model is based on the principle that either Statistics or Quantitative Literacy should be accepted as the gateway mathematics course for many programs of study.

**Just-in-time supports** – On-demand assistance provided to students when they need it.

**Learning outcomes** – Statements that specify what learners will know or be able to do as a result of a learning activity or course of study. Outcomes are usually expressed as knowledge, skills, or attitudes.

**Multiplication principle** – Thought experiment showing how developmental education courses that serve as prerequisites for Introductory Statistics serve as barriers such that only a small percentage of students are given the opportunity to take Introductory Statistics. The multiplication principle shows that the length and linear characteristics of the typical sequence to Introductory Statistics for underprepared students reduce their chances of success.

**Pathways** – A mathematics pathway is a mathematics course or sequence of courses that students take to meet the requirements of their programs of study. The concept of math pathways applies to pathways for college-ready and underprepared students.

The word *pathway* is used in multiple ways in education. Sometimes it refers to pathways from K–12 to higher education. It can also refer to program or career pathways. In the context of developmental mathematics reform, pathway refers to course sequences that allow developmental students to take mathematics courses with content aligned to different programs of study. The DCMP has three pathways: Statistics, Quantitative Literacy, and STEM Prep. In the DCMP, the term *pathway* also refers to the development of the curricular materials based on common design principles, structures, and organization. Consistent expectations, use of terminology, and integration of student success strategies create a coherent and consistent experience for students as they move through a sequence of courses.

**Placement policies** – The term *placement* often refers narrowly to the assignment of students to college courses according to an examination of student mathematics, reading, and writing skills. Some experts recommend a more comprehensive definition of placement as an informed and well-rounded process that is intentionally supported by educators, advisors, and students, and that is based upon information about student goals, prior academic experiences, outside-of-school obligations, attitudes, beliefs, and an assessment of academic skills.

**Prerequisite courses** – Courses that students are required to complete before enrolling in another course. They are intended to prepare students for success in a subsequent course.

**Program of study** — The set of courses, learning experiences, and learning outcomes required for a credential. Departments within colleges and universities define programs of study.

**Remedial education** – Instruction and support for students who are assessed by their institution of choice as being academically underprepared for postsecondary education. The intent of remedial education is to educate students in the skills that are required to successfully enter and complete a program of study. [Also variously described as *developmental education, college prep, basic skills education* and other labels, all referring to pre-collegiate work.]

**Stand-alone courses** – Non-degree-applicable credit courses and degree-applicable credit courses that are not part of an approved educational program.

**Timely completion** – The completion of credits required for a program leading to a degree or certificate of value within a recommended timeframe, generally within six years of entry into a program of study.

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## About the Dana Center Mathematics Pathways

The Dana Center Mathematics Pathways (DCMP) is a systemic approach to dramatically increasing the number of students who complete math coursework aligned with their chosen program of study and who successfully achieve their postsecondary goals. The DCMP was initially launched as the New Mathways Project (NMP) in 2012 through a joint enterprise with the Texas Association of Community Colleges. For more information about the DCMP, see www.dcmathpathways.org