

Colorado Math Pathways Task Force: Report and Recommendations

“Strengthening student success in the study of mathematics; increasing timely completion of the appropriate gateway math course for the degree program; and ensuring transferability of credits.”

Table of Contents

- Executive Summary
- A Letter from Lt. Governor Joseph A. Garcia
- Introduction
- Background
 - gtPathways State General Education Core
 - Dual Enrollment
 - Developmental Education Redesign with Co-Requisite Instruction
- Process
- Findings and Recommendations
 - Curriculum
 - CalcPath
 - StatPath
 - QuantThinkingPath
 - Pathways Exceptions
 - Advising
 - Meta-Majors
 - Multiple Measures of College Readiness
 - Coordinate with Partner Disciplines
 - Support and Professional Development
 - Communication
- Infrastructure for Implementation of Recommendations
- Steps for Implementing Recommendations
 - Curriculum Working Group
 - Advising Working Group
 - Support and Professional Development Working Group
 - Communication Working Group
 - Policy and Transfer Issues Working Group
- Appendix A: Membership
- Appendix B: Gateway mathematics courses and gtPathways participation
- Appendix C: Initial Data Pull
- References

Executive Summary

A primary concern driving the task force's work is that college freshmen and dually-enrolled high school students are often advised into college algebra by default even though it may not be appropriate math preparation for the degree program the student will eventually choose. The Colorado Math Pathways Task Force's overall goal is to:

Develop expectations and processes that result in each institution of higher education in Colorado offering pathways in mathematics that yield (1) increased success for students in the study of mathematics; (2) a higher proportion of students completing in a timely manner the appropriate gateway math course(s) for their intended degree program; and (3) effective transferability of credits for students moving from one institution to another.

Recommendation 1: Curriculum. Math pathways must be revised, with well-defined courses, to ensure students choose the most appropriate path as indicated by their intended major. The 3 pathways should be:

- a) Calculus Path – STEM, certain health sciences, and many business programs;
- b) Statistics Path - Social & Behavioral Sciences; and
- c) Quantitative Thinking Path - Arts & Humanities.

Recommendation 2: Advising. Includes the use of:

- a) meta-majors, which are groups of majors with similar core requirements, aligned with a math pathway, where all coursework applies to degree requirements of any major within the meta-major. This helps students and advisors choose a path based on the student's interests and helps prevent loss of credit due to transfer between majors;
- b) multiple measures, such as the rigor of a student's high school curriculum and GPA, to assess college readiness for placement, rather than sole reliance on ACT, SAT or Accuplacer scores; and
- c) better coordination with partner disciplines to select the most appropriate math course for the major, rather than defaulting to college algebra.

Recommendation 3: Support and Professional Development. To provide sufficiently diverse math pathway course offerings and adequately prepared instructors, the task force recommends:

- a) provide system-wide resources to expand the instructor base;
- b) new instructors be mentored by a "master" instructor or course leader;
- c) supply instructors with well-developed syllabi and materials, especially materials that will support an active and engaged learning environment, including a repository of course specific information and resources to implement common assessments; and
- d) expand faculty professional development opportunities to allow for discussion about individual courses.

Recommendation 4: Communication. Use multiple venues to distribute recommendations.



1560 Broadway, Suite 1600
Denver, CO 80202

John Hickenlooper
Governor

Lieutenant Governor Joseph A. Garcia
Executive Director

Mathematics and Colorado's completion agenda **A letter from Lt. Governor Joseph A. Garcia**

It is projected that by 2020, 74 percent of jobs in Colorado will require postsecondary education/training. Colorado is ranked third nationally in terms of the percentage of jobs requiring postsecondary education or training for employment, thus highlighting the critical importance of increasing the number of credentials awarded. One way to increase completion is to develop effective math pathways that are aligned with career pathways.

The recommendations of the Colorado Math Pathways Task Force contained in this report have been implemented successfully in other states and have not only helped raise college completion rates, but have also increased student learning in mathematics courses. Moreover, these recommendations will provide students and families with the tools and knowledge they need to make informed decisions and will increase higher education access and success for the fastest growing demographic groups.

These recommendations align nicely with several other recent higher education initiatives in Colorado. The numbers of Colorado high school students enrolling in college-level coursework grows every year. About 26,900 students participated in dual enrollment programs in the 2012-2013 school year, or 22 percent of all 11th and 12th graders in Colorado public high schools. It is imperative that these young people receive adequate advising about which math course they need for their intended degree or career interests, rather than being placed into college algebra by default. As the cost of higher education and student loan defaults increase, we cannot afford to let young people waste time and money on coursework they don't need, thus delaying their entry into paying jobs even longer.

Remediation is another factor that delays students' entry into credit-bearing coursework. The Colorado Department of Higher Education's annual Remedial Report data show that students funneled into remedial courses have far lower completion rates than those students not required to take a remedial course. When examining remediation by subject, most students required remediation in mathematics. Many of Colorado's two- and four-year institutions are placing students with limited academic deficiencies directly into college level courses with co-requisite instruction (or Supplemental Academic Instruction-SAI). Math Pathways work well with this developmental education redesign because the most appropriate and contextualized math curriculum can be assigned based upon the student's major, such as STEM vs. non-STEM. These strategies appear to be working at the institutions that have implemented them because remedial rates have decreased and retention rates have increased.

I encourage you to consider how these recommendations may be implemented on your campus to increase student learning and success.

Sincerely,

A handwritten signature in cursive script that reads 'Garcia'.

Lt. Governor Joseph A. Garcia, Executive Director
Colorado Department of Higher Education



Introduction

The Colorado Math Pathways Task Force was convened in fall 2014 by the Colorado Department of Higher Education after Colorado was selected as one of six states to receive technical assistance from the Charles A. Dana Center at the University of Texas at Austin and Complete College America through the Building Math Pathways to Programs of Study Initiative. This initiative is designed to mobilize mathematics faculty leaders from 2- and 4-year institutions to design math pathways that will enable students to complete an appropriate gateway math course which will fulfill requirements for their chosen program of study within one year. (By “gateway math courses” the task force is referring to entry-level courses in mathematics or statistics that carry college credit.) This initiative is in line with the Colorado Commission on Higher Education’s (2012) master plan, [Colorado Competes](#). Senate Bill 10-003 charged the Commission with developing a master plan for Colorado higher education, which states in part, the master plan must:

...include accountability measures that will demonstrate that students receive high-value and high-quality educational services that are provided with the efficiency necessary to reduce attrition and increase retention and enable students to attain their degrees in a reasonable period of time, and to help ensure students achieve post-graduation success.

In summer 2012, Colorado math faculty, in collaboration with high school mathematics teachers, began the conversation about modernizing and aligning gateway math courses. Those initial conversations have grown into a coordinated project to differentiate Colorado’s three primary gateway math courses, create aligned and measurable learning goals, and ensure students are advised into the appropriate math courses based on their chosen major.

It was important from the beginning that the task force be faculty-driven to encourage buy-in statewide. The task force consists of thirteen experts in the field of mathematics, representing each of the three institutional sectors: 1) research, 2) institutions primarily granting bachelor’s and master’s degrees, and 3) institutions primarily granting associate’s degrees and certificates. The task force was supported by consultants from the Charles A. Dana Center and Complete College America, as well as staff from the Colorado Department of Higher Education (see Appendix A: Membership).

The task force’s overall goal is to:

Develop expectations and processes that result in each institution of higher education in Colorado offering pathways in mathematics that yield (1) increased success for students in the study of mathematics; (2) a higher proportion of students completing in a timely manner the appropriate gateway math course(s) for their intended degree program; and (3) effective transferability of credits for students moving from one institution to another.

The mission of the Colorado Math Pathways Task Force is to:

- a) Convene math faculty leaders to decide how well gateway math courses are aligned with programs of study;
- b) Draft a public statement on the importance of better alignment of gateway math courses with programs of study;

- c) Identify and/or suggest alternative gateway math courses, that are rigorous and of quality in content and competencies, and that are more appropriately aligned with the math skills students need to succeed in their programs of study; and
- d) Work with advisors and representatives from academic disciplines to review math requirements and consider alternative courses to college algebra for majors that do not ultimately require calculus.

Background

Colorado has thirteen public 4-year institutions, thirteen community/junior colleges as part of the Colorado Community College System, and two local district community colleges, Aims Community College and Colorado Mountain College. All community colleges participate in a common course numbering system. All of the 4-year institutions were invited to participate in the task force and nine sent faculty or department chairs as representatives. Colorado School of Mines is one of the 4-year institutions without a member on the task force, but the institution offers only engineering degrees, which require calculus as the gateway math course, and so will not be affected by the task force's recommendations. The community colleges were represented by two mathematics faculty, one of whom is also a director of assessment, and one System representative. The community college mathematics faculty, as well as the System representative, have been involved in related statewide initiatives and were recommended by System leadership.

Three related Colorado initiatives have bearing on the work of the task force: 1) gtPathways state general education core, 2) dual enrollment, and 3) developmental education redesign with co-requisite instruction. These three initiatives are described in detail below.

gtPathways State General Education Core

For more than ten years, Colorado has had a state, guaranteed-to-transfer, thirty-one credit general education curriculum that forms the core of all institutions' liberal arts and sciences general education cores and fulfills all lower-division general education requirements. This statewide general education core is known as gtPathways and currently has over 1,300 approved courses. Courses nominated for participation in gtPathways are reviewed by a peer, faculty discipline group and evaluated against state-approved sets of content and competency criteria. Appendix B contains a table showing gateway mathematics courses and gtPathways participation. Most of the gateway mathematics courses are gtPathways approved; those that are not are underlined in the appendix.

Compiling this information revealed several items that present a challenge to math pathways implementation. As reflected in Appendix B, associate of science (A.S.) degree requirements within the Colorado Community College System and at Colorado Mountain College do not allow MAT 135, Introduction to Statistics, to fulfill the math requirement (though it can be used to fulfill the math requirement for associate of arts (A.A.) degrees). Aims Community College does allow MAT 135, Introduction to Statistics, to fulfill the math requirement for an A.S. degree. Another item of note is that, although many national leaders in statistics and statistical education, including leadership of the American Statistical Association recommend no pre-requisite for Introduction to Statistics, three 4-year institutions in Colorado report that they require College Algebra as a pre-requisite. Last, several 4-year institutions do not offer an Introduction to Statistics course. These differences in mathematics requirements between institutions of higher education in offerings and degree requirements make it more difficult for students, especially those who transfer, to know which mathematics courses to take. Additionally, requiring pre-requisite

courses when they are not recommended by leaders in mathematics education extends students' time to degree completion, thus delaying their entrance into the job market and careers.

Dual Enrollment

Dual enrollment refers to programs whereby high school students are allowed to take college-level courses for credit. One of these programs, called "Concurrent Enrollment" in Colorado, was created by House Bill 09-1319 (§22-35-101 et seq., Colorado Revised Statutes). The following is summarized from Colorado's Annual Report on Concurrent Enrollment for the 2012-2013 school year, released on March 27, 2014 (Colorado Department of Higher Education):

- Approximately 26,900 students participated in dual enrollment programs of any type in the 2012-2013 academic year. This figure represents about 22 percent of all 11th and 12th graders in public high schools in Colorado.
- Overall, participation in dual enrollment programs increased by about 12 percent between 2011-2012 and 2012-2013.
- The Concurrent Enrollment program continues to see sustained increases in participation. During the 2012-13 school year, 3,945 more students participated in the program than in the prior year.
- In 2012-13, Colorado high school students attempted a total of 143,939 Concurrent Enrollment credit hours.
- The average number of credit hours attempted by all participating Concurrent Enrollment students was 7.9, with an average of 7.2 hours passed.
- A large majority of students—84 percent—passed all of their Concurrent Enrollment courses in 2012-13. This figure shows an improvement from the previous year's complete pass rate of 78 percent.
- Participation in remedial Concurrent Enrollment courses is approximately 6 percent of the Concurrent Enrollment total and is limited to students in their 12th grade year.
- 775 students in Concurrent Enrollment or ASCENT programs earned some type of postsecondary credential in 2012-13. This number is a 60 percent increase over last year's credential completion total.
- Students who participated in dual enrollment programs in high school had higher first-year credit hour accumulation, grade point averages, and retention rates in college.
- Participation in dual enrollment is associated with a 23 percent increase in the likelihood of enrolling in college and a 10 percent decrease in the need for remediation, holding gender, income, race/ethnicity, and ACT scores constant.

Dual enrollment in Colorado continues to grow and a concern is that high school students are being advised into college algebra as a default in these programs, even though college algebra may not be appropriate preparation for the degree program they will eventually choose. As a result, they may need to re-take a college-level mathematics course for their eventual major. In academic years 2013 and 2014, of the 9,865 dual enrollment high school students enrolled in math courses, 8,155 (83%) were in college algebra courses versus 1,477 (15%) in statistics courses and 233 (2%) in math for the liberal arts courses. These enrollment percentages are not reflective of actual degree seeking behavior; they should be if we were more skilled in helping students enroll in math courses based on their program of study. Furthermore, of dual enrollment high school students who completed college algebra (C- or better) in academic year 2013, only six percent went on to complete Calculus I (C- or better).¹ College algebra is seen

¹ SURDS data supplied by Colorado Department of Higher Education. AY2013 = Summer 2012, Fall 2012 and Spring 2013.

as foundational to calculus and much of the curriculum is designed to help students be successful in calculus. The low enrollment of these students in subsequent calculus courses further helps to illustrate the misalignment between current enrollment patterns and actual programmatic needs of students.

Developmental Education Redesign with Co-Requisite Instruction and Supplemental Academic Instruction (SAI)

Another initiative that significantly impacts the task force's work is the Colorado Community College System's recent redesign of their developmental education program, as well as state authorization for 4-year institutions to offer co-requisite instruction (or SAI) to students with limited academic deficiencies.

Many students who transfer into baccalaureate degrees begin their college careers at one of Colorado's fifteen community colleges. Colorado Community College System campuses (and soon, Aims Community College and Colorado Mountain College) offer students one of three pathways to 100-level mathematics courses, which include co-requisite instruction: 1) non-transfer for students pursuing certificates, AGS, and AAS degrees in Career and Technical Education (CTE); 2) non-algebra classes (i.e., math for liberal arts and statistics) for students pursuing AA (and at Aims, Associate of Science) degrees that will transfer into majors that do not require calculus; and 3) algebra pathway for students pursuing AA and AS degrees that will transfer into baccalaureate degrees that require calculus. These pathways can be viewed online at <https://resources.cccs.edu/education-services/developmental-education-task-force/developmental-education-redesign/>

The co-requisite instruction model for students with limited academic deficiencies is also scaling up statewide with passage of House Bill 12-1155, which created §23-1-113(1.5), Colorado Revised Statute. Prior to this law, a student admitted into a 4-year institution who scored below statewide cut scores (set by the Colorado Commission on Higher Education in collaboration with the institutions) was typically required to enroll in a community college for non-credit-bearing, developmental education coursework. However, Supplemental Academic Instruction (SAI), which is what Colorado law calls co-requisite instruction, allows many of these students to stay at their home institution and enroll directly into credit-bearing English and mathematics general education coursework offered co-requisitely with SAI, thus enabling them to finish college faster and with fewer obstacles. Furthermore, the credit-bearing English and mathematics courses taught co-requisitely with SAI are required to be pathways approved, thus ensuring transferability and applicability to lower-division general education requirements. Currently, Colorado institutions that are authorized to offer SAI are 1) Metropolitan State University of Denver, 2) Fort Lewis College, 3) Western State Colorado University, 4) Aims Community College, 5) Colorado Community College System's thirteen campuses (as noted above), and 6) University of Northern Colorado.

Process

The Math Pathways Task Force met six times, usually for four hours per meeting, between October 3, 2014 and April 3, 2015. The last, and seventh meeting, was a two-day retreat on May 18 - 19, 2015. The chair and state facilitator reviewed national and state reports and connected with leaders of other state task forces to share information. Though each agenda was generated by the chair with assistance from the state facilitator, the process followed was one recommended by The Charles A. Dana Center. This process has worked for other states doing similar work. Task force members considered reports and data from Colorado and other states, as well as national data. They also worked in small groups on specific assignments. "Homework" was assigned and completed in between meetings so that task force members could share information and get feedback from their colleagues.

The process had key steps: 1) approve a goal and mission statement; 2) define problems the task force wanted to address; 3) review data to identify problems; 4) brainstorm solutions and strategies; and 5) vet the solutions, strategies and final recommendations with a broad audience of higher education and K12 representatives. Once the task force completed a survey of each institutions' gateway mathematics courses (Appendix B), they noted which of those courses are gtPathways-approved, learned how many high school students are dually enrolled, and learned how co-requisite instruction can help align math pathways to get students directly into the math class most appropriate for their degree path. The task force then formulated questions for its first data pull and reviewed the data. The data helped the task force more clearly define the problems they wanted to address, as well as brainstorm strategies and solutions for final recommendations.

Findings and Recommendations

Our findings can be categorized into four main themes: 1) curriculum, 2) advising, 3) support and professional development, and 4) communication. The findings and associated recommendations in each category are as follows:

Curriculum

The task force concluded that math pathways must be revised, with well-defined courses, to ensure students choose the most appropriate path as indicated by their intended major. The task force recommends three pathways, QuantThinking, CalcPath, and StatPath. For existing state transfer agreements and for transfer agreements that emerge in the future, the task force recommends that competencies from the introductory course in each of the paths be provided to partner disciplines. Then those disciplines should select the competencies that are most relevant for students in their major. Based on those selected competencies, the math required for that major should align to one of the three pathways below. Recommendations for the three math pathways are as follows:

1. CalcPath

The CalcPath is for majors requiring calculus. It is recommended institutions develop structures that support these students to meet the goal of completing Calculus I within their first year of enrollment, thereby increasing the likelihood of degree completion in four years. Though the task force acknowledges this plan may not work for every student, institutions are encouraged to find ways to create support programs for less-prepared students so they can still achieve access to and completion of calculus in their first year of college. The traditional College Algebra course may be in this pathway; however, the task force generally recommends a Precalculus course that includes the content of college algebra and trigonometry for students who need a prerequisite course to Calculus. In any case, the task force recommends that College Algebra be used to prepare students for success in calculus and not as a terminal mathematics course for students in majors that do not require Calculus. It should also be noted that some institutions have different Calculus courses which have been contextualized to different majors; the task force is including all of these versions of calculus in its recommendations regarding the CalcPath.

Existing options for completing the CalcPath include:

- Go right into Calculus I;
- Take Pre-Calculus and then Calculus I; or
- Follow the path of College Algebra, Trigonometry or Pre-Calculus, and Calculus I. To achieve the goal of enrollment in Calculus I in the first year, it is suggested that students in this sequence enroll in courses in a co-requisite rather than pre-requisite pattern.

Potential options to help support students getting through Calculus I in their first year of study could include, but are not limited to:

- Co-requisite instruction/support;
- Stretch courses (The risk here is transferring before completing the entire course; thus, departments that opt for this model should be sure to clearly articulate the competencies achieved from each semester.);
- Online support modules; and
- Compressed/accelerated modules.

2. StatPath

The StatPath is for students in majors that require statistics or whose programs of study require an understanding of statistical methods.

The task force's recommendations for the StatPath include:

- A credit-bearing prerequisite should not be required for an introductory statistics course if students are college ready (that is, have GPA and/or test scores that indicate college readiness and/or have completed remedial coursework if needed, like *MAT 050: Quantitative Literacy*).
- The lower-division syllabi/content and names of the courses should be distinct from the upper-division courses. It should be clear to students who are required to take two statistics courses that the content in the two courses is different and that the upper-division course builds upon the foundation of the lower-division course. As an example, lower-division courses could be titled something like "Statistical Thinking" or "Introduction to Statistics" and upper-division courses could be something like "Statistical Methods for Business Majors" or "Statistical Methods for Psychology Majors").
- Use the Colorado Community College System's existing Introduction to Statistics content while also encouraging a modeling approach that provides students experiences using data and the appropriate use of technology to support data analyses.
- The Colorado Community College System and Colorado Mountain College should reevaluate their A.S. degree requirements to allow *MAT 135 Introduction to Statistics* to fulfill general A.S. degree requirements (Aims Community College already allows statistics to be used this way).

Our recommendation on the prerequisite for introductory statistics being *MAT 050 Quantitative Literacy* is consistent with the results from several initiatives that show students can be successful in introductory statistics without algebraic intensive prerequisites. Leaders in mathematics including the Charles A. Dana Center, the Mathematical Association of America, and the American Mathematical Association of Two Year Colleges support increasing access to introductory statistics by eliminating barriers such as unnecessary prerequisites.

The task force recognizes that there are some unique challenges to increasing the use of the StatPath. For example, at some institutions the fact that there are separate departments of mathematics and statistics can result in resource issues due to the possible shifting of student credit hour production from the mathematics department to the statistics department. Another challenge at some institutions is that there are not sufficient numbers of faculty available and adequately prepared to teach statistics. Our recommendations under Support and Professional Development below partially address this latter issue.

3. QuantThinkingPath

The QuantThinkingPath is envisioned as the pathway to provide a foundation in college-level mathematics for students in majors that require neither calculus nor statistics. This pathway may be a terminal math course for many

students but ideally it would encourage students to continue their study of mathematics and quantitative reasoning. The task force does not recommend any one particular course in the QuantThinkingPath. We recognize that institutions have differences in their missions and therefore in the needs of their students, but we encourage institutions to develop or modify existing courses to achieve the goals of this pathway.

Courses in the QuantThinkingPath might include, but are not limited to, a new algebra-based modeling course (see below) and/or a version of the existing *Math for the Liberal Arts* (MAT 120) course. These courses should have *MAT 050 Quantitative Literacy* as the developmental education prerequisite for students who need preparatory coursework. In addition, these courses must meet the state gtPathways/core general education requirement by addressing the state general education mathematics competencies. It is essential that courses in this pathway be rigorous and support problem solving, numerical skills, and reasoning skills.

For institutions that choose to retain the Math for the Liberal Arts type course, the task force has several recommendations: 1) better consistency across institutions in key topics for this course, 2) include financial literacy, descriptive statistics, and the use of algebraic models and algebraic reasoning, and 3) other topics to be determined. In general, the task force encourages more depth and less breadth. The course should focus more on problem solving and quantitative reasoning with less emphasis on the appreciation of mathematics. The goal is for students who successfully complete a *Math for the Liberal Arts* type course to understand how numerical and quantitative reasoning can be used to better understand the world, and to say “I learned something I can use” in my future studies, and as a citizen.

Another option for the QuantThinkingPath is an algebra-based modeling course. This course would be intended for majors that need some algebra skills but are not on a calculus path, and do not require the full content of college algebra. The algebra prerequisite should be minimal and we recommend *MAT 050 Quantitative Literacy* as the developmental education prerequisite. The task force acknowledges the description of this course is somewhat vague but institutions both within the state of Colorado and without have developed successful models. The task force is recommending the formation of a working group to address the development of this course.

Institutions may create other courses that could fall within this pathway, following the curriculum development processes at their institutions.

A staffing challenge for the QuantThinkingPath is similar to the one in the StatPath. Adjunct instructors for these courses are frequently selected at the last minute and, though they have sufficient background in mathematics, they often lack experience in teaching students who are not strong in mathematics and may even fear the subject.

4. Pathways Exceptions

The task force acknowledges there are some other pathways that are appropriate and recommended for certain specific majors, and they do not fit neatly into the three primary pathways. Examples of majors that may require alternative pathways include, but are not limited to, Early Childhood Education, Elementary Education, Architecture, and Business.

Advising

The second category of recommendations is advising. Advisors play an essential role in getting students into the gateway math course that best aligns with their programs of study. The task force investigation of state data into the current enrollment patterns of our students led us to make some key recommendations in advising practices that we

believe will make substantial contributions toward a better alignment of gateway math courses with programs of study.

From the initial data review, one compelling finding was the difference between the proportion of community college students who were enrolled in college algebra versus the proportion at 4-year institutions. Specifically, the percent of community college students enrolled in college algebra out of all students enrolled in the three major categories of gateway courses (college algebra, statistics, and a liberal arts math course) is roughly two-thirds whereas at most of the 4-year institutions it is below half. While there are likely a multitude of reasons for these differences, the magnitude of the difference raises questions as to whether the practice of advising large numbers of students at community colleges into college algebra is desirable. It is likely that students are being advised into college algebra in community colleges because advisors see that as a “safe” course to enroll in if a student does not know where they might transfer in the future or what their program of study will be. In fact, while currently over half of community college students go into college algebra, far fewer than half of their eventual majors will require college algebra. While credits in college algebra will certainly transfer to any 4-year institution, if the credits do not apply toward their eventual major then that transfer is not “effective.” Even in majors in which any college math course is allowable for the degree program, such as English or History, we think that a well-designed course in the QuantThinkingPath would be a much more relevant educational experience and be better connected to their program of study than college algebra.

Colorado has gtPathways for ensuring the transfer and application of course credits between 2- and 4-year institutions. With this policy, the state has made statewide transfer agreements a priority for students to move from 2-year to 4-year environments. These agreements are referred to as degrees with designation (DwDs). To the task force members, some of these transfer agreements’ math requirements do not make sense and need re-evaluation. Partner disciplines should be clear about the use of mathematics and statistics in their students’ studies and future careers. Mathematics departments should partner with those discipline departments to ensure that the math courses required in the degree programs are the ones best positioned to help students gain the quantitative reasoning skills identified as important by the partner disciplines. In particular, we discourage the use of mathematics or statistics courses designed as a filter into certain majors and specifically want to help partner disciplines identify mathematical competencies they most want their students to master to be relevant to their discipline.

Recommendations. The task force’s three advising recommendations include the use of meta-majors in advising, using multiple measures to assess college readiness, and better coordination with partner disciplines, each of which are discussed below.

1. Meta-Majors

Meta-majors are broad academic pathways, or groups of majors with similar core requirements, that are generally aligned with a math pathway. The three recommended math pathways described above, for example, would be aligned as follows:

1. CalcPath – STEM, certain health sciences, and many business programs
2. StatPath –Social & Behavioral Sciences
3. QuantThinkingPath –Arts & Humanities

Meta-majors help students and advisors make initial choices with the idea that students would eventually narrow their pathway to an individual major, preferably allowing all coursework in the meta-major to transfer and apply to degree requirements of any major within the meta-major. Rather than making College Algebra the default math

course, or using College Algebra as a mechanism to “weed out” students, meta-majors help advisors and students to select the appropriate math course for the career pathway, or meta-major.

2. Multiple Measures of College Readiness

The task force recommends that colleges use multiple measures to assess college readiness. In particular, the task force believes that high school GPA can be an effective tool in placement, though it is currently not on the list of state-approved indicators of college readiness. Per the Colorado Commission on Higher Education policy [I, E: Statewide Remedial Education Policy](#), high school GPA is not listed as a measure of college readiness for placement into credit-bearing coursework. The task force’s recommendation is to add high school GPA to the policy’s list of primary measures of college readiness, along with the current ACT, SAT, Accuplacer, and so on.

In a related recommendation, the tables that list cut scores to indicate readiness for college-level mathematics should include sub-scores that are aligned with the recommended math pathways courses. As a result, readiness for calculus will likely require a higher ACT score than readiness for a QuantThinking course.

3. Coordinate with Partner Disciplines

To promote better coordination with partner disciplines, the task force has three recommendations.

- Mathematics departments should work with partner discipline departments to identify the primary mathematical competencies needed by disciplines and use these determinations to select the recommended gateway math course and pathway. This coordination between departments will serve two purposes. First, it will ensure that the gateway math course is appropriate to the content and not simply selected based on previous practice or tradition. Secondly, setting one clear recommendation, as opposed to allowing “any gateway math course,” will be clearer for students and advisors.
- Chief academic officers should make review of the default mathematics requirements by all programs at their institutions an essential part of the regular program review process.
- Some of the [statewide transfer articulation agreements](#), which lead to degrees with designation, should be revisited to determine if the program requires the most appropriate mathematics or statistics course for the major.

Support and Professional Development

The third category of recommendations is support and professional development for college instructors. In the work of the task force, a number of barriers were identified that would prevent reform implementation and a number of these barriers were associated with staffing issues. As we mentioned above when discussing the StatPath, some institutions report difficulties in identifying sufficient instructors who are adequately prepared to teach statistics. More generally, introductory level mathematics and statistics courses are populated with many students who are not confident in their math skills and are sometimes marginally prepared for the content. Consequently, these courses are considered to be some of the most challenging to teach. Yet, the reality of hiring is that many sections are taught by part-time instructors who may have very little to no experience and/or time to prepare for teaching courses such as the introductory statistics course or the courses in the QuantThinkingPath. It is particularly important that instructors in gateway math courses are prepared to meet the needs and experiences of all learners by promoting an active and engaging learning environment.

Recommendations. In order to provide sufficiently diverse math pathway course offerings and adequately prepared instructors to teach them, the task force recommends the following:

1. Provide system-wide resources to expand the instructor base;
2. Have new instructors be mentored by a “master” instructor or course leader;
3. Supply instructors with well-developed syllabi and materials, especially materials that will support an active and engaged learning environment;
4. Provide a repository of course specific information;
5. Expand faculty professional development opportunities to allow for discussion about individual courses (for example at Faculty-to-Faculty Conferences); and
6. Provide resources to implement common assessments.

Communication

The fourth and final category of task force recommendations is communication. To help faculty and administrators implement math pathways effectively there are a number of communication strategies that are needed to move this work forward. Various specific recommendations follow and we recognize that fostering good communication will be an on-going task.

Recommendations. The task force recommends presentations at Faculty-to-Faculty Conferences for statewide conversations involving mathematics faculty, as well as faculty from partner disciplines; P20 Regional Partnerships between high school mathematics teachers and mathematics higher education faculty to engage in a redesign of an aligned secondary to postsecondary mathematics curriculum, and instructional practices; and the use of SURDS for collecting, assimilating and analyzing course- and student-level data that can be used to assess and improve mathematics course offerings.

The task force recommends that its members be designated lead communicators with their institutions through the rollout of the task force recommendations. Because many of these recommendations will need to be implemented at the institutional level, and the implementation needs a local advocate, task force members recommend they be charged with identifying and informing those individuals who are in leadership positions at their institutions. The task force also recommends using multiple venues to distribute recommendations, including email distribution lists; in-person meetings, such as “Town Hall meetings” at individual campuses; and established conferences and state summits (such as Mathematics Association of America section meetings and the bi-annual Colorado Faculty-to-Faculty Conferences). The task force also recommends a longer term group should be established (at least over the next year) in order to provide ongoing communication and support to each institution.

Infrastructure for Implementation of Recommendations

The task force recommends that its members have an ongoing role in the implementation of this report’s recommendations. It also wants to engage more people in the work through the formation of working groups. These smaller working groups will focus on supporting implementation of the recommendations. The task force sees one of its roles as providing direction and giving “qualified responses” to the working groups as questions arise. That is, the task force is mostly a math faculty group that will look at issues holistically and provide oversight of the working groups. For instance, a role of the task force is to review proposed plans from the working groups and to give feedback based on a statewide, “big picture” perspective.

The task force concluded it should meet in October 2015 and again in January 2016 and that the state facilitator can make decisions about any need for more engagement. It is important to the task force to maintain institutional diversity in its membership. It was decided that if any member needs to step down, another representative from their institution will be sought. Maintaining some consistency in membership will give the task force the opportunity to have the “big picture” perspective, as well as the context and memory of how and why the recommendations in this report were agreed upon.

Steps for Implementing Recommendations

The first step in transitioning to a state action plan is to implement the working groups listed below. It is preferable that the working groups be chaired by current task force members, with membership from the current task force as well as other interested individuals, including those who vetted the task force’s recommendations at the Math Pathways Task Force two-day retreat in May 2015. In the following, we list the Working Groups with an initial description of the role and scope of each group. It is anticipated that each Working Group will develop a more detailed “charge” and a specific set of goals and outcomes once it is formed.

1. **Curriculum Working Group:** The goal is to develop recommendations for and models of gateway math courses that are rigorous and of quality in content and competencies. These courses will align with the curriculum recommendations for the three identified pathways: CalcPath, StatPath, and QuantThinkingPath.
2. **Advising Working Group:** The goal is to ensure that advising facilitates the placement of students into gateway math courses that align with their programs of study and in which students are likely to succeed.
3. **Support and Professional Development Working Group:** The goal is to develop resources and support for institutions of higher education in the state that will enable them to provide high quality instruction and active learning in gateway math courses. Specifically, the goals include the expansion of sustainable professional development geared toward both new and experienced instructors that encourages active learning; the identification and (re)training of appropriate instructors to teach the gateway courses; the development of alternative structures to support pathways (co-requisite instruction/supplemental academic instruction, accelerated, stretch, co-enrollment); and the development of specific resources and training for instructors in the StatPath and the QuantThinkingPath.
4. **Communication Working Group:** The goal is to communicate the recommendations of the task force and the working groups to K12 and higher education institutions. Toward that end, informational resources must be developed and assistance provided to the Colorado Department of Higher Education staff for messaging the information to faculty, administrators, advisors, students, K12, school counselor and other educator preparation programs.
5. **Policy & Transfer Issues Working Group** – A number of the recommendations involve statewide policy. It will likely require a working group to address these issues. The goal is to provide direction to the Colorado Department of Higher Education and its stakeholder groups, like the Academic and General Education Councils, to implement the recommendations when changes in state policy are required.

Appendix A: Membership

The task force's current membership can be viewed at:

<http://higherred.colorado.gov/Academics/Groups/contacts.asp?cid=267>

Chair

Dean Allison, Director and Professor
School of Mathematical Sciences
University of Northern Colorado
dean.allison@unco.edu

Members

Steve Aldrich, Professor of Mathematics
Adams State University
saldrich@adams.edu

Shelly Ray Parsons, Professor of Mathematics
Aims Community College
shelly.parsons@aims.edu

Lynn Bennethum, Associate Professor &
Undergraduate Chair
Mathematics Department
University of Colorado Denver
Lynn.Bennethum@ucdenver.edu

Dave Ruch, Professor of Mathematics
Metropolitan State University of Denver
ruch@msudenver.edu

Sandy Gilpin, Director, Freshman Math Program
Fort Lewis College
gilpin_s@fortlewis.edu

Casey Sacks, Grant Project Manager
Colorado Community College System
casey.sacks@cccs.edu

Alexander Hulpke, Undergraduate Director
Mathematics Department
Colorado State University
hulpke@math.colostate.edu

Rob Tubbs, Associate Professor of Mathematics
University of Colorado Boulder
robert.tubbs@colorado.edu

Rick Miranda, Provost & Executive VP
Colorado State University
rick.miranda@colostate.edu

Alexsis Venter, Math Faculty
Arapahoe Community College
Alexsis.Venter@arapahoe.edu

Rick Ott, Associate Professor of Statistics
Colorado Mesa University
rott@coloradomesa.edu

Frank Zizza, Chair,
Department of Mathematics & Physics
Colorado State University – Pueblo
frank.zizza@csupueblo.edu

Senior Consultant

Amy K. Getz
The Charles A. Dana Center
The University of Texas at Austin

Colorado Department of Higher Education Staff

Ian K. Macgillivray, Director of Academic Affairs
Maia E. Blom, Academic Policy Officer

Additional Consultant

Bruce Vandal, Vice President
Complete College America

Appendix B: Gateway Mathematics Courses and gtPathways Participation

Note: Most of the gateway mathematics courses are gtPathways-approved. Those that are not are underlined. Also, the names of the courses vary from institution to institution, but the ones listed here are more or less equivalent.

Institution	“Math for the Liberal Arts”	“Introduction to Statistics”	“College Algebra”
13 Colorado Community College System campuses, Aims Community College & Colorado Mountain College	MAT 120 (4cr)	MAT 135 (3cr) *Cannot be used to fulfill the math requirement for an AS degree within the CCCS and at CMC.	MAT 121 (4cr)
Adams State University	MATH 150 (3cr)	<u>MATH 205</u> *Pre-requisite is College Algebra.	MATH 106 (3cr)
Colorado Mesa University	MATH 110 (3cr)	<u>STATS 215</u> (social sciences) & STAT 200 (3cr, regular) *Pre-requisite is College Algebra or College Math.	MATH 113 (3cr)
Colorado School of Mines	This institution offers only engineering degrees, all of which require calculus.		
Colorado State University	MATH 101 (3cr) & 105 (3cr)	None	MATH 117 (1cr), 118 (1cr) & 124 (1cr)
Colorado State University - Global Campus	<u>MTH109</u> (3cr)	<u>MTH156</u> (3cr)	<u>MTH122</u> (3cr)
Colorado State University - Pueblo	MATH 109 (3cr)	MATH 156 (3cr)	MATH 121 (4cr)
Fort Lewis College	MATH 105 (3cr)	BA 253* (4cr), ES 242 (3cr) & MATH 201# (4cr) *Pre-requisite is College Algebra. # Pre-requisite is College Algebra or Math for the Liberal Arts	MATH 110 (4cr)
Metropolitan State University of Denver	MTH 1080	MTH 1210 (4cr)	MTH 1110 (4cr)
University of Colorado Boulder	MATH 1012 (3cr)	<u>MATH 2510</u>	<u>MATH 1011</u>
University of Colorado Colorado Springs	ID 1050 (3cr) and <u>ID 2000</u> (3cr)	UCCS has many introductory stats courses that are contextualized to the major, some of which pre-require math for the liberal arts or college algebra.	MATH 1040 (3cr)
University of Colorado Denver	MATH 1010 (3cr)	MATH 2830 (3cr)	MATH 110 (3cr)
University of Northern Colorado	MATH 120 (3cr)	STAT 150 (3cr)	MATH 124 (4cr)
Western State Colorado	MATH 105	¹ See note below.	MATH 140

University	(3cr)		(3cr)
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¹According to a professor of mathematics at WSCU, the institution does not “offer a true Intro to Stats course, i.e., one with no prerequisite. There are three stats classes on campus, each with different pre-reqs. Students in social sciences must first pass any math competency class (math for liberal arts, math for social sciences, or college algebra), students in business must pass College Algebra, and students in science must pass Pre-Calculus to take the required stats class for that major... If a student transferred in from a 2-year college with an intro stats class, we'd probably take it as MATH 213 (or the equivalent business or social science stats classes).”

Appendix C: Initial Data Pull

*Data were pulled from the Colorado Department of Higher Education’s Student Unit Record Data System (SURDS), which includes information from all public colleges and universities in the state and the following private institutions: University of Denver, Regis University, and Colorado Christian University. “Completion” of a course, as used in the questions below, is defined as passing the course with a C- or better. Last, these data include enrollments/completions from summer 2012 through spring 2014 semesters, the only semesters for which course-level data were available.

Question 1: Enrollment and Pass Rates

The first question was, “How many students are enrolled in College Algebra, and what are the pass rates, by institution?” The data revealed that the following institutions have almost equal enrollments in Math for the Liberal Arts, Introduction to Statistics, and College Algebra:

- Colorado State University-Pueblo
- Fort Lewis College
- Metropolitan State University of Denver
- University of Colorado Boulder
- University of Colorado Denver
- University of Northern Colorado

These data beg the questions, “How did the institutions accomplish this?” and, “To what extent does advising play a part?” (These questions, noted by the task force, will be addressed later in this report.)

Question 2: Percent of Students who Complete College Algebra and Calculus

The second question was, “What percent of students who complete College Algebra go on to complete Calculus I within three years?” The purpose of the question is to identify the extent to which College Algebra is being used as the gateway math course for programs that do not also require calculus and is based on the premise that College Algebra should be preparation for calculus. The data revealed:

- For college students, 16.35% (n=2091) enrolled in Calculus I after completing College Algebra (compared to 12% who passed Calculus I).
- For dually-enrolled high school students, 6.63% (n=225) enrolled in Calculus I after completing College Algebra (compared to 6% who passed Calculus I).

These data indicate a mismatch between the number of students who complete College Algebra and then go on to take Calculus I, indicating a possible overreliance on College Algebra as the default math course. In discussion, the task force noted that some possible causes are 1) “Some faculty see passing College Algebra as a sort of IQ test,” and 2) “College Algebra is required because that’s the way it has

always been.” Also, as part of the discussion, the question was posed, “Do we need a College Algebra class for non-Calculus-track students, if College Algebra is not going to be a terminal class for them?”

Question 3: Percent of Community College Students Who Complete College Algebra and (Pre)Calculus

The third question was, “What percent of community college students complete College Algebra and then go on to complete Pre-Calculus and/or Calculus I, whether at a 2- or 4-year institution, within 3 years?” The purpose of the question was to determine to what extent community college students are being advised to take College Algebra, even though many of them will not enter programs that require calculus. The data revealed:

- For college students, 12% (n=747) completed Pre-Calculus and/or Calculus I, whether at a 2- or 4-year institution, within 3 years after completing College Algebra.
- For dually-enrolled high school students, 8% (n=172) completed Pre-Calculus and/or Calculus I, whether at a 2- or 4-year institution, within 3 years after completing College Algebra.
- Disaggregated, the percent of students who completed Pre-Calculus after completing College Algebra was 5% (n=304) for college students and 2% (n=47) for dually-enrolled high school students. The percent of students who completed Calculus I after completing College Algebra was 9% (n=570) for college students and 7% (n=143) for dually enrolled high school students.

Question 4: Distribution of Students Completing College Algebra in Programs of Study

The fourth question was, “What is the distribution of students who complete College Algebra into specific programs of study?” The first two digits of programs’ CIP codes were used to identify programs of study. Classification of Instructional Program (CIP) codes are a taxonomic scheme that supports the accurate tracking and reporting of fields of study and program completions. It was developed by the U.S. Department of Education's National Center for Education Statistics. All certificate and degree programs offered at Colorado institutions of higher education are assigned a CIP code when entered into the SURDS database at the Colorado Department of Higher Education. These codes allowed for this question to be answered.

These data revealed the CIP area with the largest enrollment in College Algebra was area 24: Liberal Arts & Sciences, General Studies and Humanities. The task force determined the large number of students in this area is mostly undeclared community college students, enrolled in general A.A. and A.S. degrees, who are being advised into College Algebra. These data raised the point, however, about the need for accurate advising for undeclared community college students and that meta-majors, with appropriate gateway math courses, might help reduce students being misadvised into College Algebra.

Realizing the large number of undeclared community college students was skewing these data, the question was asked again and CIP area 24 was eliminated. Appendix C contains a list of all other CIP areas and percent of students enrolled who have taken College Algebra. Of note, CIP areas with about 5% or more (chosen arbitrarily) of students taking College Algebra include:

- 11: Computer and Information Sciences and Support Services (8.71%)
- 26: Biological and Biomedical Sciences (10.22%)
- 31: Parks, Recreation, Leisure, and Fitness Studies (4.56%)
- 42: Psychology (6.11%)
- 45: Social Sciences (4.99%)
- 51: Health Professions and Related Programs (25.56%)
- 52: Business, Management, Marketing, and Related Support Services (15.45%)

An unanswered question remains: “Why are numbers so low for:

- 14: Engineering (1.94%)
- 15: ENGINEERING TECHNOLOGIES AND ENGINEERING-RELATED FIELDS (2.48%)
- 27: Mathematics and Statistics (0.76%)
- 40: Physical Sciences (2.43%)

Is it because these students place into calculus and do not take college algebra?”

CIP	CIPTitle (Program/Field of Study)	COUNT	%
01	AGRICULTURE, AGRICULTURE OPERATIONS, AND RELATED SCIENCES.	37	2.60%
03	NATURAL RESOURCES AND CONSERVATION.	28	1.97%
04	ARCHITECTURE AND RELATED SERVICES.	2	0.14%
05	AREA, ETHNIC, CULTURAL, GENDER, AND GROUP STUDIES.	1	0.07%
09	COMMUNICATION, JOURNALISM, AND RELATED PROGRAMS.	37	2.60%
10	COMMUNICATIONS TECHNOLOGIES/TECHNICIANS AND SUPPORT SERVICES.	6	0.42%
11	COMPUTER AND INFORMATION SCIENCES AND SUPPORT SERVICES.	124	8.71%
12	PERSONAL AND CULINARY SERVICES.	11	0.77%
13	EDUCATION.	13	0.91%
14	ENGINEERING.	11	0.77%
15	ENGINEERING TECHNOLOGIES AND ENGINEERING-RELATED FIELDS.	62	4.35%
16	FOREIGN LANGUAGES, LITERATURES, AND LINGUISTICS.	6	0.42%
19	FAMILY AND CONSUMER SCIENCES/HUMAN SCIENCES.	27	1.90%
22	LEGAL PROFESSIONS AND STUDIES.	6	0.42%
23	ENGLISH LANGUAGE AND LITERATURE/LETTERS.	21	1.47%
26	BIOLOGICAL AND BIOMEDICAL SCIENCES.	31	2.18%
27	MATHEMATICS AND STATISTICS.	2	0.14%
30	MULTI/INTERDISCIPLINARY STUDIES.	14	0.98%
31	PARKS, RECREATION, LEISURE, AND FITNESS STUDIES.	65	4.56%
38	PHILOSOPHY AND RELIGIOUS STUDIES.	5	0.35%
39	THEOLOGY AND RELIGIOUS VOCATIONS.	1	0.07%
40	PHYSICAL SCIENCES.	6	0.42%
41	SCIENCE TECHNOLOGIES/TECHNICIANS.	7	0.49%
42	PSYCHOLOGY.	87	6.11%
43	HOMELAND SECURITY, LAW ENFORCEMENT, FIREFIGHTING AND RELATED	44	3.09%

	PROTECTIVE SERVICES.		
44	PUBLIC ADMINISTRATION AND SOCIAL SERVICE PROFESSIONS.	3	0.21%
45	SOCIAL SCIENCES.	71	4.99%
46	CONSTRUCTION TRADES.	4	0.28%
47	MECHANIC AND REPAIR TECHNOLOGIES/TECHNICIANS.	17	1.19%
48	PRECISION PRODUCTION.	13	0.91%
49	TRANSPORTATION AND MATERIALS MOVING.	33	2.32%
50	VISUAL AND PERFORMING ARTS.	32	2.25%
51	HEALTH PROFESSIONS AND RELATED PROGRAMS.	364	25.56%
52	BUSINESS, MANAGEMENT, MARKETING, AND RELATED SUPPORT SERVICES.	220	15.45%
54	HISTORY.	13	0.91%
	TOTAL	1424	100.00%

References

Colorado Department of Higher Education (March 27, 2014). Annual Report on Concurrent Enrollment: 2012-2013 School Year. Available online at:

http://highered.colorado.gov/stats/track.asp?mtr=/Publications/Reports/Enrollment/FY2013/2013_Concurrent_Enrollment_Mar_2014.pdf