Maryland College and Career Readiness Empirical Study

Final Report Appendices

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Appendix A. Complete Review of Literature on Measures of College and Career Readiness

This appendix provides a more detailed review of the relevant literature on college and career readiness (CCR) measures and their associations with students' postsecondary outcomes.

A.1. Measures of College Readiness

College Admissions and Placement Test Scores

Much of the research related to measuring college readiness focuses on norm-referenced standardized tests typically used for college admissions decisions, specifically the SAT and the ACT, and standardized tests typically used for college-level course placement decisions, specifically COMPASS and ACCUPLACER. For example, a study by the College Board (Marini et al., 2019) found positive correlations between the SAT and first-year college GPA (FYGPA) that were about the same magnitude as correlations between high school GPA (HSGPA) and FYGPA. The study also found, however, that the relationship between SAT and FYGPA was weaker at less selective colleges. Other studies conducted by the College Board provide similar evidence of the SAT's relationship with college performance (Beard & Marini, 2018; Mattern & Patterson, 2014; Westrick et al., 2020). Similarly, some studies of ACT scores find that they are positively related with FYGPA (Westrick et al., 2015).

Other studies, however, report contrasting findings that call into question the predictive validity of standardized test scores relative to other potential CCR measures, particularly HSGPA (Allensworth & Clark, 2020; Rothstein, 2004). Some of these inconsistent results are likely related to variability in the postsecondary outcomes used to validate the CCR measures. Studies of the SAT and ACT generally focus on first-year college performance (e.g., Marini et al., 2019), whereas other research (e.g., Allensworth & Clark, 2020) considers longer term definitions of college success (e.g., college graduation). In addition, some studies raise equity concerns about the reliance on college admissions tests to determine CCR. For example, Klasik and Strayhorn (2018) found that a college readiness benchmark based on the SAT could differ substantially across student groups and college selectivity. Citing equity, access, and relevance concerns, colleges across the country have moved toward test-optional admissions policies, with one in four institutions no longer requiring submission of SAT or ACT scores in student applications (Einhorn, 2022; Tugend, 2019).

Studies of placement tests such as COMPASS and ACCUPLACER have raised concerns about these tests' predictive validity. In a study that used student-level data from a statewide community college system, Belfield and Crosta (2012) found that math and literacy test scores from COMPASS and ACCUPLACER placement examinations had positive but weak associations with college outcomes such as grades in developmental education courses, college GPA, and college credits earned. Similarly, Scott-Clayton (2012) found weak associations between scores from the same placement tests and college course grades among a large urban sample of community college students. In addition, a study of multiple placement tests (i.e., COMPASS, ACT, Michigan Merit Exam) used by two Michigan community colleges found relatively weak associations between the placement tests and students' first college-level math or English course grade (Bahr, 2016). In contrast, Leeds and Mokher (2020) studied the placement test used in Florida (Postsecondary Education Readiness Test) and found that adjusting placement cutoff scores may improve placement accuracy into the appropriate lower or upper-level developmental education courses or college-level courses rather than using high school measures such as HSGPA.

State-Specific Standardized Assessment Scores

With the adoption of the Every Student Succeeds Act, states have placed more emphasis on CCR in their K–12 content standards. To reflect changes in state content standards, states revised their existing content-aligned assessments for English language arts, math, and science, in some cases adopting the assessment for one of two national consortia of states: the Smarter Balanced Assessment Consortium or the Partnership for Assessment of Readiness for College and Careers (PARCC; James, 2022). In a 2009 review of college admissions testing, Atkinson and Geiser argued that performance on curriculum-based achievement tests is a more valid indicator of college readiness than SAT/ACT scores.

There is growing evidence that scores on state content assessments administered to high school students are positively associated with college performance at about the same degree as college admissions tests such as the SAT. For example, studies conducted with data from students in Arizona (Cimetta et al., 2010), Connecticut (Coelen & Berger, 2006), and Washington (McGhee, 2003) found positive associations between the respective state assessments and college GPA. Coelen and Berger (2006) warned, however, that the quality of the relationship differs across institution type and subject area. More recently, a study of college students in New York and Kentucky found that state high school tests predicted FYGPA about as well as college admissions tests scores (Koretz et al., 2016). Similarly, a study conducted in Massachusetts examined the state's assessment and the PARCC and concluded that both tests predicted FYGPA about as well as the SAT (Nichols-Barrer et al., 2015). A study conducted in Iowa also found that readiness benchmarks on the Iowa Assessments and the ACT were similarly predictive of FYGPA in required general education courses (Fina et al., 2018).

High School GPA

Several studies on college readiness examined how well HSGPA predicts college performance, particularly in contrast or in addition to test-based measures. Although standardized test scores primarily focus on content knowledge and cognitive strategies (e.g., problem solving, reasoning) in two or three subject areas, HSGPA can reflect a student's content knowledge, cognitive strategies, and academic behaviors (e.g., self-regulation, study skills) across many subject areas and for a longer period of time (Borghans et al., 2016; Brookhart et al., 2016; Galla et al., 2019). However, some researchers have raised concerns about using HSGPA as a measure of college readiness because of the subjective nature of grading (Brackett et al., 2013; Kunnath, 2017; Lipnevich et al., 2020) and evidence of grade inflation (Camara et al., 2004; Sanchez & Moore, 2022).

Despite concerns about inconsistencies in HSGPA, several studies indicate that HSGPA is a strong and reliable predictor of various college outcomes. For example, Allensworth and Clark (2020) examined the relationship of cumulative HSGPA with college graduation rates for students in Chicago public schools. They found HSGPA was a stronger predictor of degree completion across all institution types (e.g., 4-year universities, community colleges) than ACT scores, downplaying grade inflation and GPA subjectivity concerns raised in other research. Furthermore, Belfield and Crosta (2012) studied cumulative HSGPA and found that it had positive associations with overall college GPA and cumulative college credits earned, explaining approximately 21% of the variation in overall college GPA and 14% of the variation in college credit accumulation. Similarly, Galla et al. (2019) found that HSGPA was a stronger predictor of college graduation than SAT/ACT scores. In addition, a study focused on Arkansas students (Hester et al., 2021) found that an HSGPA of at least 2.8 was a significant predictor of both initial college enrollment and sustained enrollment for more than one term (i.e., persistence).

High School Course-Taking

High school course-taking is another domain that researchers and policymakers consider as a potential measure of college readiness. For example, the Hester et al. (2021) study in Arkansas found that taking at least one advanced course in high school—defined as Advanced Placement (AP), International Baccalaureate (IB), or advanced career education—was the strongest predictor of college enrollment and success from the high school measures they examined. Similarly, Belfield and Crosta (2012) used high school transcript data and found that both college GPA and college credits were strongly correlated with high school course-taking CCR measures, such as the number of honors courses attempted, the number of college-level credits earned in high school, and whether the student ever received a failing grade.

Adelman (1999, 2006) created a composite measure of curricular intensity, which is defined by the accumulated number of core course credits (quantity) and the rigor of coursework completed in each subject (quality). Using nationally representative longitudinal survey data, Adelman found a strong relationship between curricular intensity and both postsecondary persistence and the attainment of a bachelor's degree. Indicators of quantity were based on the number of course credits completed, particularly in math, English, science, foreign language, social science, and computer science. The indicators of quality were the highest math course completed, the number of credits completed in core science courses, whether the student took at least one AP course, and whether the student took developmental math or English (Adelman, 1999). Austin (2020) proposed a shorter version of Adelman's curricular intensity index and compared the predictive validity of the proposed curricular intensity measure—a single indicator (highest math course taken) or a combination of the math indicator plus AP coursework—to that of the original curricular intensity model on several college outcomes. The new measure had predictive validity that was comparable to or better than the original, and the new model explained as much or more variance in college outcomes. However, the use of advanced course taking and dual enrollment in a CCR standard may raise equity concerns given disparate access to such opportunities (Xu et al., 2019).

Multiple Measures for College Readiness

Although much of the research on college readiness focuses on the performance of specific measures, studies also highlight the strengths of using a combination of measures to predict college readiness. For example, a 2020 report by the Education Strategy Group (ESG, 2020) reviewed the research and recommended the use of three high school measures to monitor whether students are prepared for college: ninth-grade GPA, completion of advanced coursework (i.e., AP, IB, dual enrollment), and participation in career and technical education (CTE) coursework.

Relatedly, research on college course placement decisions points to the benefits of using multiple measures. Two parallel experimental studies found that using multiple measures for placement in community college developmental courses resulted in better student outcomes than using a single measure (Cullinan & Kopko, 2022). One study included seven community colleges in New York that tested an algorithmic placement system that incorporated placement test scores, HSGPA, and information about high school graduation (Bergman et al., 2023). The other study included five community colleges in Minnesota and Wisconsin that tested a placement system that incorporated placement test scores, HSGPA, noncognitive assessment results, and scores from the ACT or SAT (Cullinan & Biedzio, 2021). Both studies found that using a placement algorithm that incorporates multiple measures instead of a single placement examination to determine who should take developmental courses increased college credits earned and reduced costs for students. In addition, the use of multiple measures may result in more equitable placement decisions, especially if HSGPA and self-directed placement mechanisms are included in the decision process (Kopko et al., 2022).

A.2. Measures of Career Readiness

As noted earlier, career readiness metrics are less standardized and less often viewed as stand-alone metrics compared with college readiness metrics. As a result, research on how well measures of career readiness predict career outcomes is much more limited than research on measures of college readiness. Still, one relatively common measure associated with career readiness that has been examined in prior research is student participation in CTE. There is growing evidence that completing a CTE curriculum gives students a leg up in the workforce. For example, using data on all Massachusetts high school students expected to graduate high school from spring 2009 to 2017, Ecton & Dougherty (2023) found that in each of the first 7 years after high school, students who attended a dedicated CTE school experienced significantly higher and increasing annual earnings than students who completed a CTE pathway within a traditional, "comprehensive" high school. In addition, they found that CTE completers (regardless of school type) had higher earnings than noncompleters in the first year after high school (about $1,400) and a higher likelihood of employment the year after high school (about 4 percentage points higher) when compared with similar CTE participants who did not complete the program or go to college.

For students who do not attend college, the effect of CTE on employment rates is much higher (about 14 percentage points). Lindsay et al. (2021) compared CTE "concentrators" with students who took two or fewer CTE courses in Indiana and Minnesota. They found that in the year after high school, concentrators were 2 percentage points to 4 percentage points more likely to be employed and earned $1,100–$1,300 more. Completing a concentrated CTE curriculum improved labor outcomes, but Ecton and Dougherty (2023) showed that the effects of CTE can vary based on the type of CTE concentration. For example, the increase in annual earnings in the year after high school was highest when students concentrated in construction ($3,100), health care ($3,000), or transportation ($3,000) and lowest when students concentrated in arts and communication ($1,000). In all cases, the effect was strongest for those who did not attend college. Although recent evidence suggests that CTE participation can lead to improved content knowledge and academic behavioral development in high school and the potential for higher earnings in the workforce, evidence regarding the types of programs that deliver the most important CCR outcomes, including CTE's impact on college readiness, is still emerging (Dougherty, 2023).

Appendix B. Programmatic Survey

B.1. Survey Instrument

The programmatic survey questions that we shared with the Maryland community colleges to follow up on the course inventory are provided below.

Survey Questions

1. Course you are providing information for (Please provide information for one course per submission):
    a. Drop down menu with courses identified through course inventory, specific to each college.
2. What is your role? Please select all that apply.
    a. Faculty
    b. Staff
    c. Administrator
    d. Department Chair
    e. Dean
    f. Other (please specify below)
3. Please upload the syllabus for this course below:
    a. You are welcome to share any of the following in addition to the course syllabus:
        i. Learning objectives
        ii. Assessments
        iii. Grading rubrics
4. At entry, approximately what proportion of your students do you believe are college ready in the following areas:
    a. Each of the areas had 7 possible mutually exclusive answers:
        i. 0–20%, 21–40%, 61–80%, 81–100%, Unsure, Not relevant for my course/program
    b. Reading literature
    c. Reading informational text
    d. Writing
    e. Speaking and listening

f. English language

g. Algebra

h. Precalculus

i. Scientific thought

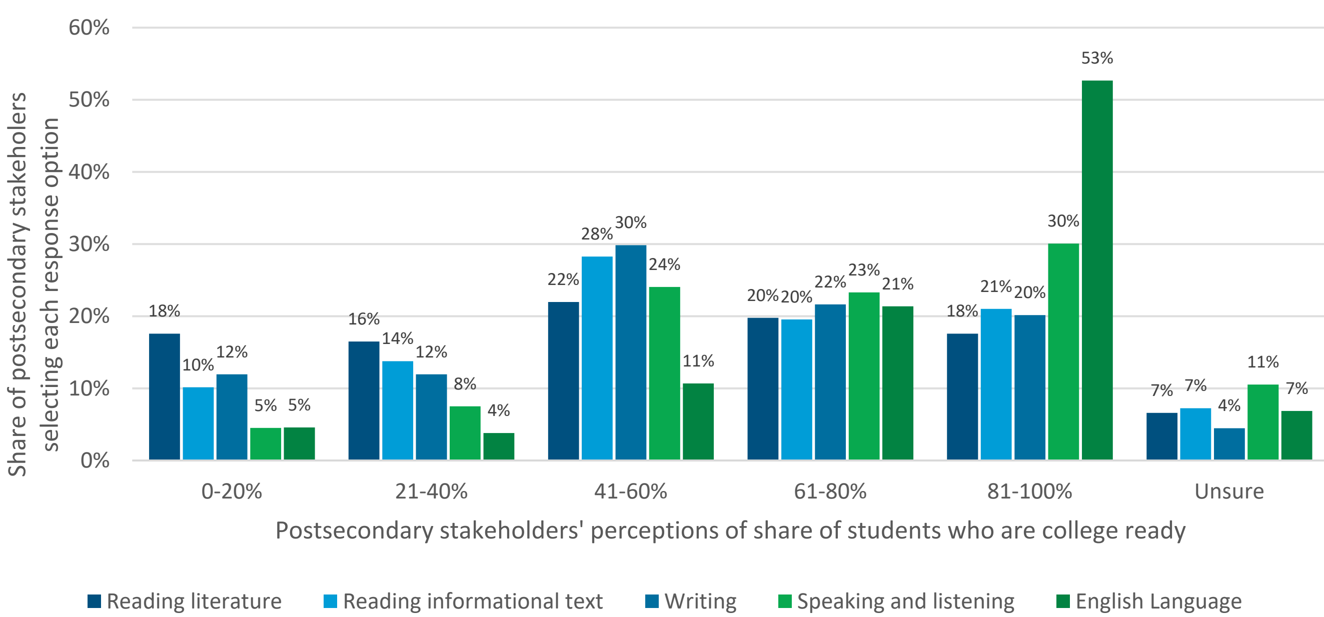
5. How are course learning objectives set and revised?

6. Is there anything else you would like to share regarding expectations for college and career readiness for students in your courses?

B.2. Survey Results

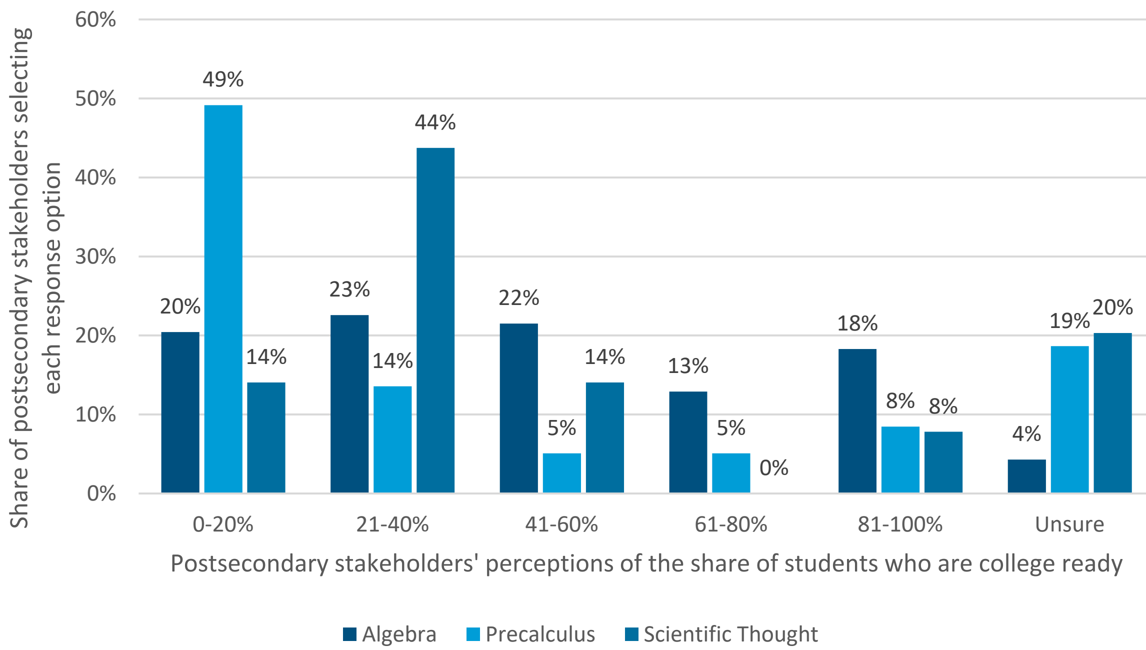
Exhibit B.2.1 provides a snapshot of the perceptions of respondents related to student readiness for ELA, organized by the categories within the Maryland CCR ELA standards. Postsecondary stakeholder responses suggest that students' ELA readiness is stronger for the "English language" component of the ELA standards than it is for other components, with more than half of respondents (53%) reporting that 81% or more of their students were college ready in "English language." Only 30% of the respondents reported that 81% or more of their students were college ready in "speaking and listening." Perceptions of readiness for reading literature and writing were mixed.

Exhibit B.2.1. ELA Readiness Perceptions by Maryland CCR ELA Standards (Strands)



Regarding math and science readiness, Exhibit B.2.2 provides a snapshot organized by categories within the Maryland CCR Math Standards along with scientific thought. Overall, postsecondary stakeholders' perceptions indicate that their students are less college ready in math and scientific thought than in ELA. Most respondents reported that, overall, their students were not college ready in math and science. Only 18% of respondents said that 81% or more of their students were college ready in algebra. And just 8% of respondents thought that 81% or more of their students were college ready in precalculus and scientific thought.

Exhibit B.2.2. Math Readiness Perceptions by Maryland CCR Math and Science Standards



Appendix C. Courses Included in Course Inventory

The following tables list the courses compiled in the Course Inventory. Exhibit C.1 shows developmental English courses and Exhibit C.2 shows first-year credit-bearing English courses.

Exhibit C.1. Course Inventory: Developmental English

College	Course title
Allegany College of Maryland	Reading/Writing Workshop I
	English Leap
	Reading/Writing Workshop II
Anne Arundel Community College	Academic Literacies
	Support for Academic Writing and Research
Baltimore City Community College	Integrated Reading and English
	Integrated Reading and English I
	Reading and English Skills II
Carroll Community College	Accelerated Learning Prog for ENGL-101
	Integrated Reading and Writing 1
	Integrated Reading and Writing 2
Cecil College	Integrated Reading and Writing
Chesapeake College	PASS English
	English Accel Learning [ALP]
College of Southern Maryland	The Academic Essay
	The Academic Presentation
	The Academic Portfolio
Community College of Baltimore County	Advanced Academic Literacy
Frederick Community College	Introduction to College Reading and Writing
	Reading and Writing in the Academic Disciplines
Garrett College	Integrated Reading and Writing
	Prep for College Writing
Hagerstown Community College	Writing Strategies for English Language Learners College Success
	Writing Strategies for College Success

College	Course title
Harford Community College	Basic Writing
	Associated Reading and Writing
	Integrated Reading and Writing
	Accelerated Writing
Howard Community College	Acad Reading/Writing
	Adv Reading/Writing
	Info Literacy/Success
Montgomery College	Introduction to College Writing Support
Prince George's Community College	Developmental Reading
	Foundations of English
	Advanced Foundations College English
Wor-Wic Community College	Reading for Speakers of Other Languages
	Grammar and Writing Skills for Speakers of Other Languages
	Listening and Speaking Skills for Speakers of Other Languages
	Foundations of College Literacy
	College Reading
	Basic Writing
	Basic Writing, Accelerated
	College Literacy: Reading and Writing

Exhibit C.2. Course Inventory: First-Year Credit-Bearing English

College	Course title
Allegany College of Maryland	English Composition I
Anne Arundel Community College	Academic Writing and Research 1
Baltimore City Community College	English Writing
	Introduction to the Term Paper and Research Methods
Carroll Community College	Focus
	College Writing
Cecil College	College Composition
Chesapeake College	Communication on the Job
	Composition
College of Southern Maryland	Composition and Rhetoric
Community College of Baltimore County	College Composition 1
Frederick Community College	Advanced Reading for Composition
	English Composition
	English Composition and Literature
Garrett College	Comp I–Expository Writing
	Comp II–Intro to Literature
Hagerstown Community College	English Composition
	English Composition for English Language Learners
	English Composition for College Success
	Technical Writing
Harford Community College	English Composition
Howard Community College	Special Topics in Lit
	College Composition
	First Year Experience
Montgomery College	Introduction to College Writing
	Principles of English Grammar
	College Vocabulary Development
	Introduction to World Mythology
	Introduction to Literature
Prince George's Community College	Composition I: Expository Writing
Wor-Wic Community College	Fundamentals of English I
	Fundamentals of English I, Accelerated

Exhibit C.3 shows developmental math courses and Exhibit C.4 shows first-year credit-bearing math courses.

Exhibit C.3. Course Inventory: Developmental Math

College	Course title
Allegany College of Maryland	Beginning Algebra
	Inter Algebra
	Beginning & Inter Algebra
Anne Arundel Community College	Pre-Statistics
	Foundations of College Algebra
	Intro to College Algebra
	Precalculus Foundations
	Introduction to Precalculus
	Quantitative Foundations
Community College of Baltimore County	Pre-Algebra
	Introductory Algebra
	Intermediate Algebra
Baltimore City Community College	Integrated Pre-Algebra and Introductory Algebra
	Intermediate Algebra
Carroll Community College	Independent Study Transitional Mathematics Advancement
	Foundations for Statistics
	Pre-Algebra
	Foundations for College Mathematics
	Foundations for College Mathematics Pt. 2
Cecil College	Introductory & Intermediate Algebra
	Advanced Intermediate Algebra (STEM)
Chesapeake College	Pre-Algebra Arithmetic
	Elementary Algebra
	Intermediate Algebra
	Special Topics in Dev Math
College of Southern Maryland	Pre-Algebra Topics
	Elementary Algebra Skills and Concepts I
	Elementary Algebra Skills and Concepts II
	Intermediate Algebra Skills and Concepts

College	Course title
Frederick Community College	Preparation for College Mathematics
	Instruction with Algebra
	Algebraic Support
Garrett College	Introductory Algebra
	Intermediate Algebra
	Fundamentals of Mathematics
	Intermediate Algebra with Geometry
Hagerstown Community College	Foundations of Algebra
	Foundations of Reasoning & Statistics
Harford Community College	Integrated Review for Contemporary Mathematics
	Intens Rev of Intermediate Algebra
	Topics in Introduction to Statistics
	Pre-Algebra I
	Pre-Algebra II
	STEM Track I
	STEM Track II
	STEM Track III
	STAT Track Mathematics
Howard Community College	Mathematical Foundations
	Basic Algebra & Geometry
	Basic Algebra and Geometry Extension
	Intro to Elementary Algebra
	Elementary Algebra
	Elementary Algebra Extension
	Intermediate Algebra
	Essentials of Intermediate Algebra
	Intermediate Algebra Support
	Adv. Topics in Intermediate Algebra

College	Course title
Montgomery College	Elements of Statistics Support
	Survey of College Mathematics Support
	Elements of Mathematics 1 Support
	Foundations of Algebra Support
	Foundations of Algebra
	Foundations of Mathematical Reasoning
	Introduction to Trigonometry
Prince George's Community College	Fundamental Mathematics with Pre-Algebra
	Introductory Algebra
	Foundations of Math Reasoning
	Intermediate Algebra
	Principles for Applied College Algebra
Wor-Wic Community College	Pre-Statistics
	Pre-Algebra
	Elementary Algebra
	Intermediate Algebra

Exhibit C.4. Course Inventory: First-Year Credit-Bearing Math

College	Course title
Allegany College of Maryland	College Algebra
Anne Arundel Community College	The Nature of Mathematics
	College Algebra
	Statistics
Baltimore City Community College	College Algebra and Trigonometry
	Precalculus I: College Algebra
	Modern Elementary Statistics
Carroll Community College	Introduction to College Mathematics
	College Algebra
	Intro to Statistical Methods
	Geometry
Cecil College	Technical Math
	Topics in Mathematics Literacy
	Introduction to Statistics
	Mathematics Concepts & Structure I
	Precalculus
Chesapeake College	Foundations of Mathematics
	Finite Mathematics
	College Algebra
	Precalculus
	Intro to Applied Calculus
	Intro to Statistics
College of Southern Maryland	Quantitative Literacy and Reasoning
Community College of Baltimore County	Finite Mathematics and Modeling
Frederick Community College	Foundations of Mathematics
	Foundations of Mathematics with Algebra
	Statistics
	Statistics with Algebra
	Statistics with Probability
	College Algebra
	College Algebra with Support
Garrett College	College Algebra
	Pre-Calculus

College	Course title
Hagerstown Community College	Fundamental Concepts of Mathematics I
	Fundamental Concepts of Mathematics II
	Statistics
	Introduction to Applied Algebra
	Quantitative Reasoning
	Precalculus I
Harford Community College	College Algebra
	Contemporary Mathematics
	Trigonometry
	Precalculus Mathematics
	Concepts in Mathematics I
Howard Community College	Concepts of Math 1
	Mathematical Literacy
	Statistics
	College Algebra
	Precalculus I
	Precalculus I & II
Montgomery College	Elements of Statistics
	Survey of College Mathematics
	Elements of Mathematics I
	Precalculus
Prince George's Community College	Mathematical Ideas
	Applied College Algebra
	Precalculus Part I
Wor-Wic Community College	Mathematical Applications
	Fundamental Concepts I
	Fundamental Concepts II

Exhibit C.5 shows first-year credit-bearing science courses.

Exhibit C.5. Course Inventory: First-Year Credit-Bearing Science

College	Course title
Allegany College of Maryland	General Biology I
	Inquiries in Physical Science I
Cecil College	General Biology
	General Physical Science with Lab
Chesapeake College	Fundamentals of Biology
	Physical Science
Frederick Community College	Fundamental Concepts of Biology
	Physical Sciences
Garrett College	Principles of Biology
Hagerstown Community College	Unity and Diversity of Living Things
	Human Biology
	General Physical Science
Harford Community College	Fundamentals of Biology
	Physical Science I
Montgomery College	General Biology
	Physical Science 1
Wor-Wic Community College	Fundamentals of Biology
	Physical Science

Appendix D. Focus Groups

D.1. Postsecondary Education Focus Group Additional Details

To recruit participants for the postsecondary focus groups, we worked with MHEC to share information about the focus groups, solicit feedback on the approach, and distribute invitations for participation. A key consideration was ensuring that all institution types were included in the recruitment, including community colleges and 4-year public and 4-year state-aided independent institutions. Following the focus groups' completion, we sent an optional feedback form to the postsecondary stakeholders who were not selected for the focus groups to allow those who were interested to share their perspectives. The form included several key questions from the focus group protocol, with open-text responses for individuals to provide feedback and additional data to complement the focus group data.

Exhibit D.1.1. Number of Participants by Subject Area in the Postsecondary Focus Groups

Subject area	Number of participants
English	6
Math	6
Science	7
Career and technical education	5
Developmental education	6
Total	**30**

Exhibit D.1.2. Number of Participants by Institution Type in the Postsecondary Focus Groups

Institution type	Number of participants
Public 2-year (community colleges)	16
Public 4-year	12
Private 4-year (state-aided independent institutions)	2
Total	**30**

D.2. Focus Group Protocols

Postsecondary Education Focus Group Protocol

Maryland College and Career Readiness Empirical Study

Postsecondary Faculty College and Career Readiness Expectations

Interviewer:

Participants/Institution:

Date/Time:

Introduction:

Thank you all for agreeing to participate in this focus group. I am ________ and also on the call is ___________. We work for the American Institutes for Research, or AIR, an independent, non-profit research organization that, in partnership with the Maryland State Department of Education, is conducting a study on the skills, knowledge, and abilities required of students to be college and career ready under the *Blueprint for Maryland's Future.* The *Blueprint* defines an initial standard for college and career readiness, or CCR, which aims to ensure that students are leaving high school prepared to be successful and directs this study to be completed to help determine the long-term CCR Standard.

As part of this study, AIR is completing several data collection activities, including gathering publicly available information about course requirements and expectations and conducting focus groups with faculty and staff from Maryland's postsecondary institutions and with members of the K–12 and workforce communities. We will synthesize and analyze the information across the data sources and create a report that will be shared with the Maryland State Department of Education, or MSDE, and the Maryland State Board of Education to articulate postsecondary readiness expectations for Maryland high school graduates.

You were invited to attend this focus group because you submitted a form to us to express your interest in participating. The purpose of today's focus group is for you to share your perspective on college and career readiness—and what it means for your students. This information will help MSDE and the State Board make improvements to the readiness standards for high school students.

Everything you share in this focus group will be kept confidential, and we encourage you to share freely and openly. In our report, we will not share any participant or institution names, or other information that would allow anyone to identify you. At most, we may attribute findings to institution type, for example, community college or four-year institution, and role, for example, faculty or staff. We also ask that you keep our conversation in this focus group confidential.

Today's focus group will take about an hour. Participation in this focus group is voluntary. You may choose to answer or not answer any question and may leave the focus group at any time without any consequences.

Are there any questions before we proceed? [*Interviewer: Wait for responses]*

Do I have everyone's consent to participate in the interview? [*Interviewer: Wait for responses]*

We would like to request your permission to record the focus group to assist us with our note taking. We will use the recording only for our data collection and will not give access to anyone outside of the research team. Any references to names, institutions, or other identifiable information will not be used in the reporting.

Do I have everyone's consent to record? [Interviewer: If everyone says yes, begin recording and note the date, time, and participants of the session]

Question
Participant Introductions (8 Minutes) *First, we want to hear a little about you and your backgrounds.*
1. Please introduce yourselves by stating your name, your institution, and … *[Interviewer to use the following that matches the population in the focus group]* a. what entry-level course(s) you teach? *[or]* b. how you are associated to the certificate-granting program at your institution? [CHATBOX] *[Interviewer: If you have enough time ask the following question]* 2. What is one thing you are proud of about your institution?
Course Readiness (40 Minutes) *Thank you, all, for those introductions. We will now move forward with our questions regarding the readiness expectations of students exiting high school and entering college. To help you further understand what we mean by readiness, please view the screen to see a few options that showcase readiness via skills or knowledge.* [Interviewer: Share screen and allow a few minutes for participants to view slide.]
3. What **skills and knowledge do you expect** of students who are college and career ready? Probes: What abilities or background knowledge do you expect your students, entering college, to have to successfully engage with the content of your entry-level course(s)/training programs? How would you describe a successful student in your entry-level course(s)/training programs?

4. Upon entering your entry-level course(s)/training programs, to what extent do students **meet those expectations** for readiness? Generally, about what share of students meet those expectations? *[Interviewer: If there are nonteaching staff in your focus group, add:* "If you are not in an instructional role, think about whether the students you work with are meeting expectations."] Probe: For students who are not meeting expectations for readiness, what skills, abilities, or background knowledge would they benefit from developing?
5a. What are the **prerequisites** for your entry-level course(s)/training programs, if any? *(e.g., courses, GPA)* 5b. What **placement tests or other measures** are used to place students in your entry-level course(s)/training programs? *(e.g., ACCUPLACER)* 5c. To what extent do you think these prerequisites and placement tests or other measures **align** with your entry-level courses'/training programs' learning objectives? Can you give us examples? 5d. To what extent do you feel the **prerequisites and placement tests or other measures reflect what is needed** to succeed in your entry-level course(s)/training programs?
6a. To what extent do you feel that entry-level course/training program prerequisites or requirements for enrollment can be **barriers** to access or success for some students? Can you share an example? 6b. To what extent do you think first-year students **understand that some prerequisites may not be college credit-bearing**? Probe: Have you had any experiences with students that suggest that the current prerequisite arrangement is inequitable?
7. [**Skip if answered before.**] Thinking generally about students who are entering college, to what extent do you think existing **policies related to college and career readiness expectations can be barriers** to student success? To what extent do you think they can support or facilitate student success?
Course Design (12 Minutes) *Thank you for all the information on course readiness. Now I am going to ask a few questions about your approach to teaching and learning in your courses.*
8a. What are the **learning objectives** of your entry-level college course(s)/training programs? [CHATBOX] 8b. Do you ever **adjust/alter the learning objectives or curriculum to meet the needs** of your students? If so, can you share an example? Probe: To what extent does your entry-level course design incorporate teaching students learning techniques such as time management, test-taking skills, note-taking skills, collaborative learning, and technology proficiency? Can you give us examples?
9. What are some **strategies you engage in to be considerate of diversity, equity, and inclusion**? Can you give us examples?

10a. In 2022, Maryland passed the “Transfer with Success” law that states that every credit-bearing community college course must transfer to a 4-year university. To what extent do you think 2-year and 4-year course expectations are aligned? 10b. To what **extent has this law impacted the way you design your entry-level course/training programs content and materials**? How so?
Wrap-Up (5 Minutes) *That brings us to the conclusion of the focus group.*
11. Before we end the call, is there anything we have not covered but is important for me to know?

Workforce Focus Group Protocol

Maryland College and Career Readiness Empirical Study

Workforce—College and Career Readiness Expectations

Interviewer:

Participants/Institution:

Date/Time:

Introduction:

Thank you all for agreeing to participate in this focus group. I am ________ and also on the call is ___________. We work for the American Institutes for Research, or AIR, an independent, non-profit research organization that, in partnership with the Maryland State Department of Education, is conducting a study on the skills, knowledge, and abilities required of students to be college and career ready under the *Blueprint for Maryland's Future.* The *Blueprint* defines an initial standard for college and career readiness, or CCR, which aims to ensure that students are leaving high school prepared to be successful and directs this study to be completed to help determine the long-term CCR Standard.

As part of this study, AIR is completing several data collection activities, including gathering publicly available information about course requirements and expectations and conducting focus groups with faculty and staff from Maryland's postsecondary institutions and with members of the K–12 and workforce communities. We will synthesize and analyze the information across the data sources and create a report that will be shared with the Maryland State Department of Education, or MSDE, and the Maryland State Board of Education to articulate postsecondary readiness expectations for Maryland high school graduates.

You were invited to attend this workforce focus group because you submitted a form to us to express your interest in participating. The purpose of today's focus group is for you to share your perspective on college and career readiness—and what it means for your business or organization. This information will help MSDE and the State Board make improvements to the readiness standards for high school students.

Everything you share in this focus group will be kept confidential, and we encourage you to share freely and openly. In our report, we will not share any participant or organization names, or other information that would allow anyone to identify you. At most, we may attribute findings to organization type, for example, different industries. We also ask that you keep our conversation in this focus group confidential.

Today's focus group will take about an hour. Participation in this focus group is voluntary. You may choose to answer or not answer any question and may leave the focus group at any time without any consequences.

Are there any questions before we proceed? [*Interviewer: Wait for responses]*

Do I have everyone's consent to participate in the interview? [*Interviewer: Wait for responses]*

We would like to request your permission to record the focus group to assist us with our note taking. We will use the recording only for our data collection and will not give access to anyone outside of the research team. Any references to names, organizations, or other identifiable information will not be used in the reporting.

Do I have everyone's consent to record? [*Interviewer: If everyone says yes, begin recording and note the date, time, and participants of the session*]

Question
Participant Introductions (8 Minutes) *First, we want to hear a little about you and your backgrounds.*
1. Please introduce yourselves. Use the Chatbox to share your name, your business or organization, and the context of your typical interactions with high school graduates (for example as a supervisor).
Career Readiness (40 Minutes) *Thank you, all, for those introductions. We will now move forward with our questions regarding the readiness expectations of students exiting high school and entering the workforce. To help you further understand what we mean by readiness, please view the screen to see a few options that showcase readiness via skills or knowledge.* [Interviewer: Share screen and allow a few minutes for participants to view slide] *The left-hand column references college-ready skills and the right-hand column references career-ready skills. With our focus today on entry-level staff straight out of high school, there may be characteristics in both columns that seem relevant at entry.*
3. What **skills and knowledge do you expect** of your entry-level staff who are coming straight out of high school that shows they are career ready? Probes: What abilities or background knowledge do you expect those joining your organization to have to be successful in your entry-level training programs and roles? How would you describe a successful individual during your entry-level training programs and afterward, in entry-level roles?

4. In your experience, what proportion of those entry-level staff **meet your expectations** for readiness when they enter your entry-level training program? Probe: For individuals who are not meeting expectations for readiness, what skills, abilities, or background knowledge would they benefit from developing?
PLEASE USE THE CHATBOX TO RESPOND TO THESE QUESTIONS: 5a. What are the **prerequisites or requirements** for your entry-level training programs, if any? *(Examples are specific courses and high school GPA.)* 5b. What **placement tests or other measures** are used to place individuals in your entry-level training programs or roles? *(Examples are pre-employment tests.)* 5c. To what extent do you think these prerequisites and placement tests or other measures **align** with your entry-level training program learning objectives and role needs? Can you give us examples?
6a. To what extent do you feel that entry-level training program prerequisites or selection/placement tests can be unfair **barriers** to access or success for some individuals? Can you share an example?
7. [**Skip if answered before.**] Are there any state **policies related to college and career readiness expectations that can be barriers** to individual success? To what extent do you think they can support or facilitate individual success?
Training Course Design (12 Minutes) *Thank you for all the information on readiness. Now I am going to ask a few questions about your approach to development for entry-level roles.*
8a. What are the **learning objectives** of your entry-level training programs? [CHATBOX] 8b. Do you ever **adjust/alter the training program learning objectives or curriculum to meet the needs** of your staff? If so, can you share an example?
9. What **strategies do you use to be considerate of diversity, equity, and inclusion**? Can you give us examples?
Wrap-Up (5 Minutes) *That brings us to the conclusion of the focus group.*
11. Before we end the call, is there anything we have not covered but is important for me to know?

Grades K–12 Education Focus Group Protocol

Maryland College and Career Readiness Empirical Study

Grades K–12—College and Career Readiness Expectations

Interviewer:

Participants/Institution:

Date/Time:

Introduction:

Thank you all for agreeing to participate in this focus group. I am ________ and also on the call is ___________. We work for the American Institutes for Research, or AIR, an independent, non-profit research organization that, in partnership with the Maryland State Department of Education, is conducting a study on the skills, knowledge, and abilities required of students to be college and career ready under the *Blueprint* for Maryland's Future*.* The *Blueprint* defines an initial standard for college and career readiness, or CCR, which aims to ensure that students are leaving high school prepared to be successful and directs this study to be completed to help determine the long-term CCR Standard.

As part of this study, AIR is completing several data collection activities, including gathering publicly available information about course requirements and expectations and conducting focus groups with faculty and staff from Maryland's postsecondary institutions and with members of the K–12 and workforce communities. We will synthesize and analyze the information across the data sources and create a report that will be shared with the Maryland State Department of Education, or MSDE, and the Maryland State Board of Education to articulate postsecondary readiness expectations for Maryland high school graduates.

You were invited to attend this workforce focus group because you submitted a form to us to express your interest in participating. The purpose of today's K–12 focus group is for you to share your perspective on college and career readiness—and what it means for your students. This information will help MSDE and the State Board make improvements to the readiness standards for high school students.

Everything you share in this focus group will be kept confidential, and we encourage you to share freely and openly. In our report, we will not share any participant or organization names, or other information that would allow anyone to identify you. At most, we may attribute findings to school type. We also ask that you keep our conversation in this focus group confidential.

Today's focus group will take about an hour. Participation in this focus group is voluntary. You may choose to answer or not answer any question and may leave the focus group at any time without any consequences.

Are there any questions before we proceed? [*Interviewer: Wait for responses]*

Do I have everyone's consent to participate in the interview? [*Interviewer: Wait for responses]*

We would like to request your permission to record the focus group to assist us with our note taking. We will use the recording only for our data collection and will not give access to anyone outside of the research team. Any references to names, organizations, or other identifiable information will not be used in the reporting.

Do I have everyone's consent to record? [*Interviewer: If everyone says yes, begin recording and note the date, time, and participants of the session*]

Question
Participant Introductions (5 Minutes) *First, we want to hear a little about you and your backgrounds.*
1. Please introduce yourselves. Use the Chatbox to share your name, your school and/or district, and the courses you teach.
Course and Career Readiness (40 Minutes) *Thank you, all, for those introductions. We will now move forward with our questions regarding the readiness expectations of students exiting high school and entering college or the workforce. To help you further understand what we mean by readiness, please view the screen to see a few options that showcase readiness via skills or knowledge.* [Interviewer: Share screen and allow a few minutes for participants to view slide] *The left-hand column references college-ready skills and the right-hand column references career-ready skills.*
2. What **skills and knowledge do you expect** of students who are college and career ready? Probes: What abilities or background knowledge do you expect those joining the workforce or college to have to be successful in industry entry-level training programs, roles, or college courses?
3. By the end of high school, what proportion of your students meet your expectations for college and career readiness?

4. In your experience, what proportion of high school students at the end of 10th grade **meet your readiness expectations when entering an additional program?** For example, when they enter industry entry-level training programs, roles, or college courses? Probe: For individuals who are not meeting expectations for readiness, what skills, abilities, or background knowledge would they benefit from developing? ***[Bigger picture is by end of high school; don't get hung up on 10th grade.]***
5. To what extent do 10th-grade readiness expectations affect opportunities in 11th or 12th grade (e.g., access to dual enrollment)?
Barriers & Strategies (10 Minutes) Thank you for answering these questions regarding readiness. Now we will be focusing on barriers and strategies for equity.
6a. [**Skip if answered before.**] Are there any state **policies related to college and career readiness expectations that can be barriers** to individual success? 6b. To what extent do you think they can support or facilitate individual success?
7. To what extent do you feel that any of the following may be unfair barriers to access or success for some individuals? • Entry-level course/training program prerequisites • Requirements for enrollment • Selection/placement tests Can you share an example?
8. What **strategies do you use to be considerate of diversity, equity, and inclusion**? Can you give us examples?
Wrap-Up (5 Minutes) *That brings us to the conclusion of the focus group.*
9. Before we end the call, is there anything we have not covered but is important for me to know?

Appendix E. Top-Performing Education Systems

E.1. Detailed Approach to Identification and Selection of Top-Performing Education Systems

The following information was used to select the three U.S. states for comparison (Massachusetts, Connecticut, and Colorado):

- **ACT and SAT Performance:** The ACT assessment defines a set of CCR benchmarks that signal whether students may be considered ready for college or the workforce; students who meet these benchmarks have a 75% or better chance of earning Grade C or above in first year entry-level courses of corresponding subjects. The ACT CCR benchmarks by section are 18 for English, 22 for mathematics, 22 for reading, and 23 for science (Allen & Radunzel, 2017). Similarly, the College Board defines SAT CCR benchmarks (College Board, 2023). SAT CCR benchmarks include a score of 480 on the Evidence-Based Reading and Writing section and a score of 530 on the Math section. The U.S. states with the greatest share of students meeting the ACT and SAT benchmarks include: Connecticut, Illinois, New Jersey, Massachusetts, Idaho, Colorado, Rhode Island, New Hampshire, Maine, and Hawaii (Alas, 2021).
- **National Assessment of Educational Progress (NAEP):** NAEP, which is administered by the National Center for Education Statistics (NCES), is an assessment that provides key information about achievement and student learning experience in a range of K–12 subjects. We examined 2022 NAEP scores by state in 8^{th} grade reading and math (NAEP also provides 12^{th} grade assessments, but not all states participate). The states with the highest average scale scores in reading include New Jersey, Massachusetts, Utah, Connecticut, Vermont, Idaho, Colorado, New Hampshire, Wisconsin, and Ohio. The states with the highest average scale scores in math include Massachusetts, Utah, Idaho, South Dakota, Wisconsin, Wyoming, New Jersey, Minnesota, Nebraska, and Virginia (NAEP, 2022).
- **Postsecondary attainment:** We also reviewed state data on postsecondary credential attainment, including 4-year, 2-year, and other post-high school certifications and credentials. Nationwide, 54% of individuals over the age of 25 have a postsecondary credential. The top states in terms of credential attainment include the District of Columbia, Massachusetts, New York, New Jersey, Vermont, Minnesota, Connecticut, and New Hampshire (Lumina Foundation, 2023). Measures of postsecondary attainment are included as a complement to the other factors in this list because they measure the

attainment of the state's population rather than the postsecondary attainment of the students educated in the state's K–12 education system.

Below (Exhibit E.1.1) is an initial list of top-performing countries based on the 2018 Programme for International Student Assessment (PISA)[1] and the 2019 the Trends in International Mathematics and Science Study (TIMSS)[2].

Exhibit E.1.1. An Initial List of Top-Performing International Education Systems

Country	Assessments used to identify top-performing systems
Canada	PISA (2018)
China (Taipei)	PISA (2018), TIMSS (2019; Math 8th), TIMSS (2019; Science 8th)
Estonia	PISA (2018)
Finland	PISA (2018), TIMSS (2019; Science 8th)
France	PISA (2018)
Germany	PISA (2018), TIMSS (2019; Math 8th), TIMSS (2019; Science 8th)
Hong Kong	PISA (2018), TIMSS (2019; Math 8th)
Japan	PISA (2018), TIMSS (2019; Math 8th), TIMSS (2019; Science 8th)
Poland	PISA (2018)
Singapore	PISA (2018), TIMSS (2019; Math 8th), TIMSS (2019; Science 8th)
South Korea	PISA (2018)
Taiwan	PISA (2018)

Assessment scores serve as a starting point, but only tell part of the story. Structural differences between some international systems and the U.S. education system (e.g., central vs. decentralized system, funding mechanisms, number of years of compulsory education) has an impact on assessment scores. For example, China is often included on lists of top education systems using assessment scores; however, China segregates advantaged students and disadvantaged students more than the OECD country average (Schleicher, 2019), leading us to exclude it from the analysis. In looking at both academic performance and structural components of the education system, we selected four countries for the in-depth landscape

[1] Launched in 2000, the Programme for International Student Assessment (PISA) is a standardized test initially developed by experts across the Organisation for Economic Co-operation and Development (OECD) countries. PISA assesses reading, math, and science knowledge, and how to apply that knowledge, among 15-year-old students across multiple nations. See: https://ncee.org/top-performing-countries/.

[2] Since 1995, the Trends in International Mathematics and Science Study (TIMSS) has assessed students in math and science in grades 4 and 8 every four years and is sponsored by the International Association for the Evaluation of Educational Achievement (IEA). In 2019, TIMSS was administered across 64 countries and 8 benchmarking systems. See: https://timss2019.org/reports/achievement/.

analysis that represent different features of the top-performing international education systems: Estonia, Germany, Japan, and Singapore. Exhibit E.1.2 provides a short description of each system.

Exhibit E.1.2. International Education Systems Included in Landscape Analysis

Country	Description
Estonia	Estonian students ranked first in reading and science and third in math of all OECD Countries on the 2018 PISA. Socioeconomic status has a relatively low impact on performance compared to OECD nations; for instance, Estonia has the largest share of students from the lowest socioeconomic quartile scoring in the highest quartile on the PISA (NCEE, n.d.-b). Additionally, Estonian K-12 schools are decentralized, with a great deal of autonomy, similar to K–12 schools in the U.S. (European Commission, 2023). Students are required to attend school between the ages of 7 and 17.
Germany	Germany scores above the OECD average on PISA and TIMSS and has made substantial progress in this area in the last two decades. After the first round of PISA scores were released in 2001, Germany implemented widespread education reforms to improve performance, which has led to the country's strong performance among OECD countries. Like the U.S. and Estonia, Germany's education system is decentralized. Compulsory education is from age 6 to 15 or 16, depending on the region (NCEE, n.d.-d). However, outcomes for students in Germany are highly stratified. The mean performance gap between advantaged and disadvantaged students in 2018 was 113 score points in Germany, the equivalent of 3.5 years of schooling (OECD, 2022a).
Japan	Japan scores in the top five of education systems in the world based on PISA and TIMSS scores, and its scores also show greater equity than in many other OECD jurisdictions, with the impact of socio-economic status on student performance well below the OECD average. Teachers and expenses are paid by the central government, and the common curriculum provides consistent expectations nationwide. These policies have in part supported relatively equal opportunities in education for those from different socioeconomic backgrounds (NCEE, n.d.-f).
Singapore	Singapore is within the top two performing countries in nearly all PISA and TIMSS categories, and it has higher racial and ethnic diversity as compared to other East Asian countries. Singapore's education system has been credited with the country's rapid development in the past decade (Vaidiyanthan, 2020). Primary education (six years) is compulsory for students between the ages of 6 and 15 (Singapore Ministry of Education, n.d.). The education system is highly stratified; those from higher socioeconomic strata have been improving academically at a much greater rate than those from lower SES groups (OECD, 2018).

E.2. All-Country Grid

The following exhibits describe information about the top-performing countries reviewed for this study (based on PISA and TIMSS performance).

Exhibit E.2.1. Singapore

5.9 Million People (NCEE, n.d.-j)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Singapore schools conduct annual self-evaluations based on nine criteria. Any necessary school improvements are organized by the Singapore school cluster system (NCEE, n.d.-j). • Teachers. The Enhanced Performance Management System conducts annual teacher evaluations. Sixteen different competencies are assessed for teachers. Excellent teachers receive national recognition and awards (NCEE, n.d.-j). • Principals. Aspiring principals must have three years of teaching experience. Additionally, principals must attend a Leaders in Education Program (NCEE - Singapore, n.d.).	• Singapore has two secondary programs: the Normal Academic Program and the Normal Technical Program. Singapore has shifted from rote learning to curricula focusing on student engagement and creativity (NCEE, n.d.-j). • A crucial part of the Singapore academic standards involves mathematical problem solving (MPS). MPS has been a key curriculum factor since the early 1990s. This may contribute to the country's academic success (Toh et al., 2019).	• The postsecondary attainment rate for those 25 years and older is 55.8% in Singapore (NCEE, n.d.-j). • Singapore has a number of admission exercises for students depending on their postsecondary goals. There are N-Level admissions exercises for students who aspire to go to vocational education and training (VET) schools. The O-Level admission exercise set is for students who aspire to attend college (Singapore Ministry of Education, n.d.).	• Governance and system structure. Unlike some other systems, CTE in Singapore is mostly offered in postsecondary institutions. Additionally, Singapore offers an online system to help students with career exploration. Singapore has one primary postsecondary CTE institution, the Institute of Technical Education (NCEE, n.d.-j). • CTE Programs. Singapore offers students 2-year programs that lead to a National ITE certificate (Nitec) (NCEE, n.d.-j). • Singapore has a program called SkillsFuture. Unlike other vocational programs, SkillsFuture focuses on the life-long accumulation of vocational skills (Sung et al., 2022).

Exhibit E.2.2. Estonia

1.2 Million People (NCEE, n.d.-b)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Estonia has no comprehensive inspections for schools, as do some other systems. Instead, every three years, schools conduct self-evaluations. Additionally, schools must create a school development plan using self-evaluations which should summarize strengths and weaknesses (NCEE - Estonia, n.d.). • Teachers. The central ministry evaluates teachers. Furthermore, principals evaluate teachers, too, on a regular basis. Additionally, more teachers in Estonia are evaluated compared with other OECD countries (NCEE, n.d.-b). • Principals. Estonia uses a nationwide competency set for principals. Additionally, principals must also have a master's degree (NCEE, n.d.-b).	• Estonia's national curriculum emphasizes problem-solving, critical thinking, and information technology (NCEE, n.d.-b). • Students who desire postsecondary education must take a set of national exams at the end of 12th grade. In addition, they must pass their school's test based on the national curriculum. Postsecondary institutions submit their own admission criteria, but they are usually based on exam scores and interviews (NCEE - Estonia, n.d.). • A recent study found that many teachers in Estonia embrace a student-centered learner style (Rosin et al., 2022).	• The postsecondary attainment rate for those 25–34 years old is 43%, and for those 25–64 years old, the postsecondary attainment rate is 41% (NCEE, n.d.-b). • Students are not required to pay higher education fees. In 2013 Estonia abolished higher education student fees (Põder & Lauri, 2021). • In higher education, Estonia spends slightly above the per-pupil OECD average (Põder & Lauri, 2021). • Some of Estonia's universities are more selective than others. Higher education admission is based on results from the standard country central exam (Põder & Lauri, 2021).	• Governance and system structure. Vocational education is offered at the upper secondary and postsecondary levels. Like other countries, external agencies work with the Ministry of Education and Research to oversee the VET programs (NCEE, n.d.-b). • CTE Programs. Vocational education and training are provided for 21 broad fields, including communication technology. VET programs use the national curricula to develop their own curricula (NCEE, n.d.-b).

Exhibit E.2.3. Japan

125 Million People (Japan, n.d.-f)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Student progress is monitored through the National Assessment of Academic Ability. Additionally, as a part of the accountability process, schools are inspected and required to complete an annual evaluation (NCEE, n.d.-f). • Teachers. The law requires teacher evaluations. Principals and vice-principals observe teachers bi-annually. Teachers in higher-performing schools are often shifted to lower-performing schools (NCEE, n.d.-f). • Principals. In Japan, individual provinces are responsible for developing principal qualifications (NCEE, n.d.-f).	• A research study that included China, Japan, Korea, and the United States examined factors associated with the career preparation of high school students. One of the major findings from this study was that career planning is an essential part of curricula standards (Xiao et al., 2016).	• The postsecondary attainment rate for ages 25–34 is 61.5%, and for ages 25–64, it is 52.7% (NCEE, n.d.-f). • Access to academic upper secondary school is competitive. Japan offers two-year junior colleges (NCEE, n.d.-f). • Students who do well on the National Center Test for University Admissions usually attend universities instead of CTE schools (NCEE, n.d.-f).	• Governance and system structure. Career and technical education occur mostly at the upper secondary levels (NCEE, n.d.-f). • CTE Programs. Even CTE programs provide advanced coursework to students. Additionally, CTE programs often partner with universities to deliver instruction (NCEE, n.d.-f). • Some specialized vocational training colleges require no entrance exam. However, university admittance is based on the National Center Test for University Admissions. This exam is known as the "Center Test." It has five fields of focus: Japanese language, foreign language, math, science, and social studies (NCEE, n.d.-f).

Exhibit E.2.4. Canada

37.9 Million People (NCEE, n.d.-a)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. If schools do not meet standards (based on student assessments taken in grades 3, 6, 9, and 10), they must develop improvement plans for professional development, curriculum coaching, and other school-based interventions (NCEE, n.d.-a). • Teachers. In Canada, teachers are scored on 16 competencies. There is no performance pay; however, teachers may receive penalties for unsatisfactory ratings on the Teacher Performance Appraisal (TPA) (NCEE, n.d.-a). • Principals. In Canada, principals must have at least five years of teaching experience along with certification (NCEE, n.d.-a).	• Canada does not have a national curriculum. • All postsecondary schools set their own admission policies (Ontario, n.d.-b). • There are a number of academic and non-academic standards for primary and secondary schools; however, there is no disaggregation for college and career readiness (Ontario, n.d.-b). • There is a 30-hour work experience or career-life exploration project (NCEE, n.d.-a). • Students who have completed an appropriate three-year advanced diploma may enroll in university courses directly (Percival et al., 2015).	• The postsecondary attainment rate for ages 25–34 is 63%, and for ages 25–65, it is 59.4% (NCEE, n.d.-a). • For university admission, there is no national or standardized exam. • Ontario lowered the cost of postsecondary education by offering grants and low-interest loans to needy families (NCEE, n.d.-a). • Students who attend community college first, do better at the university level (Quinn-Nilas et al., 2022).	• Governance and system structure. CTE classes are offered to students along with academic courses; however, most vocational education occurs at the postsecondary level. Industry representatives assist with CTE program creation (NCEE, n.d.-a). • CTE programs. Graduates may enter the workforce, or they may begin in a postsecondary institution (NCEE, n.d.-a). • The Canadian Council of Directors of Apprenticeships develops the national assessment skill standards for 56 trades. Students begin a career/life planning program while in kindergarten. Students in British Columbia must take two career education courses in high school (NCEE, n.d.-a).

Exhibit E.2.5. China

1.4 Billion People (NCEE, n.d.-i)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. The Bureau of Education Inspections monitors all schools in China. But the bureau does not dictate remedies for low-performing schools (NCEE, n.d.-i). • Teachers. Top-performing teachers are expected to help the lower-performing teachers. Additionally, administrators in top-performing schools spend time in lower-performing schools (NCEE, n.d.-i). • Principals. In China, principals must adhere to the Professional Standards for Compulsory Education Principals. Additionally, principals must complete 360 hours of professional development every five years (NCEE, n.d.-i).	• China has a national curriculum. • For Chinese high school students, career readiness is an essential step in the transition from high school to university (Gu et al., 2020). • In addition to the tests for graduation and placement, China has a national assessment that tests a sample of students in grades 4 and 8 in six subjects (NCEE, n.d.-i). • Caution. The selection of students for assessments in China is not representative of the nation. China has 32 provinces, yet PISA results are based on scores from only four provinces (Beijing, Shanghai, Jiangsu, and Zhejiang). Before Zhejiang participated, the province of Guangdong participated, and China's scores were 61 points lower (Candido et al., 2020; Loveless, 2019).	• The postsecondary attainment rate for citizens 25–34 is 18% (NCEE, n.d.-i) • The education system consists of a series of exams, but the Gaokao is the most influential (Pires, 2019). • The Gaokoa is the National College Entrance Exam. It tests skills and knowledge in Chinese, math, a foreign language, and a few other subjects. In general, candidates for vocational upper secondary schools score lower on the exam than candidates for academic schools (NCEE, n.d.-i).	• Governance and system structure. Students can choose to pursue vocational education at the end of lower secondary school, around age 15, but rural students often start vocational programs earlier. There are separate vocational secondary and postsecondary programs. About 40% of students attend vocational schools instead of academic ones (NCEE, n.d.-i). • CTE programs. Research showed that an online career readiness intervention significantly increased Chinese high school students' career readiness and reduced their career decision-making difficulties (Chen et al., 2021).

Exhibit E.2.6. Finland

Population – 5.6 Million People (NCEE, n.d.-c)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. The Finnish Education Evaluation Center (FINEEC) oversees schools. FINEEC administers examinations to students as well. It provides non-binding recommendations to schools (NCEE, n.d.-c). • Teachers. Finland has no required formal teacher evaluations. However, some municipalities create their own. Also, teachers have a great deal of teaching autonomy in Finland (NCEE, n.d.-c). • Principals. Principals must meet one of three requirements, along with being qualified to teach at their school level (1) a Certificate of Educational Administration, (2) proven experience in educational leadership, (3) or an Education leadership credential from a university (NCEE, n.d.-c).	• Finland has a national core curriculum (NCEE - Finland, 2023). • In Finland, teachers do not have punitive high-stakes testing. Instead, the Finnish curriculum focuses on diversity in assessment methods and assessments that promote and guide learning (Muuri, 2018). • Finnish schools have a great degree of autonomy. No specific regulations govern factors like class size (Fakhoury, 2022). • Eighth-grade students must decide whether they want to pursue an academic track that could lead to university study or if they want to purpose a vocational track leading to a job out of high school (NCEE, 2023). • All students are able to take the Matriculation Exam in the 12th grade for university admission (NCEE – Finland, n.d., 2023).	• The postsecondary attainment rate for ages 25–34 is 42%. The postsecondary attainment rate for ages 25–64 is 46% (NCEE, n.d.-c). • Education in Finland is free at all levels (Fakhoury, 2022). • Postsecondary institutions primarily use the Matriculation Exam for admission decisions. If students do not take the Matriculation Exam, they have the option of taking university-based exams in its place (NCEE, n.d.-c). • There is one postsecondary national application system. (Fakhoury, 2022). • Unlike most countries, when students are admitted into a bachelor's degree program, they have a right to complete a master's degree as well (Muuri, 2018).	• Governance and system structure. Industry representatives assist with creating vocational programs. Finland's education system has ten broad fields for students to choose from for their programs (NCEE, n.d.-c). • CTE programs. All vocational programs include the same set of academic studies for students. Students must pass assessments for the vocational qualification. Once they do, they receive certification. Once they receive a vocational certification, they can then move on to university-level study (NCEE, n.d.-c). • Vocational education/training is largely school-based. There are also mandatory periods of work-based learning. Vocational education is complemented by at least six months of actual work experience (Musset, 2015).

Exhibit E.2.7. Hong Kong

7.3 Million People (NCEE, n.d.-e)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Hong Kong has the Quality Assurance for Schools Program. This mandatory framework includes school self-assessment and external school inspections (NCEE, n.d.-e). • Teachers. Hong Kong does not have a formal teacher evaluation system. However, all teachers must be registered at the Hong Kong Education Bureau (NCEE, n.d.-e). • Principals. Aspiring principals must complete the Certification for Principalship, in which they complete an action research project and a professional development portfolio. Principals must complete 150 hours of professional development within a three-year time frame (NCEE, n.d.-e).	• There are nine generic skills that are promoted in the Hong Kong curriculum: Basic Skills (Communication, Numeracy/Mathematical, Information Technology), Thinking Skills (Critical et al.), Personal and Social Skills (Self-management, and Study/Self-learning, Collaboration) (Leung et al., 2019). • Students take the Hong Kong Diploma of Secondary Education Examination (HKDSE) to determine their college prospects (NCEE, n.d.-e). • Additionally, students take the Hong Kong Examination (HKALE) for university admission decisions (Chong-Sze et al., 2020). • To assess career readiness in Hong Kong, researchers have used the Career Adapt-Ability Scale (CAAS) (Leung et al., 2022).	• The postsecondary attainment rate for ages 25 and older is 29.1% (NCEE, n.d.-e). • Students need the Higher Diploma to apply to bachelor's degree programs (NCEE, n.d.-e).	• Governance and system structure. The Hong Kong Council for Accreditation of Academic and Vocational Qualifications provides oversight of Hong Kong's vocational education programs. Additionally, the Vocational Training Council, also known as VTC, provides oversight of the country's vocational education and training. VTC is a government-funded statutory body that advises the Chief Executive on Vet policy and provides VET to students (NCEE, n.d.-e) • CTE Programs. The most common vocational education credential is the Diploma of Vocational Education (DVE) program, which prepares students to enter the workforce. If students opt for the DVE, they may still pursue a bachelor's degree program once they complete a traditional Higher Diploma, which takes 1–2 years (NCEE, n.d.-e).

Exhibit E.2.8. Poland

38.2 Million People (NCEE, n.d.-h)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Poland has a required inspection system for all schools. The principal must develop a plan for approval if a school does not meet the accountability metrics. The school could be shut down if there is no improvement (NCEE, n.d.-h). • Teachers. There are two different types of teacher evaluations: performance assessment (teaching ability evaluation) and assessment of professional achievement (measures professional development toward promotion). Teachers at all grade levels must hold at least a master's degree (NCEE, n.d.-h). • Principals. In Poland, principals must have five years of teaching experience and must also have a master's degree in education administration (NCEE, n.d.-h)	• The Ministry of Education in Poland oversees a national curriculum (NCEE, n.d.-h). • In Poland, the Central Examination Board certifies, evaluates, and issues vocational qualifications (NCEE, n.d.-h).	• The postsecondary attainment rate for ages 25–34 is 43.5%, and for ages 25–64, it is 32% (NCEE, n.d.-h). • Poland has more postsecondary attrition than other OECD countries. One possible explanation for this attrition could be students not choosing the best programs based on their interests (Zajac & Komendant-Brodowska, 2019).	• Governance and system structure. Today, more than 50% of Polish students chose vocational pathways. End-of-year test scores for grade 8 also impact their postsecondary options (NCEE, n.d.-h). • CTE Programs. At the age of 15 (primary school completion, students must decide if they are going into a vocational or academic track. Students who engage in the technical track spend five years in a technical secondary program. At least half of this time must be spent on work-based learning. Upon completion of the program, vocational school students must take a national external exam to attain the vocational certification (NCEE, n.d.-h).

Exhibit E.2.9. Korea

51.7 Million People (NCEE, n.d.-g)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Schools are evaluated every one to three years by regional offices. The reviews are not punitive. Instead, they are used to provide advice on how schools can improve (NCEE, n.d.-g). • Teachers. Teacher quality is very important in Korea. Across all countries in the world, Korea has one of the highest percentages of teachers who are fully certified and have a bachelor's degree. Teachers are evaluated annually using national guidelines. Additionally, teachers rotate through different schools (NCEE, n.d.-g). • Principals. Most principals have an average of 30 years of teaching experience. They must undergo a 180-hour training program (NCEE, n.d.-g).	• Korea uses a national curriculum (NCEE, n.d.-g). • In Korea, the College Scholastic Ability (CSAT) Test is used to render college admissions decisions (Kim & Kim, 2019). • On the day of the government-sponsored CSAT, office workers start later in the day to help reduce the traffic congestion experienced by examinees, and the stock market opens late (Jun et al., 2021).	• The postsecondary attainment rate for those 25–34 years old is 70%, while the postsecondary attainment rate for those 25–64 years old is 50% (NCEE, n.d.-g). • Students in Korea usually enter college at age 19; thus, they are older than the average college student in the United States (Jun et al., 2021).	• Governance and system structure. Students begin vocational education and training (VET) while at the upper secondary school level. Once students complete upper secondary VET, they can go straight to work or apply to 2–3-year vocational programs at colleges or universities (NCEE, n.d.-g). • CTE Programs. Over half of the students in VET programs are in specialized programs such as manufacturing, information technology, or agriculture. Most VET college teachers also work in industry; thus, 84% of VET college instructors are part-time (NCEE, n.d.-g).

Exhibit E.2.9. Taiwan

23.6 Million People (NCEE, n.d.-k)

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. The major form of school accountability comes through school inspections, although schools develop their own self-evaluations. Some schools that do not meet the standards can apply for school improvement assistance (NCEE, n.d.-k). • Teachers. Teachers are evaluated annually. These evaluations focus on teaching, training, service, morality, and administrative records. The evaluations are conducted by school staff members (NCEE, n.d.-k). • Principals. Principals must have at least four years of teaching experience and two years of administrative experience. Additionally, aspiring principals must take a competitive qualification exam (NCEE, n.d.-k).	• Students in Taiwan take the General Scholastic Ability Test (GSAT) for university admission consideration. The GSAT includes 100-minute Chinese, English, mathematics, natural sciences, and social sciences tests. Also, students must take the Advanced Subjects Tests (AST) for university consideration (NCEE, n.d.-k). • In Taiwan, only the top 20% of exam takers will enter the academic tracks, while 80% will go on to vocational tracks because the senior high school entrance exam is so competitive (Li et al., 2021). • There are two categories of junior high school students in Taiwan: those who are preparing to go to senior high school and those planning for vocational technological schools (Tien & Wang, 2016).	• The postsecondary attainment rate for those 15 years and older is 46.5% (NCEE, n.d.-k).	• Governance and system structure. Some of Taiwan's vocational programs are overseen by local Bureaus of Education, while others are overseen by the Ministry of Education. • Another important point is that schools are required to integrate career planning with the required academic subject matter (NCEE, n.d.-k). • CTE Programs. Developed by the Taiwan Career Development and Consultation Association, students can choose from a variety of training programs, which consist of 140 hours, 96 hours of class work, 32 hours of practicum, and 12 hours of supervision (Tien & Wang, 2016). CTE programs are housed at dedicated vocational-only schools, comprehensive upper secondary schools, and junior colleges (NCEE, n.d.-k).

Exhibit E.2.10. Germany

80 Million People (NCEE, n.d.-d)
Germany is typically not a higher-performing country. However, the country was added at the client's request.

Design Components of the K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• Schools. Germany has no national school regulations. Instead, schools are controlled by each of the 16 German federal states (Kruse, 2019). Germany also uses inspections as a part of the accountability system (NCEE, n.d.-d). • Teachers. It is important to note that German teachers are paid more than most teachers in the OECD. Additionally, the retention rate for teachers is very high, with 95% for five years (NCEE, n.d.-d). • Principals. Germany has no required training or national principal requirements (NCEE, n.d.-d).	• Germany has three main curricula platforms. The Gymnasium is highly academic. The Realschule is academic, but it is less demanding than the Gymnasium. Lastly, the Hauptschule curriculum is a basic studies program. Based on the program of study and test scores, Germany tracks students beginning at the age of 10–12. Only the Gymnasium program and the Realschule program prepare students for higher education (Tieben, 2020). • The Abitur is the entrance exam for university admittance. Students must receive 300 points to pass the test (NCEE, n.d.-d). • Even more, the Abitur contains four to five subject areas, including German, foreign language, mathematics, etc. (NCEE, n.d.-d).	• The postsecondary attainment rate for those 25–34 years of age is 36% (OECD, 2022a). • Germany has experienced slower tertiary attainment than most of the other OECD countries (OECD, 2022a). • Postsecondary education is free to all Germans and European Union citizens (NCEE, n.d.-d).	• Governance and system structure. Like some other school systems, industry professionals prepare the training and supervise the vocational work of students. Students who complete either the Realschule or the Haupstchule curriculum usually enroll in vocational programs after high school (NCEE, n.d.-d). • CTE programs. Germany has a stronger VET program than most countries; therefore, Germany offers more career paths than other countries (OECD, 2022a).

Exhibit E.2.11. France

67.6 Million People (Statista, 2023)

France is not a higher-performing country. However, the country was added at the client's request.

France is not located in the NCEE profile directory; therefore, the format of this table differs slightly from the other tables presented.

Design Components of K-12 and Higher Education System	Academic and Nonacademic Standards, Assessments & General Information	College/University Information, More about Assessments & Misc. Education Information	Career and Technical Education Information
• France has initiated decentralization education system measures since the 1980s to reinforce the weight of local authorities. Municipal communities, departments, and regions participate in the functioning of the national education system (European Committee of the Regions, n.d.). • In France, 15-year-olds scored slightly above the OECD average in reading, mathematics, and science in PISA 2018. However, disadvantaged students were five times more likely not to reach the minimum proficiency in reading (PISA) level than their advantaged peers (OECD, 2018).	• Some students take the French Baccalaureate or "le Bac" at the end of high school. This is an extensive national examination. It marks the successful conclusion of secondary studies. Students who wish to move on to postsecondary studies must take this exam (Cultural Services French Embassy in the United States, n.d.). • In France, people with college degrees are more likely to be underemployed or unemployed than the OECD average (OECD, 2022b).	• In France, 12.8% of those 25–34 years old have attained a bachelor's degree or equivalent. This is among the lowest among countries with available data (OECD 2022b). • France has three types of higher education institutions: universities, G*randes écoles*, and specialized schools (Fulbright France, n.d.).	• Governance and system structure. • Upper-secondary level students can follow a three-year VET program if they want to pursue higher education (OECD, 2022b). • France is enhancing its upper-secondary vocational pathways to increase the number of students entering it. However, disadvantaged students are over-represented in secondary VET programs. Eighty-seven percent of the students in France's VET programs have parents with no higher education (OECD 2018, 2022b).

Appendix F. Alignment Review Information

This section provides additional information about the content and standards alignment analysis. To conduct the alignment review, AIR drafted review materials, developed an alignment index to qualitatively code the alignment of content and similarity of rigor, created an alignment tool to support the alignment review, convened reviewers for alignment sessions, and analyzed the data from the alignment sessions. In this section, we present an overview of the review materials, including a description of the high school content area standards, alignment index, and alignment tool.

F.1. Maryland CCR Standard for Content Areas Included in Alignment Review

ELA and Math

Exhibit F.1.1 outlines the high school ELA and math academic standards used to conduct the alignment review and a short rationale for their inclusion.

Exhibit F.1.1. Content Area Standards in the Maryland CCR Standard Included in the Alignment

Content area	Course content standards	Rationale
ELA	Grade 9/10 Standards	The Blueprint sets the expectation that students are college and career ready by the end of Grade 10.
Math	Algebra I, Algebra II, Geometry, Statistics Standards	The Blueprint outlines multiple potential math pathways for students to meet the CCR Standard by Grade 10, all of which include either Algebra I, Algebra II, or geometry. We also included statistics in the review since the number of students who enroll in college statistics courses as their first-year credit-bearing course is substantial.

Science

This analysis compares the high school Next Generation Science Standards Disciplinary Core Ideas (DCIs) for Physical Science and Life Science and select high school ELA and math standards to the course content expectations of first-year credit-bearing science courses, which varied across colleges in terms specificity and depth. To address the variation and develop a better understanding of the common course content across colleges, AIR synthesized information collected through the course inventory and from stakeholder input into a conceptual framework for Life Science and Physical Science (Appendix H.3). The conceptual framework aims to summarize college science course content and learning objectives into a straight-forward description of common content expectations. Using the conceptual framework as a high-level summary, as well as other materials such as a searchable Excel database of course learning objectives, course descriptions, and course syllabi, we looked for evidence that the high school Maryland CCR Science Standards (Life Science and Physical Science) were reflected within the course content expectations. In addition, we looked at the Disciplinary Literacy (Reading and Writing) Standards for Science and Technical Subjects.

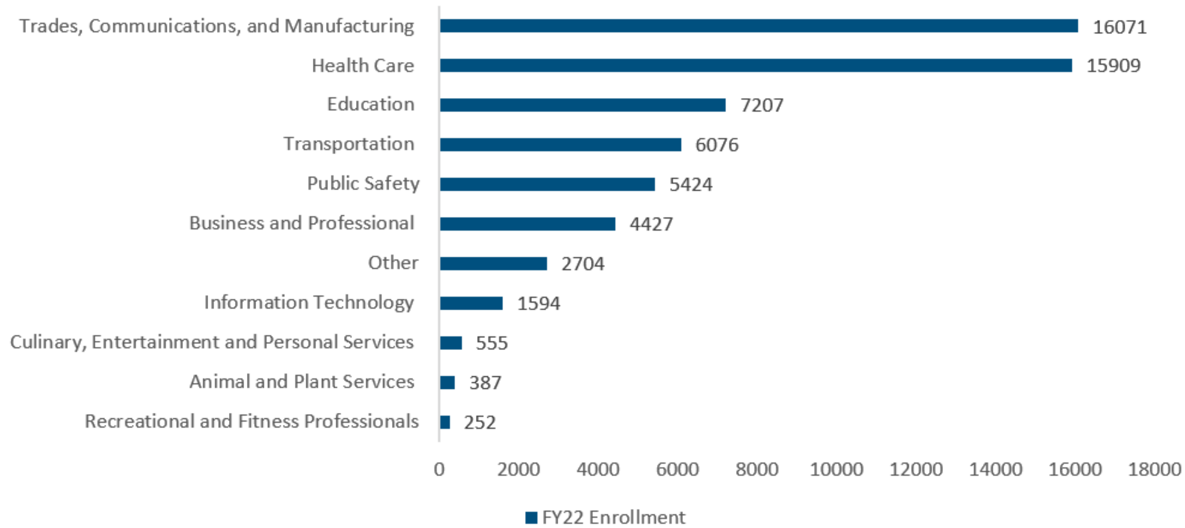
Certificate-Granting Training Programs

The standards and content alignment analysis also looked at the alignment of high school standards with content expectations for certificate-granting training programs at Maryland's community colleges. Unlike Maryland's K–12 CCR content standards, there is no commonly accepted set of college content expectations across postsecondary institutions. This variation is even more pronounced when examining certificate-granting programs.

In FY22 Maryland's community colleges offered more than 300 Workforce Training Certificate (WTC) programs and 241 different courses leading to licenses or certifications (MACC, 2022). The WTC programs with the highest enrollment[3] include those in trades, communications, and manufacturing (including apprenticeships), health care, education, transportation, public safety and business and professional areas (Exhibit F.1.2). These high-enrollment programs align with findings from a review of the high demand/high growth industries identified by Maryland's local workforce development boards in their 2021 local plans which highlighted the importance of transportation, manufacturing, health care, and business and professional services.

[3] The MACC Workforce Training Dashboard Data Dictionary defines enrollment as "The total number of registrations in a particular program. For example: One student takes 4 classes in a sequence of classes leading to a certificate of completion. This is 4 enrollments."

Exhibit F.1.2. Workforce Certificate Program Enrollment by Industry[4] (FY22)



Source: MACC Workforce Training Dashboard, FY22

We examined two existing workforce frameworks and the extent to which Maryland's Disciplinary Literacy Standards, Mathematical Practices and Science and Engineering Practices align to those content expectations. These frameworks include the U.S. Department of Labor's O*NET Content Model and the U.S. Department of Education's Employability Skills Framework.

*O*NET Content Model*

O*NET is managed and maintained by the U.S. Department of Labor and provides occupational information such as "standardized and occupation-specific descriptors on almost 1,000 occupations covering the entire U.S. economy"[5]. The O*NET Content Model provides a framework that articulates the "key attributes and characteristics of workers and occupations".[6] One component of the model focuses on Worker Requirements and includes Basic Skills that "facilitate learning or the more rapid acquisition of knowledge" (Exhibit F.1.3) and Cross-Functional Skills that 'facilitate performance of activities that occur across jobs" (Exhibit F.1.4).

[4] The Workforce Training Dashboard currently reports workforce training certificates in these eleven industry categories.
[5] https://www.onetcenter.org/overview.html
[6] https://www.onetcenter.org/content.html

Exhibit F.1.3. O*NET Basic Skills

Skill	Description
Content Skills. Background structures needed to work with and acquire more specific skills in a variety of different domains.	
Active Listening	Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.
Mathematics	Using mathematics to solve problems.
Reading Comprehension	Understanding written sentences and paragraphs in work-related documents.
Science	Using scientific rules and methods to solve problems.
Speaking	Talking to others to convey information effectively.
Writing	Communicating effectively in writing as appropriate for the needs of the audience.
Process Skills. Procedures that contribute to the more rapid acquisition of knowledge and skill across a variety of domains.	
Active Learning	Understanding the implications of new information for both current and future problem-solving and decision-making.
Critical Thinking	Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.
Learning Strategies	Selecting and using training/instructional methods and procedures appropriate for the situation when learning or teaching new things.
Monitoring	Monitoring/assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action.

Source: Basic Skills: https://www.onetonline.org/find/descriptor/browse/2.A

Exhibit F.1.4. O*NET Cross-Functional Skills

Skill	Description
Complex Problem-Solving Skills. Developed capacities used to solve novel, ill-defined problems in complex, real-world settings.	
Complex Problem Solving	Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.
Resource Management Skills. Developed capacities used to allocate resources efficiently.	
Management of Financial Resources	Determining how money will be spent to get the work done, and accounting for these expenditures.
Management of Material Resources	Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain work.
Management of Personnel Resources	Motivating, developing, and directing people as they work, identifying the best people for the job.
Time Management	Managing one's own time and the time of others.
Social Skills. Developed capacities used to work with people to achieve goals.	
Coordination	Adjusting actions in relation to others' actions.
Instructing	Teaching others how to do something.
Negotiation	Bringing others together and trying to reconcile differences.
Persuasion	Persuading others to change their minds or behavior.
Service Orientation	Actively looking for ways to help people.
Social Perceptiveness	Being aware of others' reactions and understanding why they react as they do.
Systems Skills. Developed capacities used to understand, monitor, and improve socio-technical systems.	
Judgment and Decision Making	Considering the relative costs and benefits of potential actions to choose the most appropriate one.
Systems Analysis	Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes.
Systems Evaluation	Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.
Technical Skills. Developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems.	
N/A	N/A

Note. The Technical Skills reflected in O*NET Cross-Functional Skills were deemed to be not applicable to this task and are noted as N/A above.
Source: Cross-functional Skills: https://www.onetonline.org/find/descriptor/browse/2.B

Employability Skills Framework

The Employability Skills Framework was developed by the U.S. Department of Education to support the work of the Office of Career and Technical Education. It includes nine skills across three categories that describe the academic knowledge (Applied Knowledge), technical expertise (Workplace Skills), and cross-cutting abilities (Effective Relationships) students need to develop to be college and career ready (Exhibit F.1.5).

Exhibit F.1.5. Employability Skills

Category	Skill	Description
Applied Knowledge	Applied Academic Skills	Based on academic disciplines and learning (e.g., reading, writing, mathematical strategies and procedures, scientific principles and procedures)
	Critical Thinking Skills	Includes content related to analyzing, reasoning, solving problems, planning, organizing, and making sound decisions.
Workplace Skills	Resource Management	Includes content related to successfully performing tasks by managing time and other resources.
	Information Use	Includes content related to understanding, evaluating, and using a variety of information.
	Communication Skills	Includes content related to communicating effectively with others in multiple formats.
	Systems Thinking	Includes content on successfully performing tasks by understanding relationships among the components of a system.
	Technology Use	Includes content related to applying information technology appropriately and effectively.
Effective Relationships	Interpersonal Skills	Includes content related to the ability to collaborate as part of a team, communicate effectively, maintain a positive attitude, and contribute to overarching goals.
	Personal Qualities	Includes content related to effective relationships including responsibility, self-discipline, flexibility, integrity, initiative, professionalism and self-worth, willingness to learn, and acceptance of responsibility for one's own personal growth.

Source: https://cte.ed.gov/initiatives/employability-skills-framework

F.2. Alignment Tool and Note-Taking Tool

AIR developed the Alignment Tool as a coding template to guide reviewers through the alignment process and create a space for each reviewer to independently rate alignment between high school standards and college content expectations. Reviewers selected a rating for each standard that best represents the extent to which there is evidence of content alignment and the level of rigor similarity between Maryland CCR Standards and the conceptual framework for postsecondary expectations and/or college course content.

The Alignment Tool included a field for reviewers to provide a narrative justification for their rating (e.g., evidence of alignment and/or misalignment) as well as any general comments about the standard or course content expectations.

AIR also created a Note-Taking Tool for reviewers to capture notes and thoughts during the alignment review, for use prior to entering any final information in the Alignment Tool.

F.3. Reviewers

AIR and its partner, CALCO Consulting Group, identified a set of reviewers with relevant expertise and experience to conduct the alignment reviews. Given that the findings from the ELA and math alignment reviews would also be used to ground the science and workforce alignment reviews, we identified a larger number of reviewers for those content areas to ensure a diversity of experience and perspectives contributed to the findings. Exhibit F.3.1 lists the reviewers for each content area.

Exhibit F.3.1. Alignment Reviewers

ELA Reviewers	Math Reviewers	Science and Workforce Reviewers
Lori Belzman, CALCO	Alka Arora, AIR	Tori Cirks, AIR
Christina Davis, AIR	Christy Brooks, AIR	Marissa Spang, AIR
Courtney Gross, AIR	Beverly Gilbert, CALCO	Jasmine Park, AIR
LaSantra Ledet, CALCO	Tami Hocker, CALCO	Sarah Frazelle, AIR
Nara Nayar, AIR	Amanda Mickus, AIR	
Jasmine Park, AIR	Treshonda Rutledge, AIR	
Cory Stai, AIR	Kerry Vieth, AIR	

Appendix G. Details About the Alignment Ratings

G.1. Analyzing Alignment Ratings and Justifications

As described in Section C.2 in the main body of the final report, content experts reviewed developmental and first-year credit-bearing college course materials regarding content expectations, identified topics within academic standards, and coded alignment of the high school content standards using the alignment index. To analyze the level of alignment between Maryland Grades K–12 content standards and postsecondary course content, we aggregated the individual reviewer codes and summarized the content expert rationales across high school standards to determine a single, more parsimonious, content alignment rating and rigor alignment rating for each high school standard. We aggregated the individual codes from each reviewer separately for both content alignment and rigor alignment using the median rating across reviewers. For content alignment, we rated each high school content standard as aligned, partially aligned, or not addressed in the college courses. For rigor alignment, we rated each high school content standard using the following categories: higher rigor in the college course, similar rigor as the college course, lower rigor in the college course, or not addressed in the college course. If content alignment for a high school standard was rated as not addressed in the college course, then the rigor alignment was automatically rated as not addressed in the college course.

There was no expectation that the content of every single high school standard included in the alignment review would be aligned to all college course content. In fact, the underlying assumption was that all high school standards should not be fully aligned given the breadth and depth of the high school standards and the specific focus areas on which postsecondary courses are grounded. Although we did not anticipate that each high school standard would be reflected in the developmental and first-year credit-bearing course content, we developed content maps to depict evidence of areas of alignment based on the reviewer ratings and an analysis of the alignment.

For the alignment review, reviewers relied primarily on what was explicitly included in college course materials (e.g., course descriptions, syllabi), which varied across colleges in the level of detail provided about course content and student learning objectives. While some input was provided through stakeholder activities, those conversations resulted in more general references to expectations related to academic content.

In addition to the content maps, AIR conducted a qualitative analysis of the narrative justifications that reviewers provided for the ratings to identify themes related to alignment or misalignment to inform actionable recommendations.

G.2. ELA Alignment Ratings

Overview of the ELA Standards

Reading Literature

Reading Literature contains four clusters: *Key Ideas and Details*, *Craft and Structure*, *Integration of Knowledge and Ideas*, and *Range of Reading and Level of Text Complexity*. *Key Ideas and Details* contains three anchor standards focused on utilizing textual evidence to determine central ideas and themes. *Craft and Structure* broadens the analysis to how the author conveys mood and style effects through the structure of the text. The third cluster, *Integration of Knowledge and Ideas*, widens the analytical lens from one text to comparison across media sources. For the standards in this cluster, students are expected to analyze themes in multiple works, compare different representations of a story, and evaluate the effectiveness of different artistic mediums for telling a story. The final cluster, *Range of Reading and Text Complexity*, outlines the expectation that students read and comprehend literature in the grades 9-10 text complexity band.

Reading Informational Text

Reading Informational Text contains the same four clusters as Reading Literature, but the anchor standards are altered to reflect the change in genre. The first cluster, *Key Ideas and Details*, contains three anchor standards in which students are expected to determine the central idea, identify textual evidence, and analyze the order in which an author presents information. The second cluster, *Craft and Structure*, contains three anchor standards that focus on how the author's choices impact the reader's understanding of the text. For this cluster, students are expected to interpret the meaning of words and phrases, analyze how an author's ideas develop, and determine an author's point of view. For the third cluster, *Integration of Knowledge and Ideas*, students are expected to broaden their analytical lens to include two or more texts. For the three anchor standards in this cluster, students are expected to identify and evaluate arguments, analyze multiple accounts of a subject told through different mediums, and analyze U.S. documents of historical significance. The final cluster, *Range of Reading and Text Complexity*, outlines the expectation that students read and comprehend informational text in the grades 9-10 text complexity band.

Writing

The Writing strand has four clusters: *Text Types and Purpose*, *Production and Distribution of Writing*, *Research to Build and Present Knowledge*, and *Range of Writing.* The first cluster, *Text Types and Purpose*, includes three standards separated by writing style: argumentative, informative/explanatory, and narrative. For each standard, students are expected to be able to conduct a self-analysis of their writing strengths and weaknesses, use an organizational structure appropriate for the writing purpose, effectively integrate evidence when necessary, and use a tone appropriate for the style of writing. The second cluster, *Production and Distribution of Writing*, includes three standards focused on the writing process. For this cluster, students are expected to produce writing tailored to the task and audience, strengthen writing through a revision process, and publish writing online. The third cluster is *Research to Build and Present Knowledge*. The four standards in this cluster outline expectations related to the research process. Students are expected to conduct formulate and conduct research projects, appropriately integrate information from multiple sources, draw evidence from texts to support their claims, and write over both extended and shorter time frames for a variety of audiences. The fourth cluster is *Range of Writing* and includes one standard related to students gaining experience in writing within different time frames (e.g., longer periods for research papers; shorter periods for other purposes)

Speaking and Listening

The Speaking and Listening strand has two clusters: *Comprehension and Collaboration* and *Presentation of Knowledge and Ideas*. *Comprehension and Collaboration* contains three anchor standards in which students are expected to participate in collaborative discussions, evaluate the credibility of multiple sources of information, and evaluate a speaker's point of view. The second cluster, *Presentation of Knowledge and Ideas,* contains three anchor standards. For these standards, students are expected to present information supported with evidence, utilize digital media to enhance presentations, and adapt speech to the context in which they present information.

Language

The Language strand has three clusters: *Conventions of Standard English*, *Knowledge of Language*, and *Vocabulary Acquisition and Use*. The first cluster, *Conventions of Standard English*, contains two anchor standards in which students are expected to demonstrate proficiency in the conventions of standard English grammar, usage, capitalization, punctuation, and spelling. The second cluster, *Knowledge of Language*, has one anchor standard. For this standard, students are expected to understand the function of language in different contexts in order to make appropriate stylistic choices. This standard includes the expectation that student writing conforms to the guidelines of a relevant style manual. The third cluster, *Vocabulary*

Acquisition and Use, contains three anchor standards. For these standards, students are expected to derive the meaning of a word or phrase through contextual clues, consult reference materials when necessary, demonstrate an understanding of figurative language, and independently gather vocabulary knowledge when faced with an unknown term.

Alignment of Standards to Course Content

This analysis compared specific grade-band high school ELA standards to community college course content expectations which varied across colleges in terms specificity and depth. To address the variation and develop a better understanding of the common course content across colleges, AIR synthesized information collected through the course inventory and from stakeholder input into two conceptual frameworks – one for developmental college English and one for first-year credit-bearing college English Composition (Appendix H.1). The conceptual frameworks aim to summarize college course content and learning objectives into a straight-forward description of common college content expectations.

Using the conceptual framework as a high-level summary, as well as other materials such coding outputs, a searchable Excel database of course learning objectives, course descriptions, and course syllabi, ELA content experts looked for evidence that the Maryland CCR high school ELA Standards (Grade 9–10) were reflected within the course content expectations.

Exhibits G.2.1 – G.2.5 provide alignment ratings for each standard by strand and cluster within the Maryland CCR ELA Standards.

Exhibit G.2.1. Standards for Reading Literature

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Key Ideas and Details				
RL.9-10.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	Not addressed	Not addressed	Not addressed	Not addressed
RL.9-10.2. Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.	Not addressed	Not addressed	Not addressed	Not addressed
RL.9-10.3. Analyze how complex characters (e.g., those with multiple or conflicting motivations) develop over the course of a text, interact with other characters, and advance the plot or develop the theme.	Not addressed	Not addressed	Not addressed	Not addressed

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Craft and Structure				
RL.9-10.4. Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).	Not addressed	Not addressed	Not addressed	Not addressed
RL.9-10.5. Analyze how an author's choices concerning how to structure a text, order events within it (e.g., parallel plots), and manipulate time (e.g., pacing, flashbacks) create such effects as mystery, tension, or surprise.	Not addressed	Not addressed	Not addressed	Not addressed
RL.9-10.6 Analyze a particular point of view or cultural experience reflected in a work of literature from outside the United States, drawing on a wide reading of world literature.	Not addressed	Not addressed	Not addressed	Not addressed
Integration of Knowledge and Ideas				
RL.9-10.7. Analyze the representation of a subject or a key scene in two different artistic mediums, including what is emphasized or absent in each treatment (e.g., Auden's "Musée des Beaux Arts" and Breughel's Landscape with the Fall of Icarus).	Not addressed	Not addressed	Not addressed	Not addressed
RL.9-10.8. (Not applicable to literature)	This Anchor Standard is not applicable to Literature			
RL.9-10.9. Analyze how an author draws on and transforms source material in a specific work (e.g., how Shakespeare treats a theme or topic from Ovid or the Bible or how a later author draws on a play by Shakespeare).	Not addressed	Not addressed	Not addressed	Not addressed
Range of Reading and Level of Text Complexity				
RL.9-10.10. By the end of grade 9, read and comprehend literature, including stories, dramas, and poems, in the grades 910 text complexity band proficiently, with scaffolding as needed at the high end of the range. By the end of grade 10, read and comprehend literature, including stories, dramas, and poems, at the high end of the grades 9-10 text complexity band independently and proficiently.	Not addressed	Not addressed	Not addressed	Not addressed

Exhibit G.2.2. Standards for Reading Informational Text

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Key Ideas and Details				
RI.9-10.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	Aligned	Similar	Aligned	Similar
RI.9-10.2. Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.	Partially aligned	Lower	Aligned	Similar
RI.9-10.3. Analyze how the author unfolds an analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.	Aligned	Similar	Aligned	Similar
Craft and Structure				
RI.9-10.4. Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language of a court opinion differs from that of newspaper).	Partially Aligned	Similar	Not addressed	Not addressed
RI.9-10.5. Analyze in detail how an author's ideas or claims are developed and refined by particular sentences, paragraphs, or larger portions of a text (e.g., a section or chapter).	Partially Aligned	Lower	Partially Aligned	Similar
RI.9-10.6. Determine an author's point of view or purpose in a text and analyze how an author uses rhetoric to advance that point of view or purpose.	Aligned	Similar	Aligned	Higher
Integration of Knowledge and Ideas				
RI.9-10.7. Analyze various accounts of a subject told in different mediums (e.g., a person's life story in both print and multimedia), determining which details are emphasized in each account.	Not addressed	Not addressed	Not addressed	Not addressed
RI.9-10.8. Delineate and evaluate the argument and specific claims in text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning.	Partially Aligned	Lower	Aligned	Higher

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
RI.9-10.9. Analyze seminal U.S. documents of historical and literary significance (e.g., Washington's Farewell Address, the Gettysburg Address, Roosevelt's Four Freedoms speech, King's “Letter from Birmingham Jail”), including how they address related themes and concepts.	Not addressed	Not addressed	Not addressed	Not addressed
Range of Reading and Level of Text Complexity				
RI.9-10.10. By the end of grade 9, read and comprehend literacy nonfiction in the grades 9-10 text complexity band proficiently, with scaffolding as needed at the high end of the range. By the end of grade 10, read and comprehend literary nonfiction at the end of the grades 9-10 text complexity band independently and proficiently.	Not addressed	Not addressed	Not addressed	Not addressed

Exhibit G.2.3. Standards for Writing

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Text Type and Purposes				
W.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	Aligned	Lower	Aligned	Higher
W.9-10.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.	Aligned	Lower	Aligned	Similar
W.9-10.3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.	Not addressed	Not addressed	Not addressed	Not addressed
Production and Distribution of Writing				
W.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	Aligned	Similar	Aligned	Higher
W.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.	Aligned	Similar	Aligned	Higher

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
W.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	Partially Aligned	Not addressed	Aligned	Similar
Research to Build and Present Knowledge				
W.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	Aligned	Similar	Aligned	Higher
W.9-10.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.	Aligned	Lower	Aligned	Higher
W.9-10.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.	Partially Aligned	Lower	Aligned	Similar
Range of Writing				
W.9-10.10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	Partially Aligned	Lower	Partially Aligned	Lower

Exhibit G.2.4. Standards for Speaking and Listening

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Comprehension and Collaboration				
SL.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively	Not addressed	Not addressed	Not addressed	Not addressed

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
SL.9-10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.	Not addressed	Not addressed	Partially Aligned	Lower
SL.9-10.3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.	Not addressed	Not addressed	Not addressed	Not addressed
Presentation of Knowledge and Ideas				
SL.9-10.4. Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.	Not addressed	Not addressed	Partially Aligned	Similar
SL.9-10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	Not addressed	Not addressed	Partially Aligned	Lower
SL.9-10.6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.	Not addressed	Not addressed	Not addressed	Not addressed

Exhibit G.2.5. Standards for Language

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Contents of Standard English				
L.9-10.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.	Aligned	Similar	Aligned	Higher
L.9-10.2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.	Aligned	Similar	Aligned	Similar
Knowledge of Language				
L.9-10.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.	Aligned	Lower	Aligned	Similar

Standard	Developmental English		First-year credit-bearing English	
	Content	Rigor	Content	Rigor
Vocabulary Acquisition and Use				
L.9-10.4. Determine or clarify the meaning of unknown and multiple meaning words and phrases based on grades 9-10 reading and content, choosing flexibly from a range of strategies.	Aligned	Similar	Not addressed	Not addressed
L.9-10.5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.	Not addressed	Not addressed	Not addressed	Not addressed
L.9-10.6. Acquire and use accurately general academic and domain specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	Partially aligned	Similar	Not addressed	Not addressed

G.3. Math Alignment Ratings

The Maryland College and Career Ready Mathematics Standards (MCCRMS) aim to foster a deep understanding of mathematical concepts by promoting conceptual understanding, procedural fluency, and mathematical reasoning. It encourages students to make connections between different areas of mathematics, as well as between mathematics and real-world applications. Additionally, the structure emphasizes the integration of mathematical practices such as problem-solving, reasoning, and communication skills. Students are encouraged to think critically, analyze mathematical problems, and communicate their solutions effectively.

This qualitative analysis investigated the extent of the alignment between Maryland's high school mathematic standards and developmental college math and first-year credit-bearing college math course content expectations. The analysis focused on comparing mathematical language, prevalence of content occurrence, conceptual framework, and consistency between high school standards and college expectations to determine alignment for content and similarity for rigor. The high school standards were categorized as aligned, partially aligned, or not addressed for content. For rigor, the alignment team noted whether the cognitive demand of college expectations was much higher, higher, similar, or lower than the high school standards.

The college expectations were derived from the course objectives from syllabi submitted by 11 community colleges in Maryland. AIR received 35 syllabi for developmental college math courses and 46 syllabi for first-year credit-bearing college math courses, but some of these were duplicates. Additionally, some of the first-year, credit-bearing college courses were for *teaching* mathematics. AIR excluded these syllabi from analysis.

To ensure the accuracy and reliability of the analysis, multiple reviewers independently aligned the high school standards and college-level course content. Any discrepancies or disagreements amongst reviewers were resolved through collaborative discussions. In all instances, clear justifications were provided to support the determination of alignment.

The MCCRMS framework organizes the math standards by domains (such as number systems, algebra, geometry, functions, and statistics) and clusters, which are groups of more specific topics that make up a domain. The following section provides a description of math alignment findings for the cluster level. (Domain level findings are discussed in the main body of the report.)

Detailed Alignment Findings for Algebra

Arithmetic with Polynomials and Rational Expressions (APR)

The high school standards within the Arithmetic with Polynomials and Rational Expressions (APR) cluster provide a comprehensive understanding of essential topics such as polynomial operations, factorization, graphing, proving identities, and manipulating rational expressions.

Alignment findings. The content of two of the five standards in this cluster were aligned and three were partially aligned for developmental college math course content. The level of rigor of the high school standards was similar to (two standards) or higher than (three standards) the level of rigor in the developmental college math courses. Four of the five high school standards were aligned for first-year credit-bearing college math course content expectations. The fifth standard was partially aligned for first-year credit-bearing courses. The level of rigor of the high school standards ranged from lower (one standard) to higher (one standard) than the first-year credit-bearing college math courses, with the majority (three standards) at a similar level of rigor. Throughout the APR cluster, there was a consistent emphasis on understanding and performing operations with polynomials; this was reflected in the language and performance expectations at both the high school and college levels.

Creating Equations (CED)

This algebra cluster collectively focuses on equipping students with the ability to create, manipulate, and interpret equations, inequalities, and formulas.

Alignment findings. In this cluster, all four high school mathematics standards were aligned with the math content expectations for both the developmental and first-year credit-bearing college math courses. This alignment was demonstrated through the justifications left by reviewers indicating word-for-word standards language within the college course content. The rigor of the high school standards was at a similar level to (three standards) or higher than (one standard) the rigor in the developmental college math courses. The rigor of all four of the high school standards was at a lower level than the rigor in the first-year credit-bearing math courses.

Reasoning with Equations and Inequalities (REI)

The Reasoning with Equations and Inequalities cluster covers a broad range of algebraic problem-solving skills. Students are expected to create and solve equations and inequalities including linear, quadratic, rational, and exponential functions. They also learn to create equations with multiple variables, graph them on coordinate axes, and represent constraints using equations or inequalities.

Alignment findings. Of the ten high school standards in this cluster, eight of the high school content standards were aligned with developmental math course content and all ten of the high school standards were aligned with first-year credit-bearing math course content. The rigor of the high school standards was at a lower level (one standard), similar level (six standards), or higher than (three standards) the rigor in the developmental college math courses. The rigor of five high school standards was at a lower level than the rigor in the first-year credit-bearing math courses, while the rigor of the remaining five high school standards was at a similar level as in first-year credit-bearing math courses.

Seeing Structure in Expressions (SSE)

The standards in the SSE cluster emphasize the ability to interpret expressions within their given context and recognize the structural properties of expressions.

Alignment findings. All but one of the high school standards was aligned with the math content expectations for both developmental and first-year credit-bearing math course content. For the three aligned high school standards, the rigor of the high school standards was at a similar level as in the developmental math courses. For the three aligned high school standards, the rigor of the high school standards was at a lower level than in the first-year credit-bearing courses.

Detailed Alignment Findings for Functions

Interpreting Functions (IF)

The standards in this cluster cover a wide range of skills related to understanding and analyzing functions.

Alignment findings. Six of the nine high school content standards were aligned with the math content expectations of the developmental college math course content, with two standards being partially aligned. Eight of the nine high school content standards were aligned with the math content expectations of the first-year credit-bearing math courses. The rigor of the high school standards was generally at a similar level as in the developmental college math courses, apart from two high school standards, for which the rigor was higher than in the developmental college math courses. The rigor of the high school standards was generally at a similar level as in the first-year credit-bearing college math courses, apart from three high school standards, for which the rigor was lower than in the first-year credit-bearing college math courses.

Building Functions (BF)

The two standards in this cluster focus on the skills of writing functions and sequences to describe relationships between quantities.

Alignment findings. In this cluster, of the four high school content standards, two were aligned with college math course content expectations in the developmental college math courses and one high school standard was partially aligned with the developmental college math course content while one standard was not aligned with developmental college math course content. Of the four high school standards, three were aligned with the first-year credit-bearing math course content expectations while one standard was not aligned with first-year credit-bearing college math course content. Partial alignment was determined for one high school standard because college-level course objectives address manipulating functions, but do not explicitly outline expectations for transformations as described in the high school standard.

The rigor of the high school standards varied in relation to the developmental college math courses. One standard each reflected lower, similar, or higher levels of rigor than the levels in the developmental college math courses. The rigor of the high school standards was generally at a lower level than in the first-year credit-bearing college math courses, apart from one high school standards that was not aligned.

Linear, Quadratic, and Exponential Models (LE)

This cluster in the functions domain involves distinguishing between linear and exponential functions, understanding their growth patterns, recognizing constant rate and percent rate of change situations, constructing linear and exponential functions from various representations, observing exponential growth surpassing other types of growth, using logarithms to solve exponential equations, and interpreting parameters in linear and exponential functions in context.

Alignment findings. For the LE cluster, the high school standards aligned closely with both developmental and first-year credit-bearing college math course content expectations. Only one standard was partially aligned with the college content. The level of rigor of the high school standards was at a similar level as in the developmental college math courses for four of the five strands and at a higher level of rigor for the fifth strand. The rigor of the high school standards was at a lower level than in the first-year credit-bearing college math courses for four of five standards; the fifth was at a similar level of rigor.

Trigonometric Functions (TF)

At the high school level, these standards in trigonometric functions encompass several key concepts.

Alignment findings. For the Functions domain, the trigonometric functions cluster includes four standards. While there were some matching words between high school standards and college content expectations, such as circles, sine, cosine, and tangent, they were connected to concepts outside of the TF cluster. All four standards of this cluster were not addressed in either the developmental or the first-year credit-bearing college math course content expectations. The language, skills, or context from the high school standards were not found in the college course expectations.

Detailed Alignment Findings for Number and Quantity

The Real Number System (RN)

The standards in the cluster of Real Numbers focus on understanding and manipulating rational exponents, radicals, and the properties of rational and irrational numbers.

Alignment findings. All three high school standards in this cluster were aligned with math content expectations for both the developmental and first-year credit-bearing math course content. The rigor of the high school standards was at a similar level as in the developmental college math courses (two standards) or higher (one standard). The rigor of the high school standards was at a lower level than in the first-year credit-bearing college math courses.

Quantities (Q)

The standards in the Quantities cluster focus on the use of units, accuracy, and appropriate quantities in problem-solving. Students are encouraged to utilize units as a tool to understand problems and guide their solutions, ensuring consistency in unit choices and interpretations in formulas.

Alignment findings. For the Q cluster, one high school standard was aligned, one standard was partially aligned, and one standard was not aligned with developmental college math course content expectations. Two high school standards were aligned and one standard was partially aligned with the first-year credit-bearing college math course content expectations. The rigor of the high school standards was at a similar level as in the developmental college math courses as well as the first-year credit-bearing college math courses.

The Complex Number System (CN)

Complex Number System standards introduce fundamental concepts and operations.

Alignment findings. For the CN cluster, one high school standard had partial alignment with the developmental college math course content expectations while all three high school standards were aligned with the first-year credit-bearing college math course content expectations. The rigor of the high school standards was not addressed in the developmental college math courses; the alignment team did not have enough information to determine rigor similarity for the partially aligned standard. The rigor of the high school standards was at a similar level (two standards) or lower level of rigor (one standard) as in the first-year credit-bearing college math courses.

Detailed Alignment Findings for Geometry

During the analysis, many geometry standards were not addressed in the college level courses. However, this is not surprising. The other domains included in this analysis are applicable to multiple fields and so are important for multiple college majors. Geometry, however, is a more specialized course more appropriate to math or education majors.

Congruence (CO)

This cluster covers a wide range of fundamental geometric concepts and constructions and spans 13 high school standards.

Alignment findings. For the CO cluster, one high school standard was partially aligned with developmental college math course content expectations while the other standards were not aligned with developmental course content. High school standards were fully aligned (three standards) or partially aligned (three standards) with first-year credit-bearing college math course content expectations. The one high school standard that was partially aligned with developmental college math course content expectations was at a higher level of rigor than in developmental college courses. The rigor of the high school standards varied in relation to the level of rigor in the first-year credit-bearing college math courses. Two high school standards were identified as being at a higher level of rigor, two were at a similar level, and was identified as having a lower level of rigor.

Similarity, Right Triangles, and Trigonometry (SRT)

The SRT cluster focuses on similarity transformations, properties of similar figures, and trigonometric ratios in right triangles.

Alignment findings. For the SRT cluster, none of the high school standards were found in the developmental college math course content expectations and were therefore not aligned. Four of the eight high school standards were partially aligned with first-year credit-bearing math course content expectations and three standards were fully aligned with first-year credit-bearing content. The level of rigor of the seven high school standards with any alignment varied; three high school standards were identified as being at a similar level of rigor and one was identified as being at a higher level of rigor than in first-year credit-bearing college math courses. The alignment team did not have sufficient information to determine a rigor rating for the remaining standards.

Circles (C)

High school standards with circles focus on various aspects of circles and their properties.

Alignment findings. The standards in the circles cluster were not aligned with college course content expectations either for developmental or first-year credit-bearing math course content.

Expressing Geometric Properties with Equations (GPE)

The geometry standards in this cluster focus on applying algebraic techniques to solve geometric problems.

Alignment findings. For the GPE cluster, of the five high school standards, three were not aligned, one was partially aligned, and one was aligned with developmental college math course content expectations. Three high school standards were aligned and two were partially aligned with first-year credit-bearing college math course content expectations. Where the high school standard was aligned with developmental college math course content, the level of rigor of the high school standard was similar, and where the high school standard was partially aligned, the level of rigor was higher than in developmental college math courses. Where the high school standards were aligned with first-year credit-bearing math course content expectations, the level of rigor was similar to that in first-year credit-bearing courses.

Geometric measurement and dimension (GMD)

This cluster focuses on understanding and applying formulas for geometric measurements such as circumference, area, and volume.

Alignment findings. For the GMD cluster, high school standards had varied levels of alignment with developmental college math course content expectations: one high school standard was aligned, one standard was partially aligned, and one standard was not aligned with developmental college course content. None of the three high school standards were aligned with first-year credit-bearing college math course content expectations.

Modeling with Geometry (MG)

The three MG standards emphasize the application of geometric concepts and measurements to describe objects and solve design problems.

Alignment findings. For the MG cluster, two of the high school standards were partially aligned with first-year credit-bearing college math course content expectations only. The alignment team did not have sufficient information to determine rigor ratings.

Detailed Alignment Findings for Statistics

Interpreting Categorical and Quantitative Data (ID)

This cluster covers a wide range of statistical topics, including data representation, analysis, inference, and probability.

Alignment findings. For the ID cluster, there was variation of alignment of high school standards with the developmental college math course content expectations; one high school standard was not aligned, three standards were partially aligned, and five were aligned with developmental college math course content. All nine of the high school standards aligned with the first-year credit-bearing math course content expectations. The level of rigor of the high school standards was at a similar level (six standards) or a higher level (two standards) than in developmental college math courses. The level of rigor of the high school standards was at a similar level (four standards) or lower level (five standards) than the level of rigor in first-year credit bearing college math courses).

Making Inferences and Justifying Conclusions (IC)

The statistics standards in this cluster cover various aspects of statistical inference and data analysis.

Alignment findings. For the IC cluster, two high school standards were aligned, and five high school standards were partially aligned with developmental college math course content expectations. All seven of the high school standards aligned with first-year credit-bearing college math course content expectations. The rigor of the high school standards was at a higher level than in developmental college math courses for four high school standards and at a similar level of rigor for three standards. The rigor of the high school standards was at a lower level than in first-year credit-bearing college math courses for six high school standards and at a similar level of rigor for one standard.

Conditional Probability and the Rules of Probability (CP)

The CP cluster covers concepts and skills related to probability and data analysis.

Alignment findings. For the CP cluster, five high school standards were aligned with the developmental college math course content expectations, three high school standards were partially aligned, and one standard was not addressed in developmental college math courses. All nine high school standards were aligned with the first-year credit-bearing college math course content expectations. The rigor of the high school standards that were aligned with the developmental course content were at a similar level of rigor as in developmental courses. The rigor of the high school standards that were partially aligned with the developmental course content were at a higher level of rigor than in the developmental courses. The level of rigor of five of the high school standards was at a similar level as in the first-year credit-bearing college math courses and at a lower level of rigor for four standards.

Using Probability to Make Decisions (MD)

The statistics standards in this cluster focus on probability concepts, random variables, and decision analysis.

Alignment findings. For the MD cluster, two high school standards were aligned with developmental college math course content expectations, one was partially aligned, and four standards were not aligned with developmental math course content. Six of the seven high school standards were aligned with the first-year credit-bearing math course content expectations and one standard was partially aligned. The level of rigor of the high school standards was at a similar level as in developmental college math courses for one standard, higher for two standards, and not addressed for four standards. The level of rigor of the high school standards was at a similar level as in first-year credit-bearing courses for six standards and at a higher level of rigor for one standard.

Exhibits G.3.1- G.3.5 provide alignment ratings for each high school standard by domain and cluster within the Maryland CCR Mathematics Standards.

Exhibit G.3.1. Standards for Algebra

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
Arithmetic with Polynomials and Rational Expressions (APR)				
A.APR.A.1 Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.	Aligned	Similar	Aligned	Higher
A.APR.B.2 Know and apply the Remainder Theorem: For a polynomial p(x) and a number a, the remainder on division by x - a is p(a) so p(a) = 0 if and only if (x-a) is a factor of p(x)	Partially Aligned	Similar	Aligned	Similar
A.APR.B.3 Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.	Partially Aligned	Lower	Aligned	Similar
A.APR.C.4 Prove polynomial identities and use them to describe numerical relationships. For example, the polynomial identity (x^2 + y^2)^2 = (x^2 - y^2)^2 + (2xy)^2 can be used to generate Pythagorean triples.	Partially Aligned	Lower	Partially Aligned	Lower
A.APR.D.6 Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q (x)+ r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system.	Aligned	Lower	Aligned	Similar
Creating Equations (CED)				
A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.	Aligned	Similar	Aligned	Higher
A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.	Aligned	Similar	Aligned	Higher

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
A.CED.A.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.	Aligned	Lower	Aligned	Higher
A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.	Aligned	Similar	Aligned	Higher
Reasoning with Equations and Inequality (REI)				
A.REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.	Partially Aligned	Lower	Aligned	Similar
A.REI.A.2 Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.	Aligned	Similar	Aligned	Higher
A.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.	Aligned	Similar	Aligned	Similar
A.REI.B.4 Solve quadratic equations in one variable. a. Use the method of completing the square to transform any quadratic equation in x into an equation of the form (x-p)^2=q that has the same solutions. Derive the quadratic formula from this form. b. Solve quadratic equations by inspection (e.g., for x^2=49), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as a ± bi for real numbers a and b.	Aligned	Similar	Aligned	Similar
A.REI.C.5 Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.	Partially Aligned	Lower	Aligned	Higher

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
A.REI.C.6 Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.	Aligned	Similar	Aligned	Higher
A.REI.C.7 Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. For example, find the points of intersection between the line y= -3x and the circle x^2 + y^2 = 3.	Aligned	Similar	Aligned	Similar
A.REI.D.10 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).	Aligned	Similar	Aligned	Higher
A.REI.D.11 Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.*	Aligned	Lower	Aligned	Similar
A.REI.D.12 Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.	Aligned	Higher	Aligned	Higher
Seeing Structure in Expressions (SSE)				
A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. a. Interpret parts of an expression, such as terms, factors, and coefficients. b. Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+ r)^n as the product of P and a factor not depending on P.	Aligned	Similar	Aligned	Higher
A.SSE.A.2 Use the structure of an expression to identify ways to rewrite it. For example, see x^4 - y^4 as (x^2)^2 - (y^2)^2, thus recognizing it as a difference of squares that can be factored as (x^2 - y^2) (x^2 - y^2).	Aligned	Similar	Aligned	Higher

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. a. Factor a quadratic expression to reveal the zeros of the function it defines. b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. c. Use the properties of exponents to transform expressions for exponential functions. For example, the expression 1.15^t can be rewritten as (1.15^1/12)^12 t ≈ 1.012^12t to reveal the approximate equivalent monthly interest rate if the annual rate is 15%	Aligned	Similar	Aligned	Higher
A.SSE.B.4 Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. For example, calculate mortgage payments.	Not addressed	Not addressed	Not addressed	Not aligned or unable to determine

Exhibit G.3.2. Standards for Functions

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
Building Functions (BF)				
F.BF.A.1 Write a function that describes a relationship between two quantities. a. Determine an explicit expression, a recursive process, or steps for calculation from a context. b. Combine standard function types using arithmetic operations. For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model.	Aligned	Similar	Aligned	Higher
F.BF.A.2 Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.	Not addressed	Not addressed	Not addressed	Not addressed

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
F.BF.B.3 Identify the effect on the graph of replacing f(x) by f(x) + k, kf(x), f(kx), and f (x+k) for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them.	Partially Aligned	Lower	Aligned	Higher
F.BF.B.4 Find inverse functions. a. Solve an equation of the form f (x) = c for a simple function f that has an inverse and write an expression for the inverse. For example, *f* (x) = 2x^3 or f (x) = x + 1/ x - 1 for x ≠ 1.	Aligned	Higher	Aligned	Higher
Interpreting Functions (IF)				
F.IF.A.1 Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph of f is the graph of the equation y=f(x).	Aligned	Similar	Aligned	Higher
F.IF.A.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.	Aligned	Similar	Aligned	Similar
F.IF.A.3 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. For example, the Fibonacci sequence is defined recursively by f(0) = f(1) = 1, f(n+1) = f(n) + f(n-1) for n≥1	Not addressed	Not addressed	Not addressed	Not addressed
F.IF.B.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.	Aligned	Similar	Aligned	Higher

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
F.IF.B.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.	Aligned	Similar	Aligned	Similar
F.IF.B.6 Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.	Aligned	Similar	Aligned	Higher
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. a. Graph linear and quadratic functions and show intercepts, maxima, and minima. b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.	Partially Aligned	Lower	Aligned	Similar
F.IF.C.8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. b. Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as y = (1.02)^t, y = (0.97)^t, y = (1.01)^12t, y = (1.2)^t/10' and classify them as representing exponential growth or decay.	Aligned	Similar	Aligned	Similar

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
F.IF.C.9 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.	Partially Aligned	Lower	Aligned	Similar
Linear, Quadratic, and Exponential Models (LE)				
F.LE.A.1 Distinguish between situations that can be modeled with linear functions and with exponential functions. a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.	Aligned	Similar	Aligned	Higher
F.LE.A.2 Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).	Aligned	Similar	Aligned	Similar
F.LE.A.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.	Partially Aligned	Lower	Aligned	Higher
F.LE.A.4 For exponential models, express as a logarithm the solution to ab^ct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.	Aligned	Similar	Aligned	Higher
F.LE.B.5 Interpret the parameters in a linear or exponential function in terms of a context.	Aligned	Similar	Aligned	Higher
Trigonometric Functions (TF)				
F.TF.A.1 Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.	Not addressed	Not addressed	Not addressed	Not addressed

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
F.TF.A.2 Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.	Not addressed	Not addressed	Not addressed	Not addressed
F.TF.B.5 Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.	Not addressed	Not addressed	Not addressed	Not addressed
F.TF.C.8 Prove the Pythagorean identity sin^2 (Θ) + cos^2 (Θ) = 1 and use it to find sin (Θ), cos (Θ), or tan (Θ), given sin (Θ), cos (Θ), or tan (Θ) and the quadrant of the angle.	Not addressed	Not addressed	Not addressed	Not addressed

Exhibit G.3.3. Standards for Geometry

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
Circles (C)				
G.C.A.1 Prove that all circles are similar.	Not addressed	Not addressed	Not addressed	Not addressed
G.C.A.2 Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.	Not addressed	Not addressed	Not addressed	Not addressed
G.C.A.3 Construct the inscribed and circumscribed circles of a triangle, and prove properties of angles for a quadrilateral inscribed in a circle.	Not addressed	Not addressed	Not addressed	Not addressed
G.C.B.5 Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector.	Not addressed	Not addressed	Not addressed	Not addressed
Congruence (CO)				

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
G.CO.A.1 Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.	Partially Aligned	Lower	Aligned	Similar
G.CO.A.2 Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).	Not addressed	Not addressed	Partially Aligned	Higher
G.CO.A.3 Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.	Not addressed	Not addressed	Aligned	Similar
G.CO.A.4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.	Not addressed	Not addressed	Partially Aligned	Lower
G.CO.A.5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.	Not addressed	Not addressed	Aligned	Higher
G.CO.B.6 Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.	Not addressed	Not addressed	Not addressed	Not addressed
G.CO.B.7 Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent.	Not addressed	Not addressed	Not addressed	Not addressed
G.CO.B.8 Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions.	Not addressed	Not addressed	Partially Aligned	Lower

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
G.CO.C.10 Prove theorems about triangles. Theorems include: measures of interior angles of a triangle sum to 180°; base angles of isosceles triangles are congruent; the segment joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point.	Not addressed	Not addressed	Not addressed	Not addressed
G.CO.C.11 Prove theorems about parallelograms. Theorems include: opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.	Not addressed	Not addressed	Not addressed	Not addressed
G.CO.C.9 Prove theorems about lines and angles. Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints.	Not addressed	Not addressed	Not addressed	Not addressed
G.CO.D.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.	Not addressed	Not addressed	Not addressed	Not addressed
G.CO.D.13 Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.	Not addressed	Not addressed	Not addressed	Not addressed
Geometric Measurement and Dimension (GMD)				
G.GMD.A.1 Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.	Partially Aligned	Lower	Not addressed	Not addressed
G.GMD.A.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems	Aligned	Similar	Not addressed	Not addressed

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
G.GMD.B.4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.	Not addressed	Not addressed	Not addressed	Not addressed
Expressing Geometric Properties with Equations (GPE)				
G.GPE.A.1 Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.	Not addressed	Not addressed	Aligned	Similar
G.GPE.B.4 Use coordinates to prove simple geometric theorems algebraically. For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that the point (1,√3) lies on the circle centered at the origin and containing the point (0, 2).	Not addressed	Not addressed	Partially Aligned	Not addressed or unable to determine
G.GPE.B.5 Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).	Aligned	Similar	Aligned	Similar
G.GPE.B.6 Find the point on a directed line segment between two given points that partitions the segment in a given ratio.	Not addressed	Not addressed	Partially Aligned	Not addressed or unable to determine
G.GPE.B.7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.	Partially Aligned	Lower	Aligned	Similar
Modeling with Geometry (MG)				
G.MG.A.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).	Not addressed	Not addressed	Partially Aligned	Not addressed or unable to determine
G.MG.A.2 Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).	Not addressed	Not addressed	Not addressed	Not addressed or unable to determine

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
G.MG.A.3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).	Not addressed	Not addressed	Partially Aligned	Not addressed or unable to determine
Similarity, Right Triangles, and Trigonometry (SRT)				
G.SRT.A.1 Verify experimentally the properties of dilations given by a center and a scale factor. a. A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged. b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor	Not addressed	Not addressed	Not addressed	Not addressed or unable to determine
G.SRT.A.2 Given two figures, use the definition of similarity in terms of similarity transformations to decide if they are similar; explain using similarity transformations the meaning of similarity for triangles as the equality of all corresponding pairs of angles and the proportionality of all corresponding pairs of sides.	Not addressed	Not addressed	Partially Aligned	Not addressed or unable to determine
G.SRT.A.3 Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.	Not addressed	Not addressed	Partially Aligned	Not addressed or unable to determine
G.SRT.B.4 Prove theorems about triangles. Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem proved using triangle similarity	Not addressed	Not addressed	Partially Aligned	Lower
G.SRT.B.5 Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.	Not addressed	Not addressed	Partially Aligned	Unable to Determine*
G.SRT.C.6 Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.	Not addressed	Not addressed	Aligned	Similar
G.SRT.C.7 Explain and use the relationship between the sine and cosine of complementary angles.	Not addressed	Not addressed	Aligned	Similar

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
G.SRT.C.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.	Not addressed	Not addressed	Aligned	Similar

Exhibit G.3.4. Standards for Number and Quantity

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
The Complex Number System (CN)				
N.CN.A.1 Know there is a complex number i such that i^2 = -1, and every complex number has the form a + bi with a and b real.	Not addressed	Not addressed	Aligned	Higher
N.CN.A.2 Use the relation i^2 = -1 and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.	Not addressed	Not addressed	Aligned	Similar
N.CN.C.7 Solve quadratic equations with real coefficients that have complex solutions.	Partially Aligned	Not addressed*	Aligned	Similar
Quantities				
N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	Aligned	Similar	Partially Aligned	Similar
N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	Partially Aligned	Similar	Aligned	Similar
N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	Not addressed	Not addressed	Aligned	Similar
The Real Number Systems (RN)				

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
N.RN.A.1 Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. For example, we define 5^1/3 to be the cube root of 5 because we want (5^1/3)^3 = 5^(1/3)^3 to hold, so 5^(1/3)^3 must equal 5.	Aligned	Similar	Aligned	Higher
N.RN.A.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents	Aligned	Similar	Aligned	Higher
N.RN.B.3 Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.	Aligned	Lower	Aligned	Higher

Exhibit G.3.5. Standards for Statistics

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
Conditional Probability and the Rules of Probability (CP)				
S.CP.A.1 Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," “and," "not").	Aligned	Similar	Aligned	Similar
S.CP.A.2 Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities and use this characterization to determine if they are independent.	Aligned	Similar	Aligned	Higher
S.CP.A.3 Understand the conditional probability of A given B as P(A and B) / P(B), and interpret independence of A and B as saying that the conditional probability of A given B is the same as the probability of A, and the conditional probability of B given A is the same as the probability of B.	Aligned	Similar	Aligned	Higher

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
S.CP.A.4 Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. For example, collect data from a random sample of students in your school on their favorite subject among math, science, and English. Estimate the probability that a randomly selected student from your school will favor science given that the student is in tenth grade. Do the same for other subjects and compare the results.	Aligned	Similar	Aligned	Higher
S.CP.A.5 Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. For example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer.	Aligned	Similar	Aligned	Higher
S.CP.B.6 Find the conditional probability of A given B as the fraction of B's outcomes that also belong to A and interpret the answer in terms of the model.	Partially Aligned	Lower	Aligned	Similar
S.CP.B.7 Apply the Addition Rule, P (A or B) = P(A) + P(B) - P (A and B), and interpret the answer in terms of the model.	Partially Aligned	Lower	Aligned	Similar
S.CP.B.8 Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A) P(B\A) = P(B) P (A\B), and interpret the answer in terms of the model.	Partially Aligned	Lower	Aligned	Similar
S.CP.B.9 Use permutations and combinations to compute probabilities of compound events and solve problems.	Not addressed	Not addressed	Aligned	Similar
Making Inferences and Justifying Conclusions (IC)				
S.IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. a. Introduce sampling distributions as a means to explore variability in sample statistics and ultimately evaluate a claim about a population.	Aligned	Similar	Aligned	Higher

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
S.IC.A.2 Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?	Partially Aligned	Lower	Aligned	Higher
S.IC.B.3 Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.	Partially Aligned	Similar	Aligned	Higher
S.IC.B.4 Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.	Partially Aligned	Lower	Aligned	Higher
S.IC.B.5 Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.	Partially Aligned	Lower	Aligned	Higher
S.IC.B.6 Evaluate reports based on data.	Aligned	Similar	Aligned	Similar
S.IC.B.7 Conduct Statistical investigations. a. Conduct observational studies. b. Conduct Statistical experiments.	Partially Aligned	Lower	Aligned	Higher
Interpreting Categorical and Quantitative Data (ID)				
S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms and box plots).	Aligned	Similar	Aligned	Similar
S.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	Aligned	Similar	Aligned	Similar
S.ID.A.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).	Partially Aligned	Similar	Aligned	Similar

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
S.ID.A.4 Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.	Partially Aligned	Lower	Aligned	Higher
S.ID.B.5 Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.	Partially Aligned	Lower	Aligned	Similar
S.ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. b. Informally assess the fit of a function by plotting and analyzing residuals. c. Fit a linear function for a scatter plot that suggests a linear association.	Aligned	Similar	Aligned	Higher
S.ID.C.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.	Aligned	Similar	Aligned	Higher
S.ID.C.8 Compute (using technology) and interpret the correlation coefficient of a linear fit.	Aligned	Similar	Aligned	Higher
S.ID.C.9 Distinguish between correlation and causation.	Not addressed	Not addressed	Aligned	Higher
Using Probability to Make Decisions (MD)				
S.MD.A.1 Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.	Not addressed	Not addressed	Partially Aligned	Similar
S.MD.A.2 Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.	Not addressed	Not addressed	Aligned	Similar

Standard	Developmental		Introductory	
	Content Rating	Rigor Rating	Content Rating	Rigor Rating
S.MD.A.3 Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; find the expected value. For example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices, and find the expected grade under various grading schemes.	Partially Aligned	Lower	Aligned	Lower
S.MD.A.4 Develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically; find the expected value. For example, find a current data distribution on the number of TV sets per household in the United States, and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?	Not addressed	Not addressed	Aligned	Similar
S.MD.B.5 Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values. a. Find the expected payoff for a game of chance. For example, find the expected winnings from a state lottery ticket or a game at a fast-food restaurant. b. Evaluate and compare strategies based on expected values. For example, compare a high-deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident.	Not addressed	Not addressed	Aligned	Similar
S.MD.B.6 Use probabilities to make fair decisions (e.g., drawing by lots, using a random number generator).	Aligned	Similar	Aligned	Similar
S.MD.B.7 Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).	Aligned	Lower	Aligned	Similar

G.4. Science Alignment Ratings

Exhibits G.4.1 through G.4.5 provide alignment ratings for high school standards within the Maryland CCR Life Science, Physical Science and Disciplinary Literacy Standards.

Overview of the Science Standards

Disciplinary Core Ideas: Life Science and Physical Science

Disciplinary Core Ideas (DCIs) are the foundational ideas or knowledge that a student requires to engage in science learning from kindergarten to Grade 12 and continue to build upon following high school. DCIs can be thought of as the fundamental scientific content that is specific to a science discipline. Life Sciences (LS) and Physical Science (PS) each have four main DCIs (with subtopics) that a student must know and be able to do at varying rigor appropriate to grade-level (Exhibit G.4.1).

Exhibit G.4.1. Disciplinary Core Ideas: Life Science and Physical Science (High School)

DCI	Sub-Topics
Life Science	
LS1: From Molecules to Organisms: Structures and Processes	• LS1.A: Structure and Function • LS1.B: Growth and Development of Organisms • LS1.C: Organization for Matter and Energy Flow in Organisms
LS2: Ecosystems: Interactions, Energy, and Dynamics	• LS2.A: Interdependent Relationships in Ecosystems • LS2.B: Cycles of Matter and Energy Transfer in Ecosystems • LS2.C: Ecosystem Dynamics, Functioning, and Resilience • LS2.D: Social Interactions and Group Behavior
LS3: Heredity: Inheritance and Variation of Traits	• LS3.A: Inheritance of Traits • LS3.B: Variation of Traits
LS4: Biological Evolution: Unity and Diversity	• LS4.A: Evidence of Common Ancestry and Diversity • LS4.B: Natural Selection • LS4.C: Adaptation • LS4.D: Biodiversity and Humans
Physical Science	
PS1: Matter and Its Interactions	• PS1.A: Structure and Properties of Matter • PS1.B: Chemical Reactions • PS1.C: Nuclear Processes
PS2: Motion and Stability: Forces and Interactions	• PS2.A: Forces and Motion • PS2.B: Types of Interactions • PS2.C: Stability and Instability in Physical Systems

DCI	Sub-Topics
PS3: Energy	• PS3.A: Definitions of Energy • PS3.B: Conservation of Energy and Energy Transfer • PS3.C: Relationship Between Energy and Forces • PS3.D: Energy in Chemical Processes and Everyday Life
PS4: Waves and Their Applications in Technologies for Information Transfer	• PS4.A: Wave Properties • PS4.B: Electromagnetic Radiation • PS4.C: Information Technologies and Instrumentation

Alignment of Standards to Course Content

We looked at first-year credit-bearing science courses and the extent to which Maryland's CCR standards in ELA, math, and science were aligned to college life science and physical science course content expectations.

For life science, standards for disciplinary core ideas were aligned to first-year credit-bearing life science course content for all standards. The level of rigor of high school standards was similar to the level of rigor of college life science course content.

For physical science, standards for disciplinary core ideas were aligned to first-year credit-bearing physical science course content for all but three standards. Of those three, one standard was partially aligned to college course content and two were not aligned. The level of rigor of high school standards was similar to the level of rigor of college physical science course content.

Exhibit G.4.2. Detailed Alignment Findings for Disciplinary Core Ideas: Life Science (LS)

Standard	First-year Credit-bearing Science	
	Content	Rigor
LS1: From Molecules to Organisms: Structures and Processes		
LS1.A: Structure and Function		
Systems of specialized cells within organisms help them perform the essential functions of life.	Aligned	Similar
All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.	Aligned	Similar
Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	Aligned	Similar
LS1.B: Growth and Development of Organisms		
In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.	Aligned	Similar
LS1.C: Organization for Matter and Energy Flow in Organisms		
The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	Aligned	Similar
The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.	Aligned	Similar
As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	Aligned	Similar
As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	Aligned	Similar
LS2: Ecosystems: Interactions, Energy, and Dynamics		
LS2.A: Interdependent Relationships in Ecosystems		
Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems		
Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	Aligned	Similar
Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	Aligned	Similar
Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	Aligned	Similar
LS2.C: Ecosystem Dynamics, Functioning, and Resilience		
A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	Aligned	Similar
Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.	Aligned	Similar
LS2.D: Social Interactions and Group Behavior		
Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
LS3: Heredity: Inheritance and Variation of Traits		
LS3.A: Inheritance of Traits		
Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	Aligned	Similar
LS3.B: Variation of Traits		
In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.	Aligned	Similar
Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	Aligned	Similar
LS4: Biological Evolution: Unity and Diversity		
LS4.A: Evidence of Common Ancestry and Diversity		
Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	Aligned	Similar
LS4.B: Natural Selection		
Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.	Aligned	Similar
The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
LS4.C: Adaptation		
Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	Aligned	Similar
Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.	Aligned	Similar
Adaptation also means that the distribution of traits in a population can change when conditions change.	Aligned	Similar
Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.	Aligned	Similar
Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	Aligned	Similar
LS4.D: Biodiversity and Humans		
Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).	Aligned	Similar
Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.	Aligned	Similar

Exhibit G.4.3. Detailed Alignment Findings for Disciplinary Core Ideas: Physical Science (PS)

Standard	First-year Credit-bearing Science	
	Content	Rigor
PS1: Matter and Its Interactions		
PS1.A: Structure and Properties of Matter		
Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.	Aligned	Similar
The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	Aligned	Similar
The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	Aligned	Similar
A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.	Aligned	Similar
PS1.B: Chemical Reactions		
Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	Aligned	Similar
In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.	Aligned	Similar
The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	Aligned	Similar
PS1.C: Nuclear Processes		
Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	Aligned	Similar
PS2: Motion and Stability: Forces and Interactions		
PS2.A: Forces and Motion		
Newton's second law accurately predicts changes in the motion of macroscopic objects.	Aligned	Similar
Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	Aligned	Similar
PS2.B: Types of Interactions		
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	Aligned	Similar
Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.	Aligned	Similar
Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	Aligned	Similar
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	Aligned	Similar
PS3: Energy		
PS3.A: Definitions of Energy		
"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.	Aligned	Similar
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	Aligned	Similar
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	Aligned	Similar
These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	Aligned	Similar
PS3.B: Conservation of Energy and Energy Transfer		
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	Aligned	Similar
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	Aligned	Similar
The availability of energy limits what can occur in any system.	Aligned	Similar
Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	Aligned	Similar
PS3.C: Relationship Between Energy and Forces		
When two objects interacting through a field change relative position, the energy stored in the field is changed.	Aligned	Similar
PS3.D: Energy in Chemical Processes and Everyday Life		
Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	Aligned	Similar
Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.	Not addressed	Not addressed
PS4: Waves and Their Applications in Technologies for Information Transfer		
PS4.A: Wave Properties		
The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	Aligned	Similar
Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	Not addressed	Not addressed
[From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)	Aligned	Similar
PS4.B: Electromagnetic Radiation		
Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	Aligned	Similar

Standard	First-year Credit-bearing Science	
	Content	Rigor
When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	Aligned	Similar
Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	Aligned	Similar
PS4.C: Information Technologies and Instrumentation		
Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	Partially aligned	Similar

Exhibit G.4.4. Detailed Alignment Findings for Reading Standards for Literacy in Science and Technical Subjects: Key Ideas and Details

Standard	Life Science		Physical Science	
	Content	Rigor	Content	Rigor
Key Ideas and Details				
RST 9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	Partially aligned	Lower	Partially aligned	Lower
RST. 9-10.2 Determine the central ideas or conclusions of a text; trace the text’s explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.	Partially aligned	Lower	Partially aligned	Similar
RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	Aligned	Higher	Aligned	Similar
Craft and Structure				
RST. 9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.	Aligned	Similar	Partially aligned	Lower
RST.9-10.5 Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, frictions, reaction force, energy).	Aligned	Similar	Aligned	Similar

Standard	Life Science		Physical Science	
	Content	Rigor	Content	Rigor
RST.9-10.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.	Not addressed	Not addressed	Not addressed	Not addressed
Integration of Knowledge and Ideas				
RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or a chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.	Partially aligned	Lower	Aligned	Lower
RST.9-10.8 Assess the extent to which the reasoning and evidence in a text supports the author's claim or a recommendation for solving a scientific or technical problem.	Aligned	Similar	Partially aligned	Lower
RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiment(s), noting when the findings support or contradict previous explanations or accounts).	Aligned	Lower	Aligned	Similar
Range of Reading and Level of Text Complexity				
RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.	Not addressed	Not addressed	Not addressed	Not addressed

Exhibit G.4.5. Detailed Alignment Findings for Writing Standards for Literacy in Science and Technical Subjects

Standard	Life Science		Physical Science	
	Content	Rigor	Content	Rigor
Text Type and Purposes				
WHST.9-10.1 Write arguments focused on discipline-specific content.	Aligned	Similar	Aligned	Lower
WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	Aligned	Similar	Aligned	Similar
WHST.9-10.3 (not applicable)	Not addressed	Not addressed	Not addressed	Not addressed
Production and Distribution of Writing				
WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	Partially aligned	Similar	Partially aligned	Similar

Standard	Life Science		Physical Science	
	Content	Rigor	Content	Rigor
WHST.9-10.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.	Not addressed	Not addressed	Not addressed	Not addressed
WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	Partially aligned	Lower	Not addressed	Not addressed
Research to Build and Present Knowledge				
WHST.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	Aligned	Similar	Aligned	Similar
WHST.9-10.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.	Aligned	Similar	Partially aligned	Lower
WHST.9-10.9 Draw evidence from informational texts to support analysis, reflection, and research.	Aligned	Similar	Aligned	Similar
Range of Writing				
WHST.9-10.10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	Not addressed	Not addressed	Not addressed	Not addressed

G.5. Certificate-Granting Training Programs Alignment Ratings

Since we were unable to develop a conceptual framework from the available information about expectations related to certificate-granting programs, we examined two existing workforce frameworks and the extent to which Maryland's Disciplinary Literacy Standards, Mathematical Practices and Science and Engineering Practices align to those content expectations.

Exhibits G.5.1 through G.5.7 provide alignment ratings for high school standards within the Maryland CCR Disciplinary Literacy Standards, Mathematical Practices, and Science and Engineering Practices and college programs.

Overview of Certificate-Granting Training Programs

O*NET Content Model

O*NET is managed and maintained by the U.S. Department of Labor and provides occupational information such as "standardized and occupation-specific descriptors on almost 1,000 occupations covering the entire U.S. economy".[7] The O*NET Content Model provides a framework that articulates the "key attributes and characteristics of workers and occupations".[8] One component of the model focuses on Worker Requirements and includes Basic Skills that "facilitate learning or the more rapid acquisition of knowledge" (Exhibit G.5.1) and Cross-Functional Skills that 'facilitate performance of activities that occur across jobs" (Exhibit G.5.2).

Exhibit G.5.1. O*NET Basic Skills

Skill	Description
Content Skills. Background structures needed to work with and acquire more specific skills in a variety of different domains.	
Active Listening	Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.
Mathematics	Using mathematics to solve problems.
Reading Comprehension	Understanding written sentences and paragraphs in work-related documents.
Science	Using scientific rules and methods to solve problems.
Speaking	Talking to others to convey information effectively.
Writing	Communicating effectively in writing as appropriate for the needs of the audience.

[7] https://www.onetcenter.org/overview.html
[8] https://www.onetcenter.org/content.html

Skill	Description
Process Skills. Background structures needed to work with and acquire more specific skills in a variety of different domains.	
Active Learning	Understanding the implications of new information for both current and future problem-solving and decision-making.
Critical Thinking	Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.
Learning Strategies	Selecting and using training/instructional methods and procedures appropriate for the situation when learning or teaching new things.
Monitoring	Monitoring/Assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action.

Source: Basic Skills: https://www.onetonline.org/find/descriptor/browse/2.A

Exhibit G.5.2. O*NET Cross-Functional Skills

Skill	Description
Complex Problem-Solving Skills. Developed capacities used to solve novel, ill-defined problems in complex, real-world settings.	
Complex Problem Solving	Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.
Resource Management Skills. Developed capacities used to allocate resources efficiently.	
Management of Financial Resources	Determining how money will be spent to get the work done, and accounting for these expenditures.
Management of Material Resources	Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain work.
Management of Personnel Resources	Motivating, developing, and directing people as they work, identifying the best people for the job.
Time Management	Managing one's own time and the time of others.
Social Skills. Developed capacities used to work with people to achieve goals.	
Coordination	Adjusting actions in relation to others' actions.
Instructing	Teaching others how to do something.
Negotiation	Bringing others together and trying to reconcile differences.
Persuasion	Persuading others to change their minds or behavior.
Service Orientation	Actively looking for ways to help people.
Social Perceptiveness	Being aware of others' reactions and understanding why they react as they do.
Systems Skills. Developed capacities used to understand, monitor, and improve socio-technical systems.	
Judgment and Decision Making	Considering the relative costs and benefits of potential actions to choose the most appropriate one.

Skill	Description
Systems Analysis	Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes.
Systems Evaluation	Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.
Technical Skills. Developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems.	
N/A	N/A

Source: Cross-functional Skills: https://www.onetonline.org/find/descriptor/browse/2.B

Employability Skills Framework

The Employability Skills Framework was developed by the U.S. Department of Education to support the work of the Office of Career and Technical Education. It includes nine skills across three categories that describe the academic knowledge (Applied Knowledge), technical expertise (Workplace Skills), and cross-cutting abilities (Effective Relationships) students need to develop to be college and career ready (Exhibit G.5.3).

Exhibit G.5.3. Employability Skills

Category	Skill	Description
Applied Knowledge	Applied Academic Skills	Skills based on academic disciplines and learning (e.g., reading, writing, mathematical strategies and procedures, and scientific principles and procedures)
	Critical Thinking Skills	Critical Thinking includes content related to analyzing, reasoning, solving problems, planning, organizing, and making sound decisions.
Workplace Skills	Resource Management	Resource Management includes content related to successfully performing tasks by managing time and other resources.
	Information Use	Information Use includes content related to understanding, evaluating, and using a variety of information.
	Communication Skills	Communication Skills includes content related to communicating effectively with others in multiple formats.
	Systems Thinking	Systems Thinking includes content on successfully performing tasks by understanding relationships among the components of a system.
	Technology Use	Technology Use includes content related to applying information technology appropriately and effectively.

Category	Skill	Description
Effective Relationships	Interpersonal Skills	Interpersonal Skills includes content related to the ability to collaborate as part of a team, communicate effectively, maintain a positive attitude and contribute to overarching goals.
	Personal Qualities	Personal Qualities include content related to effective relationships including responsibility, self-discipline, flexibility, integrity, initiative, professionalism and self-worth, willingness to learn, and acceptance of responsibility for one's own personal growth.

Source: https://cte.ed.gov/initiatives/employability-skills-framework

Using the O*NET Content Model and the Employability Skills Framework for employability, the raters provided alignment ratings for standards within the Maryland CCR Disciplinary Literacy Standards, Mathematical Practices, and Science and Engineering Practices. Exhibits G.5.4 through G.5.7 provide alignment ratings.

Detailed Alignment Findings for Certificate-Granting Training Programs

Exhibit G.5.4. Reading Standards for Literacy in Science and Technical Subjects

Standard	O*NET		Employability Skills Framework	
	Content	Rigor	Content	Rigor
Key Ideas and Details				
RST 9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	Aligned	N/A	Aligned	N/A
RST. 9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.	Not addressed	N/A	Partially aligned	N/A
RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	Aligned	N/A	Partially aligned	N/A
Craft and Structure				
RST. 9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.	Aligned	N/A	Partially aligned	N/A

Standard	O*NET		Employability Skills Framework	
	Content	Rigor	Content	Rigor
RST.9-10.5 Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, frictions, reaction force, energy).	Partially aligned	N/A	Partially aligned	N/A
RST.9-10.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.	Not addressed	N/A	Partially aligned	N/A
Integration of Knowledge and Ideas				
RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or a chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.	Partially aligned	N/A	Partially aligned	N/A
RST.9-10.8 Assess the extent to which the reasoning and evidence in a text supports the author's claim or a recommendation for solving a scientific or technical problem.	Aligned	N/A	Partially aligned	N/A
RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiment(s), noting when the findings support or contradict previous explanations or accounts).	Aligned	N/A	Partially aligned	N/A
Range of Reading and Level of Text Complexity				
RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.	Not addressed	N/A	Partially aligned	N/A

Exhibit G.5.5. Writing Standards for Literacy in Science and Technical Subjects

Standard	O*NET		Employability Skills	
	Content	Rigor	Content	Rigor
Text Type and Purposes				
WHST.9-10.1 Write arguments focused on discipline-specific content.	Partially aligned	N/A	Partially aligned	N/A
WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	Partially aligned	N/A	Partially aligned	N/A
WHST.9-10.3 (not applicable)	N/A	N/A	N/A	N/A

Standard	O*NET		Employability Skills	
	Content	Rigor	Content	Rigor
Production and Distribution of Writing				
WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	Aligned	N/A	Aligned	N/A
WHST.9-10.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.	Partially aligned	N/A	Partially aligned	N/A
WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	Not addressed	N/A	Partially aligned	N/A
Research to Build and Present Knowledge				
WHST.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	Partially aligned	N/A	Partially aligned	N/A
WHST.9-10.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.	Partially aligned	N/A	Aligned	N/A
WHST.9-10.9 Draw evidence from informational texts to support analysis, reflection, and research.	Aligned	N/A	Aligned	N/A
Range of Writing				
WHST.9-10.10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	Not addressed	N/A	Not addressed	N/A

Exhibit G.5.6. Mathematical Practices

Standard	O*NET		Employability Skills	
	Content	Rigor	Content	Rigor
Make sense of problems and persevere in solving them.	Aligned	N/A	Aligned	N/A
Reason abstractly and quantitatively.	Aligned	N/A	Aligned	N/A
Construct viable arguments and critique the reasoning of others.	Partially aligned	N/A	Aligned	N/A
Model with mathematics.	Partially aligned	N/A	Partially aligned	N/A
Use appropriate tools strategically.	Not addressed	N/A	Partially aligned	N/A
Attend to precision.	Partially aligned	N/A	Not addressed	N/A
Look for and make use of structure.	Aligned	N/A	Partially aligned	N/A
Look for and express regularity in repeated reasoning.	Not addressed	N/A	Partially aligned	N/A

Exhibit G.5.7. Science and Engineering Practices

Standard	O*NET		Employability Skills	
	Content	Rigor	Content	Rigor
Asking Questions and Defining Problems	Partially aligned	N/A	Partially aligned	N/A
Developing and Using Models	Not addressed	N/A	Not addressed	N/A
Planning and Carrying Out Investigations	Partially aligned	N/A	Partially aligned	N/A
Analyzing and Interpreting Data	Partially aligned	N/A	Partially aligned	N/A
Using Mathematics and Computational Thinking	Partially aligned	N/A	Partially aligned	N/A
Constructing Explanations and Designing Solutions	Partially aligned	N/A	Partially aligned	N/A
Engaging in Argument from Evidence	Partially aligned	N/A	Partially aligned	N/A
Obtaining, Evaluating, and Communicating Information	Partially aligned	N/A	Partially aligned	N/A

Appendix H. Conceptual Frameworks

We developed conceptual frameworks to synthesize key information about what is expected of students and what they will need to know to succeed in the following Maryland college programs: developmental ELA and math courses and first-year credit-bearing ELA, math, and science courses. The appendix provides the conceptual framework for each of the five college programs. The information contained within the conceptual frameworks is aggregated from the course inventory, syllabi submitted through the programmatic survey conducted with the community colleges, and focus groups with postsecondary, workforce development, and K–12 stakeholders.

H.1. ELA Frameworks

First-Year Credit-Bearing English

Conceptual Framework

Across Maryland's 16 community colleges, more than 30 first-year credit-bearing courses are offered, including courses focused on English composition, literature, and mythology. The *Conceptual Framework for First-Year Credit-Bearing English* serves as a composite of common course content across colleges for English composition.[9]

The *Conceptual Framework for First-Year Credit-Bearing English* is organized using the College and Career Readiness Standards Organizer, which identifies two types of knowledge and skills that inform student readiness goals and expectations:

- **Academic and technical content.** This includes the academic and technical knowledge that learners must master to graduate from primary and secondary school, make the transition to college, and/or succeed across a variety of career trajectories.
- **Employability skills.** These are the general skills and knowledge that are necessary for success in the labor market at all employment levels and in all sectors.

English Composition Summary Description

First-year English composition courses offer instruction and practice in the skills that are necessary to read college-level texts critically; write effective, persuasive, thesis-driven text; understand the recursive writing process; and incorporate feedback into writing. Students learn to use the conventions of standard written American English to establish a clear purpose in their writing, support their purpose with adequate and pertinent evidence, and adapt their writing to suit a range of audiences. Students also learn how to conduct academic research, navigate a library's resources, and correctly cite sources.

[9] Maryland's General Education Requirements for Public Institutions specify an English composition requirement (COMAR 13B.06.01.03).

English Composition Summary Content

Exhibit H.1a.1 describes the common academic and technical content and employability skills across first-year credit-bearing English composition courses. Content and skills are listed in the order of emphasis observed within the combined course syllabi.

Exhibit H.1a.1. Common Content Across English Composition Courses

Academic and technical content	Employability skills
• Writing conventions include content related to grammar, punctuation, spelling, sentence structure, paragraphing, and other mechanics of writing.	• Technology use includes content related to applying information technology appropriately and effectively.
• Idea/thesis generation includes content related to developing an argument or organizing principle in which to ground writing products.	• Information use includes content related to understanding, evaluating, and using a variety of information.
• Research includes content related to conducting and documenting research used to inform writing.	• Critical thinking includes content related to analyzing, reasoning, solving problems, planning, organizing, and making sound decisions.
• Text analysis includes content related to reading and analyzing texts that are used to inform writing.	• Communication includes content related to communicating effectively with others in multiple formats.
• The writing process includes content related to the key steps in writing, as well as collecting and incorporating feedback.	
• Rhetorical knowledge includes content related to audience and purpose, and applying that knowledge to produce the appropriate type of writing.	
• Text summarization includes content related to annotating and summarizing college-level texts.	

Note. Descriptions of employability skills are adapted from the Employability Skills Framework, developed by the Office of Career, Technical, and Adult Education, U.S. Department of Education. The framework was developed in collaboration with career and technical education stakeholders, adult education stakeholders, workforce development and business organizations, and other federal agencies (https://s3.amazonaws.com/PCRN/docs/Employability_Skills_Framework_OnePager_20180212.pdf).

Exhibit H.1a.2 provides sample course objectives from submitted course syllabi. They are representative of the common technical content and employability skills found in first-year credit-bearing English courses.

Exhibit H.1a.2. Sample Course Learning Objectives

Course content	Sample course objectives and/or expectations
Academic and technical content	
Writing conventions	• Use linguistic structures in accordance with the conventions of standard written English—including grammar, mechanics, punctuation, and spelling—when composing and revising written products. • Use structural conventions such as formatting, organizing, and paragraphing.
Idea/thesis generation	• Use a thesis, either clearly stated or implied, as the organizing principle for a logical and coherent college-level essay. • Develop thesis statements for expository and argumentative essays.
Research	• Conduct, integrate, and document academic research. • Demonstrate standard citation and documentation procedures to write with integrity and avoid plagiarism.
Text analysis	• Analyze how contexts shape content in texts by authors from a variety of backgrounds. • Analyze and evaluate stylistic features of a text, such as tone, organization, patterns of development, and argumentative appeals.
Writing process	• Use multiple strategies of invention, drafting, and revision. • Use prewriting, drafting, revising, and editing skills to contribute to the clear communication of ideas, taking into consideration the feedback of instructors and peers.
Rhetorical knowledge	• Produce writing that responds appropriately to a variety of rhetorical situations. • Use rhetorical strategies, based on audience and purpose, to develop academic essays.
Text comprehension	• Annotate texts to practice college-level active reading. • Summarize and analyze college-level readings.

Course content	Sample course objectives and/or expectations
Employability skills	
Technology use	• Use computer applications to draft, write, edit, and revise papers in accordance with a standard manuscript format. • Use technology to produce writing, conduct research, and communicate within a writing community.
Information use	• Use multiple forms of media to identify, gather, and synthesize information from a variety of sources. • Locate specific and relevant primary and secondary sources through various means and technologies, including library resources.
Critical thinking	• Demonstrate the ability to organize ideas, support claims, report findings, and think critically. • Critically read and analyze academic texts to understand each argument's major assertions and assumptions and evaluate its supporting evidence.
Communication	• Produce effective and appropriate oral, written, and visual information for a specific subject, discipline, purpose, audience, and context.

DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

The following sources were used to develop the conceptual framework:

- **Course descriptions.** Course descriptions were collected for the identified first-year credit-bearing English courses.
- **Course syllabi and materials.** Eleven colleges provided syllabi and/or other course materials for 18 first-year credit-bearing English courses.
- **Stakeholder input.** Focus groups were conducted and additional input was gathered through surveys.
- **Alignment analysis.** Emergent themes informed an early draft of the framework, which was provided to alignment reviewers as a resource. Reviewers provided helpful feedback, which was used to develop the final framework.

Developmental English

Conceptual Framework

Across Maryland's 16 community colleges, more than 40 developmental English courses are offered, focused on developing basic reading and writing skills to prepare students for credit-bearing courses. The *Conceptual Framework for Developmental English* serves as a composite of common course content across colleges for developmental English courses.[10]

The *Conceptual Framework for Developmental English* is organized using the College and Career Readiness Standards Organizer, which identifies two types of knowledge and skills that inform student readiness goals and expectations:

- **Academic and technical content.** This includes the academic and technical knowledge that learners must master to graduate from primary and secondary school, make the transition to college, and/or succeed across a variety of career trajectories.
- **Employability skills.** These are the general skills and knowledge that are necessary for success in the labor market at all employment levels and in all sectors.

Developmental English Summary Description

Developmental English courses integrate reading and writing instruction to prepare students for success in college-level credit-bearing courses. Students learn to use the conventions of standard written American English to establish a clear purpose in their writing, use information from texts and research to support their ideas, adapt their writing to suit a range of audiences, and gain an understanding of the writing process by incorporating feedback. Students engage with texts by reading, annotating, summarizing, and analyzing. Students also focus on developing their vocabulary, critical thinking skills, and other personal qualities.

Developmental English Summary Content

Exhibit H.1b.1 describes the common academic and technical content and employability skills across developmental English courses. Content and skills are listed in the order of emphasis observed within the combined course syllabi.

[10] Some colleges offer separate developmental reading courses and developmental writing courses, while others offer combined developmental reading and writing courses. This framework reflects combined content from across all developmental reading and writing courses.

Exhibit H.1b.1. Common Content Across Developmental English Courses

Academic and technical content	Employability skills
• **Writing conventions** include content related to grammar, punctuation, spelling, sentence structure, paragraphing, and other mechanics of writing.	• **Critical thinking** includes content related to analyzing, reasoning, solving problems, planning, organizing, and making sound decisions.
• **The writing process** includes content related to the key steps in writing, as well as collecting and incorporating feedback.	• **Personal qualities** include content related to effective relationships, such as responsibility, self-discipline, flexibility, integrity, initiative, professionalism, self-worth, willingness to learn, and acceptance of responsibility for personal growth.
• **Text comprehension** includes content related to annotating and summarizing college-level texts.	
• **Vocabulary** includes content related to developing and using appropriate vocabulary.	
• **Text summarization** includes content related to reading and summarizing texts to support the understanding and processing of information.	
• **Text analysis** includes content related to reading and analyzing texts used to inform writing.	
• **Research** includes content related to conducting and documenting research to inform writing.	

Academic and technical content		Employability skills	
	• **Idea/thesis generation** includes content related to developing an argument or organizing principle in which to ground writing products.		
	• **Rhetorical knowledge** includes content related to audience and purpose, and applying that knowledge to produce the appropriate type of writing.		

Note. Descriptions of employability skills are adapted from the Employability Skills Framework, developed by the Office of Career, Technical, and Adult Education, U.S. Department of Education. The framework was developed in collaboration with career and technical education stakeholders, adult education stakeholders, workforce development and business organizations, and other federal agencies (https://s3.amazonaws.com/PCRN/docs/Employability_Skills_Framework_OnePager_20180212.pdf).

Exhibit H.1b.2 provides sample course objectives from submitted course syllabi. They are representative of common technical content and employability skills found in developmental English courses.

Exhibit H.1b.2. Sample Course Learning Objectives

Course content	Sample course objectives and/or expectations
Academic and technical content	
Writing conventions	• Use grammar and mechanics, including parts of speech and sentence-level editing, in essay writing and revision. • Recognize and apply the conventions of standard English in reading and writing.
Writing process	• Produce material that reflects some use of writing process strategies, such as brainstorming, essay skeleton creation, outlining, drafting, revising, editing, and proofreading. • Develop and use effective revision strategies in preparation for college-level writing assignments.
Text comprehension	• Practice active reading strategies, including annotating, outlining, paraphrasing, and summarizing. • Integrate a variety of strategies to comprehend texts.

Course content	Sample course objectives and/or expectations
Vocabulary	• Use college-level vocabulary in standard written English in paragraphs and essays. • Determine the meaning of unfamiliar words in texts written in standard English, using decoding skills, contextual or structural analysis, or a dictionary.
Text summarization	• Apply college-level reading skills to summarize a variety of texts. • Read sources critically and take notes in order to write summaries and responses.
Text analysis	• Describe and apply insights gained from reading and writing a variety of texts. • Find specific, text-based information; and infer, analyze, and evaluate information from a variety of texts.
Research	• Generate ideas and gather information relevant to the topic and purpose, incorporating the ideas and words of other writers. • Engage in inquiry-driven research, properly attributing and citing the language and ideas of others to avoid plagiarism in a well-reasoned essay.
Idea/thesis generation	• Formulate and support a focused thesis statement with adequate evidence while adhering to the conventions of standard written English in a well-structured essay. • Compose written products that connect a thesis statement/topic sentence with topic sentences/supporting sentences to (a) organize the written products, and (b) refer back to the given assignment.
Rhetorical knowledge	• Identify and analyze the audience, purpose, and message across a variety of texts. • Determine and use effective rhetorical approaches and strategies for given reading and writing situations.
Employability skills	
Critical thinking	• Employ critical reading, writing, and thinking processes that contribute to independent learning. • Evaluate the relevance and quality of ideas and information.
Personal qualities	• Monitor progress, self-assess, reflect, transfer skills, and adapt personal strategies. • Self-evaluate to gain awareness of habits and attitudes that affect success.

DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

The following sources were used to develop the conceptual framework:

- **Course descriptions.** Course descriptions were collected for the identified developmental English courses.
- **Course syllabi and materials.** Eleven colleges provided syllabi and/or other course materials for 25 developmental English courses.
- **Stakeholder input.** Focus groups were conducted and additional input was gathered through surveys.
- **Alignment analysis.** Emergent themes informed an early draft of the framework, which was provided to alignment reviewers as a resource. Reviewers provided helpful feedback, which was used to develop the final framework.

H.2. Math Frameworks

First-Year Credit-Bearing Mathematics

Conceptual Framework

Across Maryland's 16 community colleges, more than 30 first-year credit-bearing courses are offered, including courses focused on foundational mathematics. The *Conceptual Framework for First-Year Credit-Bearing Mathematics* serves as a composite of common course content across colleges for mathematics.[11]

The *Conceptual Framework for First-Year Credit-Bearing Mathematics* is organized using the College and Career Readiness Standards Organizer, which identifies two types of knowledge and skills that inform student readiness goals and expectations:

- **Academic and technical content.** This includes the academic and technical knowledge that learners must master to graduate from primary and secondary school, make the transition to college, and/or succeed across a variety of career trajectories.
- **Employability skills.** These are the general skills and knowledge that are necessary for success in the labor market at all employment levels and in all sectors.

Mathematics Summary Description

First-year mathematics courses develop a solid foundation in fundamental mathematical concepts and skills across various domains, including arithmetic, algebra, geometry, and statistics. Students are expected to demonstrate proficiency in problem solving, critical thinking, mathematical reasoning, and communication. They should be able to analyze and interpret mathematical information; apply mathematical techniques to solve problems; and effectively communicate mathematical ideas, both orally and in written form. Students are also expected to use mathematical modeling and data analysis, and to use technology and digital tools to enhance understanding and visualization of mathematical concepts.

[11] Maryland's General Education Requirements for Public Institutions specify a mathematics requirement (COMAR 13B.06.01.03).

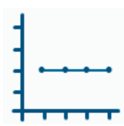
Mathematics Summary Content

Exhibit H.2a.1 describes the common academic and technical content and employability skills across first-year credit-bearing mathematics courses. Content and skills are listed in alphabetic order.

Exhibit H.2a.1. Common Content Across Mathematics Courses

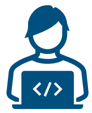
Academic and technical content	Employability skills
• Algebraic concepts. Use concepts such as expressions, equations, and inequalities. Solve and simplify equations, inequalities, and expressions, while also building skills to visually represent these mathematical relationships through algebraic graphing.	• **Critical thinking skills.** The ability to analyze problems of varying complexity, identify patterns, think creatively, identify and apply appropriate strategies, and develop innovative solutions using mathematical reasoning.
• Arithmetic operations. Perform operations, making comparisons and understanding the order of operations with addition, subtraction, multiplication, and division of real and complex numbers.	• **Interpersonal skills.** The capacity to work effectively in teams, communicate mathematical ideas, and collaborate with others to solve problems and complete mathematical tasks.
• Data organization and interpretation. Provide a foundational understanding of organizing and representing data, calculating measures of central tendency and variability, and interpreting various types of graphs (e.g., bar graphs, line graphs, scatter plots) to effectively represent and analyze data within diverse mathematical contexts.	• **Communication skills.** The ability to express ideas clearly, both orally and in written form; and to effectively communicate reasoning and problem-solving strategies to diverse audiences.

Academic and technical content		Employability skills	
	• Exponential and logarithmic functions. Expand upon the foundational understanding of logarithmic and exponential functions by delving deeper into their properties, exploring advanced growth and decay models, and applying these concepts in more intricate real-world scenarios, including intricate population growth patterns, complex compound interest calculations, and exponential decay phenomena.		• **Technology use.** Proficiency in using digital tools, mathematical software, and technology to enhance mathematical understanding, conduct analyses, and present results.
	• Finances. Develop proficiency in foundational skills in personal financial management, including budgeting; calculating interest; understanding credit and debt; interpreting financial statements; and making informed		• **Information use.** The ability to locate, evaluate, and use mathematical resources effectively; and to apply ethical principles when collecting, analyzing, and interpreting mathematical data.
	• Functions and graphing. Analyze, manipulate, and apply functions from algebraic, graphical, and numerical perspectives; synthesize information from equations and graphs; evaluate transformations; find domains and ranges; and solve problems involving various types of functions.		• **Personal qualities.** The willingness to embrace new mathematical concepts, adapt to different problem-solving approaches, and adjust strategies when faced with challenges or changing circumstances; and to develop a mindset for continuous learning, seeking opportunities to enhance mathematical knowledge and skills, and staying updated with advancements in mathematical thinking and technology.

Academic and technical content		Employability skills	
	• Geometric measurement. Develop proficiency in applying advanced geometric concepts and techniques to accurately measure and quantify attributes of geometric figures, including length, area, volume, and angle measures, while using appropriate formulas, tools, and mathematical reasoning.		
	• Graphs. Effectively graph and interpret data, functions, equations, and mathematical models across various content areas, demonstrating proficiency in understanding graphical representations and using them to analyze and communicate mathematical concepts.		
	• Linear equations. Solve, graph, and apply linear equations across diverse contexts, including advanced interpretation of slope, intercepts, and systems of linear equations; and employ advanced algebraic techniques and graphical representations to analyze and solve complex real-world problems involving linear relationships and systems of equations.		
	• Measurement. Accurately measure and apply appropriate units, understand measurement conversions, calculate and compare measurements, and use measurement tools and formulas to solve problems in various mathematical contexts.		

Academic and technical content		Employability skills	
①② ③	• Numbers. Comprehend and operate within different number systems, including real numbers, rational numbers, irrational numbers, integers, and complex numbers, applying their properties and relationships to solve mathematical problems and reason abstractly.		
%	• Percentages. Calculate percentages; understand their applications in real-world contexts; convert between percentages, decimals, and fractions; and apply percentage calculations to solve mathematical and financial problems.		
	• Polynomials. Manipulate and solve polynomial expressions, including factoring, expanding, simplifying, and performing operations, as well as applying polynomial concepts to analyze and model mathematical situations.		
	• Probability. Understand and apply the principles of probability, including calculating probabilities of events, analyzing independent and dependent events, using counting techniques, interpreting probability distributions, and applying probability concepts to real-world situations.		
	• Problem-solving strategies. Apply mathematical concepts effectively to solve complex real-world problems by translating them into mathematical equations or models, selecting appropriate problem-solving strategies, and interpreting the solutions in the context of the given situations.		

Academic and technical content		Employability skills	
	• Quadratic equations. Solve, graph, and interpret quadratic equations, including factoring, completing the square, using the quadratic formula, identifying key features of quadratic functions, and applying quadratic equations to real-world scenarios.		
	• Radical expressions. Simplify, manipulate, and solve radical expressions, including understanding properties of radicals, rationalizing denominators, simplifying expressions with radicals, and applying radical operations to solve equations and real-world problems.		
	• Rates of change. Analyze and interpret rates of change, including understanding the concepts of average and instantaneous rates of change, calculating derivatives, applying the concept of slope to functions and graphs, and using rates of change to model and solve problems.		
	• Rational exponents. Understand and manipulate rational exponents, including converting between radical and exponential forms, simplifying expressions with rational exponents, solving equations involving rational exponents, and applying rational exponents in various mathematical contexts.		
	• Statistics. Analyze and interpret data using statistical methods, including collecting, organizing, and summarizing data; understanding and applying descriptive and inferential statistics; using probability concepts; conducting hypothesis tests; and interpreting statistical results to make informed decisions.		

Academic and technical content		Employability skills	
	• Writing/English language arts (ELA). Write to communicate mathematical understanding, concepts, and application.		

Note. Descriptions are adapted from the Employability Skills Framework, developed by the Office of Career, Technical, and Adult Education, U.S. Department of Education. The framework was developed in collaboration with career and technical education stakeholders, adult education stakeholders, workforce development and business organizations, and other federal agencies (https://s3.amazonaws.com/PCRN/docs/Employability_Skills_Framework_OnePager_20180212.pdf).

Exhibit H.2a.2 provides sample course objectives from submitted course syllabi. They are representative of the common technical content and employability skills found in first-year credit-bearing mathematics courses.

Exhibit H.2a.2. Sample Course Learning Objectives

Course content	Sample course objectives and/or expectations
Academic and technical content	
Algebraic concepts	• Evaluate algebraic expressions. • Simplify algebraic expressions using properties and rules.
Arithmetic operations	• Add, subtract, multiply, and divide real and complex numbers. • Perform mathematical operations and apply them to practical situations. • Use and create models for addition, subtraction, multiplication, and division of integers.
Data organization and interpretation	• Display and analyze data using a basic understanding of descriptive statistics. • Use appropriate symbols, notation, and vocabulary to accurately communicate statistical concepts. • Analyze data using descriptive statistics, including measures of central tendency, variation, and distribution type. • Use technology to accurately solve statistical problems and analyze data. • Apply statistical reasoning to analyze data and draw conclusions. • Understand and apply the terminology used in statistics.

Course content	Sample course objectives and/or expectations
Exponential and logarithmic functions	• Solve problems involving applications of inverse functions and exponential, logarithmic, and logistic equations. • Analyze polynomial functions of higher degrees. • Determine the exponential growth or decay of exponential functions. • Convert logarithmic equations to exponential equations and solve them.
Finances	• Analyze financial problems using mathematical techniques. • Use formulas to solve applications involving loans, credit cards, and mortgages. • Solve finance problems involving simple interest, compound interest, annual percentage yield, future value of an ordinary annuity, present value of an ordinary annuity, loans, and mortgages.
Functions and graphing	• Apply, analyze, and investigate the properties of functions from an algebraic, graphing, and numerical perspective. • Synthesize results from the graphs and/or equations of functions. • Solve problems involving applications of linear, quadratic, absolute value, circle, average rate of change, and piecewise defined functions. • Create a new function by composition of functions. • Factor functions. • Translate words into equations for quadratic functions and determine values and meanings. • Determine values and explain the meaning of asymptotes, intercepts, and extrema for rational functions in real-life situations. • Find and determine the domain and range of various types of functions. • Set up and solve application problems using multiple types of functions.

Course content	Sample course objectives and/or expectations
Geometric measurement	• Determine the center and radius of a circle. • Find the vertex point for the graphs of absolute value and radical functions and sideways parabolas and solve these equations. • Convert radicals to fractional exponents to solve problems. • Use inverse trigonometric functions to solve applied problems and find angles or distances. • Measure angles. • Use the Pythagorean Theorem to find the length of an edge for a right triangle. • Evaluate sine, cosine, and tangent using right triangle trigonometry. • Solve application problems using right triangles. • Recognize and identify geometric terms and apply mathematical relationships for various shapes and figures.
Graphs	• Solve systems of nonlinear equations graphically or algebraically. • Solve linear inequalities and represent their solutions on a number line or graph. • Solve quadratic inequalities and represent their solutions on a number line or graph. • Solve systems of linear inequalities and represent their solutions on a graph.
Linear equations	• Solve linear equations in one variable algebraically. • Solve systems of linear equations using different techniques (substitution, elimination, matrices). • Linear systems of equations with two unknowns: Student will be able to translate words to equations in which students will need to solve a system of linear equations with two variables.
Measurement	• Use units of measure accurately while solving application problems. • Perform basic unit conversions without a conversion chart.
Numbers	• Classify a real number as a natural, whole, integer, rational, or irrational number. • Use the properties of real numbers (commutative, associative, distributive, inverse, and identity).

Course content	Sample course objectives and/or expectations
Percentages	• Review properties of and operations on decimal numbers and percentages. • Word problems with percentages. • Reasoning about percent. • Percentage increase or decrease. • Interest rates.
Polynomials	• Identify the degree and leading coefficient of polynomials and perform operations with polynomials of several variables. • Perform operations on polynomials, including addition, subtraction, multiplication, and division. • Factor polynomials completely. • Identify and factor out the greatest common factor of a polynomial expression.
Probability	• Use set and counting principles to calculate basic probabilities • Determine probabilities used in decision making. • Apply methods of probability and inferential statistics to inform good decision making. • Understand and apply the concepts of discrete probability, including conditional probability and the rules of probability. • Use counting methods to calculate probabilities, including permutations and combinations.
Problem-solving strategies	• Demonstrate a variety of problem-solving techniques using different mathematical tools and alternative representations of numerical and analytical concepts with application to numerical data. • Solve word problems and be able to describe real-world events using algebra. • Apply the rules of logic in mathematical and real-life contexts. • Perform mathematical operations and apply them to practical situations. • Describe and discuss mathematical concepts and techniques that can be applied to other disciplines. • Interpret quantitative information from selected real-world word problems so that data can be encapsulated into suitable mathematical models.
Quadratic equations	• Solve quadratic equations using various methods (factoring, completing the square, quadratic formula). • Solve quadratic equations either by factoring or using the quadratic formula.

Course content	Sample course objectives and/or expectations
Radical expressions	• Simplify rational expressions and perform operations on them. • Solve radical equations. • Factor expressions using fractional or negative exponents. Simplify rational expressions. Multiply rational expressions. Divide rational expressions. Add and subtract rational expressions. Simplify complex rational expressions.
Rates of change	• Calculate quantities related to simple and compound interest. • Find the growth rate. • Predict the time to reach a given population. • Model exponential growth and decay.
Rational exponents	• Understand rules of exponents (negative, fractional, zero, quotient, and power of a product and a quotient). • Solve equations involving rational exponents. • Use the Rational Zero Theorem to find rational zeros.
Statistics	• Understand and apply formulas used in statistics and perform calculations. • Fit least squares regression to data and understand the meaning of regression terminology, measures, and calculations. • Solve problems involving confidence intervals and parameter estimation. • Interpret and analyze tables, graphs, and diagrams to convey quantitative information and solve statistical problems. • Apply statistical methods to hypothesis testing and make inferences based on the results. • Apply regression and correlation analysis to examine relationships between variables. • Interpret and analyze data using regression models to make predictions and draw conclusions.

Course content	Sample course objectives and/or expectations
Writing/ELA	• Articulate the concepts of practical mathematics. This will be accomplished through writing and speaking in effective, organized, clear, and grammatically correct English that is appropriate for mathematics. • Write interpretive results in clear, concise English sentences, tailored to meet the needs of the target audience. • Use the correct vocabulary to explain alternative methods for mathematical skills and concepts to a variety of listeners using appropriate physical models, technology, and/or activities.
Employability skills	
Critical thinking skills	• Apply the rules of logic in mathematical and real-life contexts. • Perform mathematical operations and apply them to practical situations. • Describe and discuss mathematical concepts and techniques that can be applied to other disciplines. • Explore issues through creative, interdisciplinary, and innovative approaches.
Interpersonal skills	• Work collaboratively with classmates to foster community and learning. Experience has shown that when students form study groups and spend time discussing course topics with other students, their understanding of many of the difficult concepts greatly increases, and test scores improve as a consequence.
Communication skills	• Articulate the concepts of practical mathematics. This will be accomplished through writing and speaking in effective, organized, clear, and grammatically correct English that appropriate for mathematics. • Write interpretive results in clear, concise English sentences, tailored to meet the needs of the target audience. • Communicate ideas in written, oral, and other modes as appropriate to a situation and audience.

Course content	Sample course objectives and/or expectations
Technology use	• Use technology to conduct data and statistical analysis. • Use technology to solve and analyze mathematical concepts. • Use a calculator. • Use Excel for various functions. • Use computer software such as Excel and/or use calculator software such as the TVM Solver, Equation Solver, and/or matrix menus when appropriate. • Use technological tools to solve mathematical problems.
Information use	• Understand the terminology, symbols, and methods of data collection. • Collect, organize, interpret, and analyze data to draw conclusions about the world around us. • Demonstrate an understanding of the importance of random sampling and randomization in producing data that allow one to draw conclusions about the underlying populations. • Evaluate sources of information for accuracy, relevance, and reliability.
Personal qualities	• Behave in a manner becoming of an adult with thoughtfulness and respect for others. • Attendance is extremely important and vital to [students'] success. • Academic honesty. • Practice over and over to understand the how and why of the topic at hand. • Setting up a schedule […] and working on the course material consistently are key to [students'] success.

DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

The following sources were used to develop the conceptual framework:

- **Course descriptions.** Course descriptions were collected for the identified first-year credit-bearing mathematics courses.
- **Course syllabi and materials.** Eleven colleges provided syllabi and/or other course materials. The number of submitted syllabi varied across colleges, ranging from one to six. Seven of the colleges submitted syllabi that included precalculus, calculus, or trigonometry as objectives. However, these objectives were not taken into account during the alignment process, as they are not typically covered by Grade 10 high school students. Additionally, five colleges submitted syllabi intended for students in either a teacher education program or an engineering program, which required college algebra as a prerequisite. Given the specialized nature of this mathematics content, these objectives were also excluded from the alignment considerations. Proportionally, college algebra had the highest number of submitted syllabi, followed by statistics. Only three syllabi included objectives related to geometric concepts.
- **Stakeholder input.** Focus groups were conducted and additional input was gathered through surveys.
- **Alignment analysis.** Emergent themes informed an early draft of the framework, which was provided to alignment reviewers as a resource. Reviewers provided helpful feedback, which was used to develop the final framework.

Developmental Mathematics

Conceptual Framework

Across Maryland's 16 community colleges, more than 35 developmental courses are offered focusing on mathematics, primarily algebra. The *Conceptual Framework for Developmental Mathematics* serves as a composite of common course content across colleges for mathematics.[12]

The *Conceptual Framework for Developmental Mathematics* is organized using the College and Career Readiness Standards Organizer, which identifies two types of knowledge and skills that inform student readiness goals and expectations:

- **Academic and technical content.** This includes the academic and technical knowledge that learners must master to graduate from primary and secondary school, make the transition to college, and/or succeed in a variety of career trajectories.
- **Employability skills.** These are the general skills and knowledge that are necessary for success in the labor market at all employment levels and in all sectors.

Mathematics Summary Description

Developmental mathematics courses provide students with the foundational mathematical knowledge and skills that are necessary for success in college entry–level mathematics courses. These courses typically focus on strengthening fundamental concepts in arithmetic, algebra, geometry, and statistics to ensure students have a solid mathematical foundation. Expectations include developing proficiency in basic operations, understanding numerical relationships, solving equations and inequalities, working with geometric concepts, and analyzing and interpreting data. Developmental mathematics courses also emphasize problem-solving strategies, critical thinking skills, and effective communication of mathematical ideas to support students in overcoming mathematical challenges and building confidence in their mathematical abilities.

[12] Maryland's General Education Requirements for Public Institutions specify a mathematics requirement (COMAR 13B.06.01.03).

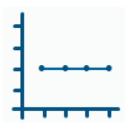
Mathematics Summary Content

Exhibit H.2b.1 describes the common academic and technical content and employability skills across developmental mathematics courses. Content and skills are listed in alphabetic order.

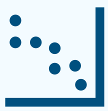
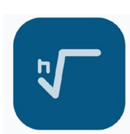
Exhibit H.2b.1. Common Content Across Mathematics Courses

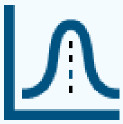
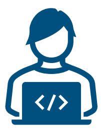
Academic and technical content	Employability skills
• Algebraic concepts. Introducing fundamental concepts such as solving and simplifying equations, inequalities, and expressions, while building skills to represent these mathematical relationships visually through algebraic graphing.	• **Critical thinking skills.** The ability to analyze problems of varying complexity, identify patterns, think creatively, identify and apply appropriate strategies, and develop innovative solutions using mathematical reasoning.
• Arithmetic operations. Review and practice of addition, subtraction, multiplication, and division involving whole numbers, fractions, decimals, and percentages, with the aim of proficiency in handling positive and negative numbers, including performing operations, making comparisons, and understanding the order of operations.	• **Interpersonal skills.** The capacity to work effectively in teams, communicate mathematical ideas, and collaborate with others to solve problems and complete mathematical tasks.
• Data organization and interpretation. Introducing basic concepts of data analysis, encompassing organizing and representing data, calculating measures of central tendency and variability, and interpreting various types of graphs (e.g., bar graphs, line graphs, scatter plots) to effectively represent and analyze data in diverse mathematical contexts.	• **Communication skills.** The ability to express ideas clearly, both orally and in written form; and to effectively communicate reasoning and problem-solving strategies to diverse audiences.

Academic and technical content	Employability skills
• Exponential and logarithmic functions. Developing an understanding of the fundamental properties and applications of logarithmic and exponential functions, understanding growth and decay models, and applying these concepts in real-world contexts such as population growth, compound interest, and exponential decay.	• **Technology use.** Proficiency in using digital tools, mathematical software, and technology to enhance mathematical understanding, conduct analyses, and present results.
• Finances. Developing foundational skills in personal financial management, including budgeting, calculating interest, understanding credit and debt, interpreting financial statements, and making informed decisions related to savings, investments, and financial planning.	• **Information use.** The ability to locate, evaluate, and use mathematical resources effectively; and to apply ethical principles when collecting, analyzing, and interpreting mathematical data.
• Functions and graphing. Understanding basic properties of domain and range of function as well as concepts of functions, including input-output relationships, graphing linear functions, and interpreting graphs.	• **Personal qualities.** The willingness to embrace new mathematical concepts, adapt to different problem-solving approaches, and adjust strategies when faced with challenges or changing circumstances; and to develop a mindset for continuous learning, seeking opportunities to enhance mathematical knowledge and skills, and staying updated with advancements in mathematical thinking and technology.
• Geometric measurement. Establishing foundational skills in accurately measuring and quantifying basic attributes of geometric figures, including length, area, volume, and angle measures, while utilizing basic formulas, tools, and basic mathematical reasoning.	

Academic and technical content		Employability skills	
	• Graphs. Developing the ability to graph and interpret data, functions, equations, and mathematical models across various content areas, demonstrating proficiency in understanding graphical representations and using them to analyze and communicate mathematical concepts.		
	• Linear equations. Developing the ability to solve, graph, and apply linear equations in a variety of contexts, including interpreting slope, intercepts, and systems of linear equations, and utilizing algebraic techniques and graphical representations to analyze and solve real-world problems.		
	• Measurement. Developing foundational skills in measuring quantities using appropriate units, comprehending measurement conversions, calculating and comparing measurements, and utilizing basic measurement tools and formulas to solve problems within a variety of mathematical contexts.		
①② ③	• Numbers. Developing fundamental skills in comprehending and operating within various number systems, such as real numbers, rational numbers, irrational numbers, integers, and complex numbers. This includes applying their basic properties and relationships to solve mathematical problems and engage in abstract reasoning.		

Academic and technical content		Employability skills	
%	• Percentages. Building foundational skills in calculating percentages, comprehending their practical applications in real-world contexts, converting between percentages, decimals, and fractions, and utilizing percentage calculations to solve basic mathematical and financial problems.		
	• Polynomials. Developing foundational skills in manipulating and solving polynomial expressions, including basic factoring, expanding, simplifying, and performing operations, while applying polynomial concepts to analyze and model basic mathematical situations.		
	• Probability. Establishing fundamental skills in understanding and applying the principles of probability, such as calculating probabilities of basic events, analyzing simple independent and dependent events, utilizing basic counting techniques, interpreting basic probability distributions, and applying probability concepts to straightforward real-world situations.		
	• Problem-solving strategies. Apply mathematical concepts effectively to solve complex real-world problems by translating them into mathematical equations or models, selecting appropriate problem-solving strategies, and interpreting the solutions in the context of the given situations.		

Academic and technical content		Employability skills	
	• Quadratic equations. Developing the ability to apply mathematical concepts effectively to solve complex real-world problems by translating them into mathematical equations or models, selecting appropriate problem-solving strategies, and interpreting the solutions in the context of the given situations.		
	• Radical expressions. Establishing fundamental skills in simplifying, manipulating, and solving basic radical expressions, including understanding the basic properties of radicals, rationalizing simple denominators, simplifying expressions with radicals, and applying basic operations involving radicals to solve equations and solve basic real-world problems.		
	• Rates of change. Developing foundational skills in analyzing and interpreting basic rates of change, including understanding basic concepts of average and instantaneous rates of change, calculating simple derivatives, applying the concept of slope to basic functions and graphs, and utilizing basic rates of change to model and solve straightforward problems.		
	• Rational exponents. Establishing fundamental skills in understanding and manipulating basic rational exponents, including basic conversions between radical and exponential forms, simplifying expressions with rational exponents, solving basic equations involving rational exponents, and applying basic rational exponents in simple mathematical contexts.		

Academic and technical content		Employability skills	
	• Statistics. Building foundational skills in analyzing and interpreting basic data using simple statistical methods, including basic techniques for collecting, organizing, and summarizing data. Additionally, gaining an understanding of basic descriptive and inferential statistics, simple probability concepts, conducting basic hypothesis tests, and interpreting basic statistical results to make informed decisions.		
	• Writing/English language arts. Writing to communicate mathematical understanding, concepts, and application.		

Note. Descriptions are adapted from the Employability Skills Framework, developed by the Office of Career, Technical, and Adult Education, U.S. Department of Education. The framework was developed in collaboration with career and technical education stakeholders, adult education stakeholders, workforce development and business organizations, and other federal agencies (https://s3.amazonaws.com/PCRN/docs/Employability_Skills_Framework_OnePager_20180212.pdf).

Exhibit H.2b.2 provides sample course objectives from submitted course syllabi. They are representative of the common technical content and employability skills found in developmental mathematics courses.

Exhibit H.2b.2. Sample Course Learning Objectives

Course content	Sample course objectives and/or expectations
Academic and technical content	
Algebraic concepts	• Simplify algebraic expressions (involving real numbers, polynomials, and rationals) using appropriate rules. • Combine algebraic expressions (involving polynomials, radicals, and rationals) through addition, subtraction, multiplication, and division. • Simplify algebraic expressions by the order of operations.

Course content	Sample course objectives and/or expectations
Arithmetic operations	• Simplify complex rational expressions. • Perform operations on whole numbers, integers, fractions, and decimals. • Evaluate arithmetic and algebraic expressions using the order of operations for whole numbers, integers, fractions, and decimals.
Data organization and interpretation	• Summarize and analyze data. • Categorize data as either qualitative or quantitative. • Use visual displays to organize and interpret data. • Summarize data numerically. • Represent a data set with the appropriate display (table, pie chart, bar graph, line graph, boxplot, stemplot, histogram).
Exponential and logarithmic functions	• Construct and graph linear, quadratic, exponential, and logarithmic functions, and evaluate their domains and ranges. • Identify, evaluate, and graph key characteristics of linear, exponential, and logarithmic functions.
Finances	• Apply simple interest/pie charts. • Solve finance problems involving simple interest, compound interest, annual percentage yield, future value of an ordinary annuity, present value of an ordinary annuity, loans, and mortgages. • Calculate the annual percentage yield for an account earning compound interest.

Course content	Sample course objectives and/or expectations
Functions and graphing	• Identify the properties of functions, evaluate functions, and determine the domain and range of a variety of graphs. • Find the sum, difference, product, quotient, and composite of two different functions. • Find the inverse of a one-to-one function. • Demonstrate an understanding of function notation and properties of functions, including their graphs. • Demonstrate an understanding of advanced properties of functions and their graphs, including rational and radical functions. • Use rates and unit rates to problem solve. • Use function notation to represent the relationship between inputs and outputs, and read function inputs and outputs from various representations. • Identify the properties of functions, evaluate functions, and determine the domain and range of a variety of graphs.
Geometric measurement	• Demonstrate knowledge of geometric figures and their properties. • Calculate the perimeter and area of standard and composite shapes. • Calculate the length of any side of a right triangle. • Find the area and circumference of a circle. • Find the volume of standard three-dimensional shapes. • Apply geometric formulas to problem solving and real-world applications. • Use dimensional analysis to convert between units of measurement. • Solve application problems involving geometric formulas. • Apply geometric properties and equations to model and solve problems.
Graphs	• Graph linear equations, derive equations of lines, and read information from graphs. • Read and interpret graphs. • Create box-and-whisker plots, histograms, and ogives. • Graph equations in the form $y = mx + b$.

Course content	Sample course objectives and/or expectations
Linear equations	• Solve linear and literal equations and inequalities. • Solve for a specified variable. • Solve linear equations, inequalities, rational equations, and radical equations with one or more variables. • Translate, solve, and graph linear equations. • Solve systems of linear equations using multiple methods.
Measurement	• Calculate measures of center. • Use dimension analysis to convert between units of measurement in the metric system. • Convert between different units of measurement for length, mass, and capacity.
Numbers	• Round decimals to a specific place value. • Demonstrate an understanding of real numbers and operations on real numbers. • Write numbers in scientific notation and perform operations with scientific notation.
Percentages	• Express and compare quantities using percentages, fractions, and decimals. • Apply basic percent properties. • Solve for part, whole, or percent given any two of the three values. • Find percent increase and percent decrease. • Convert between fractions, decimals, and percentages.
Polynomials	• Perform operations with exponents, scientific notation, and polynomials. • Factor polynomials and solve quadratic equations by factoring. • Perform operations on polynomials, including solving polynomial equations with an emphasis on quadratics. • Add, subtract, multiply, and divide polynomials, rational expressions, and radical expressions. • Factor polynomials using the greatest common factor, grouping, and formulas. • Apply various factoring techniques to polynomials.

Course content	Sample course objectives and/or expectations
Probability	• Calculate probabilities. • Apply basic probability concepts and laws to determine the likelihood of events. • Use contingency tables to analyze relationships and determine probabilities. • Solve basic probability problems using ratios, proportions, two-way tables, and percentages.
Problem-solving strategies	• Interpret and analyze mathematical models, equations, and figures to draw inferences and solve geometry-related problems. • Design and conduct statistical experiments or surveys—including sampling methods, data collection, and analysis techniques—to draw valid conclusions and make reliable predictions. • Interpret quantitative information from selected real-world word problems so that data can be encapsulated into suitable mathematical models. • Solve application problems.
Quadratic equations	• Solve quadratic equations using factoring, the square root method, completing the square, and the quadratic formula, then apply a method to related applications. • Use the discriminant to determine the nature of the roots of a quadratic equation, find the vertex and intercepts of a quadratic function, and graph a quadratic function using appropriate technology.
Radical expressions	• Evaluate and simplify radical expressions, including higher order radical expressions. • Evaluate, differentiate, and perform mathematical operations with radical expressions, rational exponents, and equations containing radicals.
Rates of change	• Recognize and analyze linear functions, including identifying the slope and initial value. • Calculate and interpret slopes as rates of change, and use regression equations to predict outputs and determine growth or decay rates. • Recognize that compound interest grows exponentially.

Course content	Sample course objectives and/or expectations
Rational exponents	• Simplify radical expressions and expressions containing rational exponents. • Change radical expressions to expressions with rational exponents. • Simplify expressions and solve equations containing radicals and rational exponents.
Statistics	• Interpret and construct visual displays to organize and analyze data, including tables, graphs, and charts. • Calculate and interpret descriptive statistics, such as measures of center and spread, for data sets. • Demonstrate knowledge of foundational processes of statistics and reasoning, including estimating and rounding numerical values, solving and interpreting percentage word problems, and defining and using statistical terms.
Writing/English language arts	• Write interpretive results in clear, concise English sentences, tailored to meet the needs of the target audience. • Use writing to communicate mathematical topics.
Employability skills	
Critical thinking skills	• Evaluate and use expressions to describe real-world situations. • Interpret quantitative information from selected real-world word problems so that data can be encapsulated into suitable mathematical models. • Apply the problem-solving procedure for solving problems.
Interpersonal skills	• Take notes in peer posts. • Participate actively in each discussion. • Show respect toward each other and behave with dignity. • If you have been absent and/or are behind, please try to help yourself first by […] studying with a group of classmates. • Participation means demonstrating respect for others' ideas through acknowledging their views and asking for clarification when you're not sure. • Form study groups and meet at least once a week with classmates. •

Course content	Sample course objectives and/or expectations
Communication skills	• Use writing to communicate mathematical topics. • Communicate mathematical information symbolically, visually, and/or numerically using appropriate terminology related to prealgebra, elementary algebra, and intermediate algebra.
Technology use	• Use technology to calculate summary statistics. • Use technology to graph linear, quadratic, radical, exponential, and logarithmic functions and systems of equations, and interpret and analyze the graph.
Information use	• Summarize and analyze data. • Evaluate and/or interpret mathematical information, relationships, and/or concepts related to prealgebra, elementary algebra, and intermediate algebra.
Personal qualities	• Tap into your positive attitude and believe that you can succeed. • Academic honesty. • A good attitude and willingness to learn. • Regular class attendance. • By joining this classroom community, you are committing to bringing a growth mindset to this work, which means we will work together to learn from each other and become more compassionate.

DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

The following sources were used to develop the conceptual framework:

- **Course descriptions.** Course descriptions were collected for the identified developmental mathematics courses.
- **Course syllabi and materials.** Eleven colleges provided syllabi and/or other course materials. The number of syllabi submitted per college ranged from one to seven. The alignment process did not consider the objectives of one syllabus, which served as a prerequisite for the teacher education program. Additionally, one syllabus involved concurrent enrollment in another mathematics course, featuring laboratory experiences. Among the submissions, four syllabi had a science, technology, engineering, and mathematics (STEM) focus. Several colleges offered basic or fundamental mathematics courses without credit. While geometry concepts were absent in most of the submitted syllabi, certain algebra and statistics classes incorporated geometric measurement concepts.
- **Stakeholder input.** Focus groups were conducted and additional input was gathered through surveys.
- **Alignment analysis.** Emergent themes informed an early draft of the framework, which was provided to alignment reviewers as a resource. Reviewers provided helpful feedback, which was used to develop the final framework.

H.3. Science Framework

First-Year Credit-Bearing Science

Conceptual Framework

Across Maryland's 16 community colleges, more than 125 first-year credit-bearing science courses are offered, focused on astronomy, biology, chemistry, climate and environmental science, geology, meteorology, physical science, and zoology. The *Conceptual Framework for First-year Credit-bearing Science* serves as a composite of common course content across colleges for general life science and physical science courses.[13]

The *Conceptual Framework for First-year Credit-bearing Science* is organized using the College and Career Readiness Standards Organizer, which identifies two types of knowledge and skills that inform readiness goals and expectations:

- **Academic and technical content.** This includes the academic and technical knowledge that learners must master to graduate from primary and secondary school, make the transition to college, and/or succeed in a variety of career trajectories.
- **Employability skills.** These are the general skills and knowledge that are necessary for success in the labor market at all employment levels and in all sectors.

Physical Science Summary Description

Physical science courses typically contain content from several physical science disciplinary ideas. These ideas include matter and its interactions, motion and stability, energy, and waves and their applications in technologies for information transfer. Courses also include scientific methods and math skills along with developing skills in investigation, information use, and critical thinking.

Life Science Summary Description

Life science courses typically contain content from several life science disciplinary ideas. These ideas include biochemistry, structures and processes of molecules and organisms, and ecosystems, heredity, and biological evolution. Courses also include scientific methods, as well as information and technology use.

[13] Maryland's General Education Requirements for Public Institutions specifies "biological and physical sciences" as meeting the science requirement, so the framework is focused on the common content found across general first-year courses in those areas (COMAR 13B.06.01.03).

Physical Science Summary Content

Exhibit H.3.1 describes the common academic and technical content and employability skills across first-year credit-bearing physical science courses. Content and skills are listed in the order of emphasis observed within the combined course syllabi.

Exhibit H.3.1. Common Content Across Physical Science Courses

Academic and technical content	Employability skills
• **The scientific method** includes content related to understanding and applying the scientific method.	• **Scientific investigations, data collection and analysis, and technical communications** include content related to how to conduct an investigation or experiment using the scientific method and how to collect, analyze, and communicate empirical data.
• **Measurement** includes content related to understanding the basic units of measurements used in laboratory experiments.	• **Information use** includes content related to understanding, evaluating, and using a variety of information.
• **Force and motion** include content related to Newton's laws of motion.	• **Critical thinking** includes content related to analyzing, reasoning, solving problems, planning, organizing, and making sound decisions.
• **Waves** includes content related to understanding and applying wave theory (light and sound).	
• **Electricity and magnetism** include content related to the basic principles of electricity and magnetism.	
• **Thermodynamics** includes content related to understanding heat as a form of energy and its properties.	

Academic and technical content		Employability skills	
	• **Atoms and molecules** include content related to the structures of atoms and molecules.		
	• **Chemical bonds and reactions** include content related to the interactions between atoms and molecules.		
	• **Mathematics** includes content related to math skills, calculations, data collection, and unit conversions required within the context of physical science.		

Note. Descriptions of employability skills are adapted from the Employability Skills Framework, developed by the Office of Career, Technical, and Adult Education, U.S. Department of Education. The framework was developed in collaboration with career and technical education stakeholders, adult education stakeholders, workforce development and business organizations, and other federal agencies (https://s3.amazonaws.com/PCRN/docs/Employability_Skills_Framework_OnePager_20180212.pdf).

Exhibit H.3.2 provides sample course objectives from submitted course syllabi. They are representative of common technical content and employability skills found in first-year credit-bearing physical science courses.

Exhibit H.3.2. Sample Course Learning Objectives

Course content	Sample objectives and/or expectations
Academic and technical content	
The scientific method	• Demonstrate an understanding of the scientific method through the design, conduct, and reporting of simple experiments. • Use the scientific method to conduct experiments that demonstrate scientific concepts.
Measurement	• Collect, evaluate, and interpret primary data using appropriate measurements. • Describe the process of scientific thinking and the significance of the fundamentals of measurement.
Force and motion	• Calculate velocity, acceleration, force, energy, and other values related to the laws of motion and energy. • Evaluate and solve problems in mechanics by applying the basic principles of motion and Newton's laws.
Waves	• Apply wave theory to sound and the electromagnetic spectrum. • Understand wave dynamics and how they relate to sound and light.
Electricity and magnetism	• Explain the forces of electricity and magnetism, and distinguish between their similarities and differences. • Explain the fundamentals of basic physics such as mechanics, electricity, magnetism, and thermodynamics.
Thermodynamics	• Apply the laws of thermodynamics to heat problems. • Use the relationships among temperature, heat, and thermal properties of matter, as well as appreciate the basics of thermodynamics.
Atoms and molecules	• Describe and demonstrate an understanding of the structure and function of atoms and molecules. • Differentiate between molecules and ions and the forces that create them.
Chemical bonds and reactions	• Define and describe physical and chemical changes.

Course content	Sample objectives and/or expectations
Mathematics	• Demonstrate an understanding of the relationship between variables using computer/calculator software, and construct the resultant of vector addition using graphical techniques. • Perform quantitative and qualitative functions as related to classical physics. • Given a set of measurements, apply the correct International System of Units (SI) units. • Given a set of measurements, use dimensional analysis to carry out unit conversions. • Calculate velocity, acceleration, force, energy, and other values related to the laws of motion and energy. • Calculate electrical parameters within an electrical circuit. • Calculate various parameters using data collected in laboratory experiments.
Employability skills	
Scientific investigations, data collection and analysis, and technical communications	• Demonstrate an understanding of the scientific method through the design, conduct, and reporting of simple experiments. • Employ in problem solving and for scientific communication: scientific notation, significant figures, unit conversions, and dimensional analysis of the fundamental quantities of science. • Collect, evaluate, and interpret primary data using appropriate measurements, and appropriately report associated measurement and experimental errors. • Apply relevant physical science concepts to conduct experiments, solve problems, and interpret data. • Create graphs to adequately display the relationships between variables.
Information use	• Access, process, analyze, and synthesize scientific information. • Demonstrate an ability to collect and report data.
Critical thinking	• Access, interpret, and present information about the application of the basic concepts of physical science in modern technology. • Analyze, interpret, and use scientific data to evaluate hypotheses in physics and astronomy.

Life Science Summary Content

Exhibit H.3.3 describes the common academic and technical content and employability skills across first-year credit-bearing life science courses. Content and skills are listed in the order of emphasis observed within the combined course syllabi.

Exhibit H.3.3. Common Content Across Life Science Courses

Academic and technical content	Employability skills
• **The scientific method** includes content related to understanding and applying the scientific method.	• **Scientific investigations, data collection and analysis, and technical communications** include content related to how to conduct an investigation or experiment using the scientific method and how to collect, analyze, and communicate empirical data.
• **Biochemistry** includes content related to the chemistry of living organisms.	• **Information use** includes content related to understanding, evaluating, and using a variety of information.
• **Cell structures and functions** include content related to the types and structures of cells; cell life cycles and cellular reproduction; and photosynthesis, metabolism, and cellular respiration.	• **Critical thinking** includes content related to analyzing, reasoning, solving problems, planning, organizing, and making sound decisions.
• **Molecular biology** includes content related to how molecules within living organisms interact and function.	• **Technology use** includes content related to applying information technology appropriately and effectively.
• **Genetics** includes content related to genetics and inheritance patterns.	

Academic and technical content		Employability skills	
	• **Evolution** includes content related to evolution and natural selection.		
	• **Ecology** includes content related to ecosystems and the environment.		

Note. Descriptions of employability skills are adapted from the Employability Skills Framework, developed by the Office of Career, Technical, and Adult Education, U.S. Department of Education. The framework was developed in collaboration with career and technical education stakeholders, adult education stakeholders, workforce development and business organizations, and other federal agencies (https://s3.amazonaws.com/PCRN/docs/Employability_Skills_Framework_OnePager_20180212.pdf).

Exhibit H.3.4 provides sample course objectives from submitted course syllabi. They are representative of the common technical content and employability skills found in first-year credit-bearing life science courses.

Exhibit H.3.4. Sample Course Learning Objectives

Course content	Sample course objectives and/or expectations
Academic and technical content	
The scientific method	• Use the scientific method as a tool for critical thinking and learning about the natural world. • Construct or evaluate investigations using the scientific method.
Biochemistry	• List the characteristics of living organisms and the biochemistry of organisms. • Explain basic inorganic and organic chemistry of living organisms.
Cell structure and functions	• Explain the cell cycle, controls, mitosis, and meiosis. • Describe the structure and function of cells.
Molecular biology	• Explain the structure of an atom and the chemical bonds that occur within molecules. • Apply basic biological principles and explain the functioning of biological systems.
Genetics	• Use fundamental principles of genetics to describe the diversity of living organisms.
Evolution	• List the basic causes of evolution: natural selection, mutation, genetic drift, gene flow, and speciation.

Course content	Sample course objectives and/or expectations
Ecology	• Identify and describe the basic interrelationships between living organisms and their environments.
Employability skills	
Scientific investigations, data collection and analysis, and technical communications	• Demonstrate facility with laboratory skills relevant to biological investigation, and analyze experimental results. • Produce effective and appropriate oral and written information for specific laboratory and classroom purposes.
Information use	• Interpret and synthesize information from oral, written, and/or visual texts. • Distinguish science from nonscience.
Critical thinking	• Collect, organize, and analyze empirical scientific data. • Apply basic core principles of biology to an open-ended framework in order to solve scientific problems.
Technology use	• Use and understand the application of technology appropriate for the study of different chemical systems. • Use technology to access and evaluate public and scientific information for informed decision-making related to individuals and society.

DEVELOPMENT OF THE CONCEPTUAL FRAMEWORK

The following sources of information were used to develop the conceptual framework:

- **Course descriptions.** Course descriptions were collected for the identified first-year credit-bearing science courses.
- **Course syllabi and materials.** Nine colleges provided syllabi and/or other course materials for 18 first-year credit-bearing science courses.
- **Stakeholder input.** Focus groups were conducted and additional input was gathered through surveys.
- **Alignment analysis.** Emergent themes informed an early draft of the framework, which was provided to alignment reviewers as a resource. Reviewers provided helpful feedback, which was used to develop the final framework.

Appendix I. Additional Details about the Predictive Validity Analysis

I.1. Initial Postsecondary Pathways

Initial postsecondary pathways were defined based on enrollment in a postsecondary institution in the fall term immediately following expected on-time high school graduation. The primary analytic sample focuses on the initial postsecondary pathways for students who enrolled in a Maryland college. Exhibit I.1.1 lists the colleges and universities included in each Maryland postsecondary pathway, inclusive of Maryland community colleges (*n* = 16); Maryland public 4-year institutions (*n* = 13); and Maryland state-aided independent institutions (*n* = 13). Exhibits I.1.2, I.1.3, and I.1.4 show the composition of students in each pathway, broken down by cohort, demographics, and local education agency, respectively.

In cases when a student had duplicate enrollment records for the same academic year and term (either within a postsecondary institution or across multiple institutions), a single primary enrollment record was retained based on the following priority considerations:

- Institution at which the student attempted the greatest number of credits applicable toward a degree (i.e., largest value rather than smaller and missing values)
- Maryland postsecondary institution rather than out-of-state institution
- 4-year institution rather than 2-year institution
- Most recently reported data

For students attending a college affiliated with the Maryland Higher Education Commission, academic statuses were screened to exclude non-degree-seeking enrollment records (e.g., summer enrollment at a community college as a non-degree-seeking student) and enrollment when the recorded credential sought is above the bachelor's degree (e.g., master's degree, postbaccalaureate certificate). Enrollment records for dual-enrolled high school students (i.e., postsecondary enrollment before high school completion) also were excluded.

Exhibit I.1.1. Maryland Postsecondary Institutions Included in Each Initial Postsecondary Pathway

Postsecondary sector	Postsecondary institutions
Maryland community colleges	Allegany College of Maryland
	Anne Arundel Community College
	Baltimore City Community College
	Carroll Community College
	Cecil College
	Chesapeake College
	College of Southern Maryland
	Community College of Baltimore County
	Frederick Community College
	Garrett College
	Hagerstown Community College
	Harford Community College
	Howard Community College
	Montgomery College
	Prince George’s Community College
	Wor-Wic Community College
Maryland public 4-year institutions	Bowie State University
	Coppin State University
	Frostburg State University
	Morgan State University
	Salisbury University
	St. Mary’s College of Maryland
	Towson University
	University of Baltimore
	University of Maryland–Baltimore
	University of Maryland–Baltimore County
	University of Maryland–College Park
	University of Maryland–Eastern Shore
	University of Maryland–Global Campus

Postsecondary sector	Postsecondary institutions
Maryland state-aided independent institutions	Capitol Technology University[a]
	Goucher College
	Hood College
	Johns Hopkins University
	Loyola University Maryland
	Maryland Institute College of Art
	McDaniel College
	Mount St. Mary's University
	Notre Dame of Maryland University
	St. John's College
	Stevenson University
	Washington Adventist University
	Washington College

[a] The source data file lists this institution under its former name, Capitol College.

Exhibit I.1.2. Prevalence of Initial Postsecondary Pathways for the Grade 10 Sample, by Student Cohort

Student cohort	Grade 10 Sample (HSY2)	MD Community College	MD Public 4-year Inst.	MD State-Aided Independent Inst.	Non-MD 4-Year Inst.	No Enrollment
Total student sample	318,967	19%	16%	3%	15%	46%
Class of 2017	61,514	21%	16%	2%	16%	43%
Class of 2018	63,775	20%	16%	3%	16%	44%
Class of 2019	63,020	20%	16%	3%	16%	45%
Class of 2020	65,853	19%	15%	3%	14%	49%
Class of 2021	64,805	16%	17%	2%	15%	49%

Note. HSY = high school year; MD = Maryland; Inst. = Institution.

Exhibit I.1.3. Prevalence of Initial Postsecondary Pathways for the Grade 10 Sample, by Student Characteristics

Student group	Grade 10 Sample (HSY2)	MD Community College	MD Public 4-year Inst.	MD State-Aided Independent Inst.	Non-MD 4-Year Inst.	No Enrollment
All students	318,967	19%	16%	3%	15%	46%
Sex/gender						
Female	156,512	20%	18%	3%	18%	39%
Male	162,441	18%	14%	2%	12%	53%
Race/ethnicity[a]						
Asian	21,085	22%	39%	3%	17%	18%
Black/African American	107,715	17%	16%	2%	12%	52%
Hispanic/Latinx	50,316	19%	6%	2%	6%	66%
White	126,381	21%	16%	3%	22%	38%
Multiracial	12,299	19%	16%	3%	18%	43%
English learners, current[b]	20,564	11%	2%	1%	1%	85%
English learners, recent exit[b]	13,718	26%	19%	3%	8%	43%
Students with disabilities	32,903	16%	3%	1%	4%	76%
FARMS eligible	120,395	18%	10%	2%	6%	65%

Note. Student characteristics were defined based on a student's status as of the end of their second year of high school. The table does not include students who attended a 2-year non-Maryland college because less than 1% of students had this as their initial postsecondary pathway. MD = Maryland; Inst. = Institution; FARMS = free and reduced-price meals services; HSY = high school year.

[a] Less than 1% of students were classified as American Indian, Alaska Native, Native Hawaiian, or Pacific Islander.

[b] For the purposes of our analysis, students were considered a current English learner if they were classified as an English learner at the end of their second year of high school. Students were considered a recent exit if they were reclassified within 2 years prior to the end of their second year of high school.

Exhibit I.1.4. Prevalence of Initial Postsecondary Pathways for the Grade 10 Sample, by Maryland Local Education Agency

Local education agency	Grade 10 Sample (HSY2)	MD Community College	MD Public 4-year Inst.	MD State-Aided Independent Inst.	Non-MD 4-Year Inst.	No Enrollment
All local education agencies	318,967	19%	16%	3%	15%	46%
Allegany County	3,060	23%	15%	1%	8%	52%
Anne Arundel County	28,559	23%	13%	2%	15%	45%
Baltimore City	25,057	13%	13%	3%	6%	65%
Baltimore County	39,482	20%	17%	4%	12%	47%
Calvert County	6,433	24%	14%	2%	18%	41%
Caroline County	1,990	17%	11%	2%	8%	60%
Carroll County	10,225	22%	15%	5%	20%	37%
Cecil County	5,702	22%	8%	2%	12%	54%
Charles County	10,535	22%	14%	2%	17%	45%
Dorchester County	1,580	14%	12%	3%	6%	64%
Frederick County	15,751	23%	15%	4%	20%	37%
Garrett County	1,418	23%	8%	–	12%	55%
Harford County	14,000	24%	13%	3%	16%	43%
Howard County	21,091	22%	28%	3%	22%	24%
Kent County	708	13%	9%	–	15%	58%
Montgomery County	59,845	18%	20%	2%	23%	36%
Prince George’s County	45,499	15%	14%	1%	9%	59%
Queen Anne’s County	2,890	22%	14%	3%	20%	40%
Somerset County	6,307	22%	10%	1%	14%	52%
St. Mary’s County	935	21%	10%	1%	5%	62%
Talbot County	1,768	19%	13%	4%	15%	48%
Washington County	8,476	23%	7%	2%	13%	53%
Wicomico County	5,162	17%	17%	2%	9%	54%
Worcester County	2,494	16%	20%	2%	14%	47%

Note. The exhibit does not include students who attended a 2-year non-Maryland college because less than 1% of students had this as their initial postsecondary pathway. – indicates the cell value was suppressed due to small sample size. HSY = high school year; MD = Maryland; Inst. = Institution.

I.2. High School Measures of College and Career Readiness

In determining potential alternative measures of college and career readiness, we considered a long list of metrics that are available throughout a student's high school career. Each of these metrics has important limitations and caveats that were considered while narrowing down our list to the metrics ultimately included in the alternative CCR measures that were proposed and evaluated in this report. This section outlines those potential measures and discusses these nuances and definitions in greater detail. The final list of high school measures of college and career readiness considered for the predictive validity analysis is presented in Exhibit I.2.1.

One important caveat for Maryland standardized tests is how the test changed over time. During the time period in which the student sample was in high school (2013–14 to 2020–21), the Maryland state assessment changed from the Maryland High School Assessment (HSA) to the PARCC in 2016 and then to the Maryland Comprehensive Assessment Program (MCAP) in 2021.[14] The HSA included a reading and math assessment that is analogous to the English 10 and Algebra 1 requirements in the interim CCR standard but did not include tests of Algebra 2 or Geometry. Both the PARCC and MCAP have tests for English 10, Algebra 1, Algebra 2, and Geometry. At the time of this study, MCAP scores were not available in the MLDS, although almost all the students in our study sample should have taken at least English 10 and Algebra 1 prior to the state's transition to the MCAP. For these test score measures, we went as far back as a student's seventh-grade year to capture student test-taking and used the student's highest score if they took the same test multiple times by the time point of interest. For example, the Algebra 1 state assessment score for students in the class of 2017 would be the student's highest Algebra 1 score between 2012 and 2015 for the HSY2 measure and between 2012 and 2017 for the HSY4 measure.

While SAT scores are an often-used measure of student preparation for postsecondary education, availability of these scores is limited at the HSY2 time point. Even by the HSY4 time point, only about two thirds of students had an SAT score, and that rate was much lower for the 2021 cohort partly because of the COVID-19 pandemic and many colleges changing to test-optional admissions requirements. To illustrate this point, Exhibit I.2.2 shows the percentage of students with test scores by student cohort. Similarly, the measures of advanced course success were limited for the HSY2 time point, as very few students take AP, IB, dual enrollment, or CTE courses in the first two year of high school. Given this pattern, our primary measures for course completion examine courses completed by the HSY4 time point, though some supplemental analyses consider these measures at the HSY2 time point for completeness.

[14] The MCAP officially started in 2019, but the 2019 administration used items from PARCC, and the 2020 administration was disrupted by the COVID-19 pandemic.

Data used for the calculation of HSGPA come from the annual enrollment files from the Maryland State Department of Education (MSDE). For school years 2012–13 through 2015–16, these enrollment files provide information on the letter grade earned and the number of units attempted in each course. For school years 2016–17 through 2020–21, we used letter grades from the enrollment files and the course lookup table to determine units attempted because enrollment files in these years do not have information on units attempted. We calculated cumulative GPA at the end of HSY2 as the sum of all grade points earned in the first two years of high school attendance divided by the total number of credits attempted for a grade in the first two years of high school attendance. A similar calculation was made for cumulative GPA at the end of HSY4. The grade points for a specific course are equal to the product of the number of credits in the course (typically 1 or 0.5) and the grade points associated with each letter grade (see Exhibit I.2.3). Courses taken as credit/no credit or were listed as 0 credits were not included in the calculation of GPA. In some cases, IB courses between 2017 and 2021 provided the student's score on the IB examination in place of a letter grade. In these cases, IB examination scores were converted to grade points according to the crosswalk provided by Gia Su (2021).

In cases where students did not have reported GPAs for one or more academic years, we determined cumulative GPA at 2 years and 4 years based on a few rules. If a student was missing GPA for Year 1 but not Year 2, then cumulative GPA at the end of Year 2 was equal to the GPA from Year 2. If a student was missing GPA for Year 2, but not Year 1, then cumulative GPA at the end of Year 2 was equal to the GPA from Year 1. Cumulative GPA at the end of Year 4 was calculated as the cumulative GPA from all courses taken in the four years since the student first attended a Maryland public high school, even if the student did not attempt courses in one or more of those years.

In addition to calculating overall GPA, we calculated two other versions of GPA: GPA in core courses and GPA in primary core courses. Core courses are those flagged as "core academic subjects" as outlined in the 2015 SCGT Manual (MSDE, 2015). These include courses such as language, art, dance, science, math, and social studies but exclude courses such as agriculture, marketing, journalism, physical education, and psychology (see Exhibit I.2.4). Cumulative GPAs using only these core courses are highly correlated with overall cumulative GPAs (r = 0.98). Finally, we calculated cumulative GPAs in "primary core courses" by limiting the calculation to courses in only math, science, English, and social studies. Cumulative GPAs using only these primary core courses also are highly correlated with overall cumulative GPAs (r = 0.95).

Despite having a long list of potential measures of CCR, our final analyses focused on a few key measures of CCR. For example, instead of using overall HSGPA, HSGPA in academic subjects, *and* HSGPA in core academic subjects, we only included overall HSGPA in our final analyses due the very high correlation between each measure of HSGPA. Exhibit I.2.5 presents the pairwise correlations for each potential measure of CCR to illustrate the strong correlation that exists between related measures of CCR.

Exhibit I.2.1. High School Measures of College and Career Readiness Considered for the Predictive Validity Analysis

Type of measure	Measure	Description
Test score[a]	English 10 state assessment score	Scale score on the HSA Reading or PARCC English 10 assessment. We converted the HSA scores to PARCC-equivalent scores using the concordance table developed by MARC.
Test score[a]	Algebra 1 state assessment score	Scale score on the HSA Algebra or PARCC Algebra 1 assessment. We converted the HSA scores to PARCC-equivalent scores using the concordance table developed by MARC.
Test score[a]	Algebra 2 state assessment score	Scale score on the PARCC Algebra 2 assessment.
Test score[a]	Geometry state assessment score	Scale score on the PARCC Geometry assessment.
Test score[a]	SAT math score	SAT math score.
Test score	SAT reading score	SAT "evidence-based reading and writing" score. Prior to 2016, the SAT included separate verbal and writing scores. For the earlier version of the SAT, we created one reading score by taking the average of the verbal and writing scores.
Test score	SAT composite score	Sum of a student's highest SAT math and SAT reading scores.
Test score	PSAT math score	PSAT math score on the NMSQT version. Prior to 2016, the PSAT was on a different scale and was not comparable to the current version. We converted the earlier PSAT scores to the current PSAT scale using concordance tables developed by the College Board (2016).
Test score	PSAT reading score	PSAT reading score on the NMSQT version. Prior to 2016, the PSAT was on a different scale and was not comparable to the current version. In addition, the earlier version included separate reading and writing scores. We converted the earlier PSAT scores (total reading and writing score) to the current PSAT scale using concordance tables developed by the College Board (2016).
Test score	PSAT composite score	Sum of a student's highest PSAT math and PSAT reading scores on the NMSQT version of the PSAT.
Test score	ACT math score	ACT math score.
Test score	ACT reading score	Average of the ACT reading and ACT English scores.
Test score	ACT composite score	Average of the ACT math, ACT reading, ACT English, and ACT science scores.

Type of measure	Measure	Description
HSGPA	Overall GPA	We calculated a student's GPA by taking the sum of all grade points earned in every course a student took for a grade in the first 2 (or 4) years of high school and divided by the sum of all units attempted for a grade in the same period.
HSGPA	Academic subjects GPA	The sum of all grade points earned in every course identified as "academic" by MSDE (2015) taken for a grade in the first 2 (or 4) years of high school, divided by the sum of all units attempted for a grade in every course identified as "academic" by MSDE in the first 2 (or 4) years of high school. [b]
HSGPA	Core academic subjects GPA	The sum of all grade points earned in every core academic course (English, math, science, and social studies) taken for a grade in the first 2 (or 4) years of high school divided by the sum of all units attempted for a grade in every core academic course in the first 2 (or 4) years of high school. [b]
Advanced course success	AP/IB courses passed	The number of AP or IB courses in which the student received a passing grade (D or higher, "credit," or "passing") or received a passing score on the AP or IB test.
Advanced course success	Passed 2 or more AP/IB courses	Received a passing grade (D or higher, "credit," or "passing") or received a passing score on the AP or IB test in 2 or more in an AP or IB courses.
Advanced course success	CTE courses passed	The number of CTE courses in which the student received a passing grade (D or higher, "credit," or "passing").
Advanced course success	CTE completion	Received a passing grade (D or higher "credit," or "passing") in 3 or more CTE courses.
Advanced course success	Passed college-level course	Earned credit in at least one dual-enrollment course.

Note. AP = Advanced Placement; CTE = career and technical education; HSA = Maryland High School Assessment; HSGPA = high school grade point average; IB = International Baccalaureate; MARC = Maryland Assessment Research Center; MSDE = Maryland State Department of Education; NMSQT = National Merit Scholarship Qualifying Test; PARCC = Partnership for Assessment of Readiness for College and Careers.

[a] Measure is part of the interim college and career readiness standard.

[b] See Exhibit I.2.4 for a list of subjects designated as academic and core academic course.

Exhibit I.2.2. Percentage of Students with Test Scores, by Student Cohort

Measure and timing	2017 cohort	2018 cohort	2019 cohort	2020 cohort	2021 cohort
Number of students	61,514	63,775	63,020	65,853	64,805
PARCC, English 10					
By end of HSY2	86%	91%	90%	89%	91%
By end of HSY4	92%	95%	95%	94%	91%

Measure and timing	2017 cohort	2018 cohort	2019 cohort	2020 cohort	2021 cohort
PARCC, Algebra 1					
By end of HSY2	91%	89%	91%	91%	92%
By end of HSY4	93%	91%	93%	93%	92%
PARCC, Algebra 2					
By end of HSY2	25%	23%	21%	16%	8%
By end of HSY4	44%	42%	37%	17%	8%
PARCC, Geometry					
By end of HSY2	0%	1%	4%	10%	13%
By end of HSY4	3%	4%	5%	10%	13%
PSAT, composite					
By end of HSY2	79%	77%	71%	67%	68%
By end of HSY4	85%	83%	79%	79%	80%
SAT, composite					
By end of HSY2	2%	2%	2%	2%	2%
By end of HSY4	60%	61%	66%	72%	25%
ACT, composite					
By end of HSY2	0%	0%	0%	0%	0%
By end of HSY4	19%	23%	21%	13%	5%
High school GPA					
By end of HSY2	98%	98%	97%	98%	98%
By end of HSY4	98%	98%	98%	98%	99%

Note. PARCC English 10 and PARCC Algebra 1 include students who took the equivalent HSA test. If a student has a composite score, they also have the subject-specific scores included in the composite. HSA = Maryland High School Assessment; HSY = high school year; PARCC = Partnership for Assessment of Readiness for College and Careers.

Exhibit I.2.3. Grade Points Used for Each Letter Grade

Letter grade	Grade points
A+	4.0
A	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

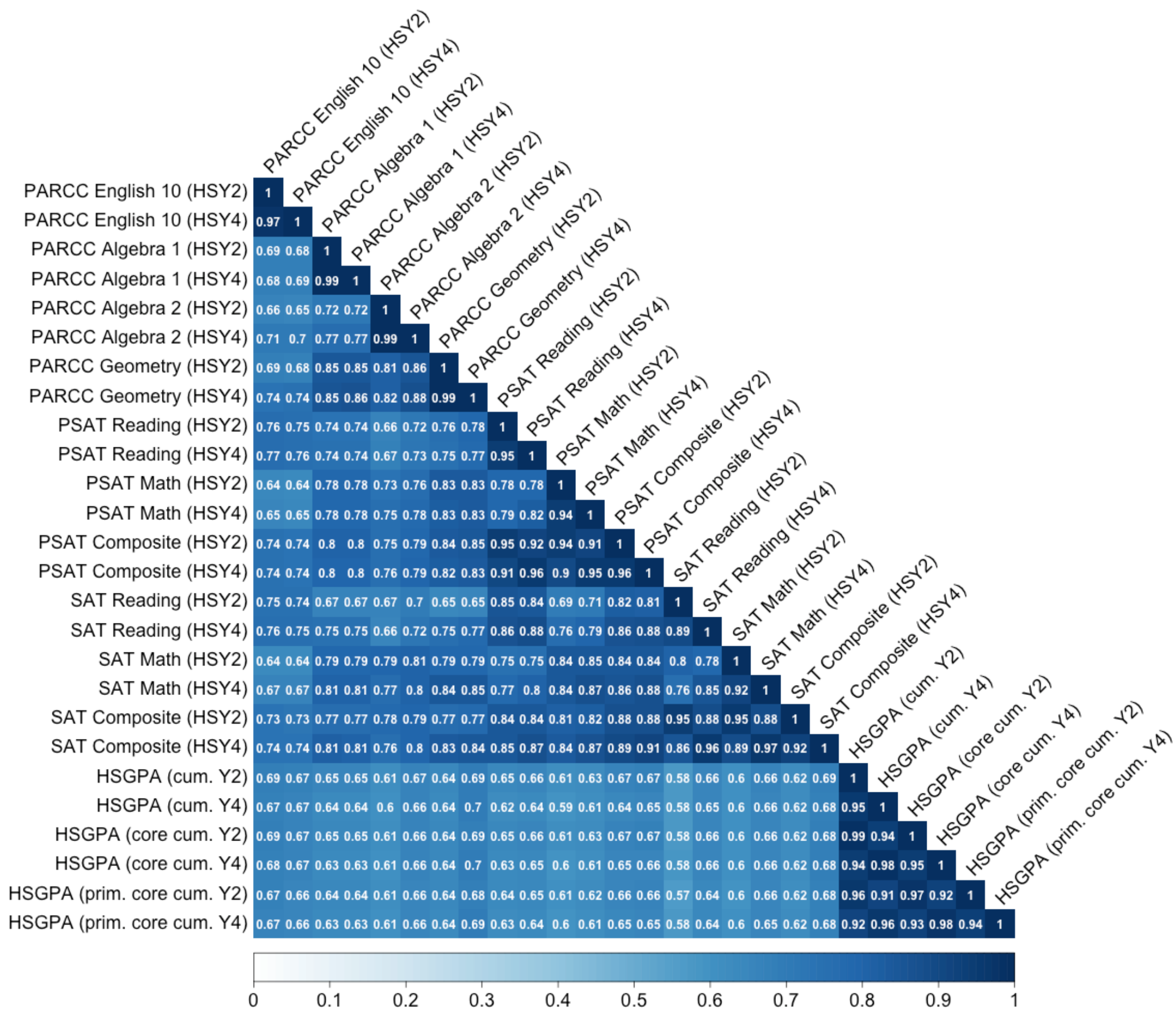
Exhibit I.2.4. MDSE Core Academic Subjects

Art	Dance	Drama/theatre
Kindergarten education	Elementary education	English[a]
Reading	ESOL	French
German	Latin	Russian
Spanish	Other foreign language	Multiple language course
Arabic	Chinese	Italian
Japanese	Portuguese	Turkish
Mathematics[a]	Music	Biology[a]
Chemistry[a]	Earth/space science[a]	General science[a]
Geology[a]	Physical science[a]	Physics[a]
Environmental science[a]	Economics	Geography
History	Political science	Social studies[a]

Note. ESOL = English for speakers of other languages.

[a] Denotes subjects that we include in measures for "primary core academic subjects."

Exhibit I.2.5. Pairwise Correlations Between High School Measures of College and Career Readiness



	PARCC English 10 (HSY2)	PARCC English 10 (HSY4)	PARCC Algebra 1 (HSY2)	PARCC Algebra 1 (HSY4)	PARCC Algebra 2 (HSY2)	PARCC Algebra 2 (HSY4)	PARCC Geometry (HSY2)	PARCC Geometry (HSY4)	PSAT Reading (HSY2)	PSAT Reading (HSY4)	PSAT Math (HSY2)	PSAT Math (HSY4)	PSAT Composite (HSY2)	PSAT Composite (HSY4)	SAT Reading (HSY2)	SAT Reading (HSY4)	SAT Math (HSY2)	SAT Math (HSY4)	SAT Composite (HSY2)	SAT Composite (HSY4)	HSGPA (cum. Y2)	HSGPA (cum. Y4)	HSGPA (core cum. Y2)	HSGPA (core cum. Y4)	HSGPA (prim. core cum. Y2)	HSGPA (prim. core cum. Y4)
PARCC English 10 (HSY2)	1																									
PARCC English 10 (HSY4)	0.97	1																								
PARCC Algebra 1 (HSY2)	0.69	0.68	1																							
PARCC Algebra 1 (HSY4)	0.68	0.69	0.99	1																						
PARCC Algebra 2 (HSY2)	0.66	0.65	0.72	0.72	1																					
PARCC Algebra 2 (HSY4)	0.71	0.7	0.77	0.77	0.99	1																				
PARCC Geometry (HSY2)	0.69	0.68	0.85	0.85	0.81	0.86	1																			
PARCC Geometry (HSY4)	0.74	0.74	0.85	0.86	0.82	0.88	0.99	1																		
PSAT Reading (HSY2)	0.76	0.75	0.74	0.74	0.66	0.72	0.76	0.78	1																	
PSAT Reading (HSY4)	0.77	0.76	0.74	0.74	0.67	0.73	0.75	0.77	0.95	1																
PSAT Math (HSY2)	0.64	0.64	0.78	0.78	0.73	0.76	0.83	0.83	0.78	0.78	1															
PSAT Math (HSY4)	0.65	0.65	0.78	0.78	0.75	0.78	0.83	0.83	0.79	0.82	0.94	1														
PSAT Composite (HSY2)	0.74	0.74	0.8	0.8	0.75	0.79	0.84	0.85	0.95	0.92	0.94	0.91	1													
PSAT Composite (HSY4)	0.74	0.74	0.8	0.8	0.76	0.79	0.82	0.83	0.91	0.96	0.9	0.95	0.96	1												
SAT Reading (HSY2)	0.75	0.74	0.67	0.67	0.67	0.7	0.65	0.65	0.85	0.84	0.69	0.71	0.82	0.81	1											
SAT Reading (HSY4)	0.76	0.75	0.75	0.75	0.66	0.72	0.75	0.77	0.86	0.88	0.76	0.79	0.86	0.88	0.89	1										
SAT Math (HSY2)	0.64	0.64	0.79	0.79	0.79	0.81	0.79	0.79	0.75	0.75	0.84	0.85	0.84	0.84	0.8	0.78	1									
SAT Math (HSY4)	0.67	0.67	0.81	0.81	0.77	0.8	0.84	0.85	0.77	0.8	0.84	0.87	0.86	0.88	0.76	0.85	0.92	1								
SAT Composite (HSY2)	0.73	0.73	0.77	0.77	0.78	0.79	0.77	0.77	0.84	0.84	0.81	0.82	0.88	0.88	0.95	0.88	0.95	0.88	1							
SAT Composite (HSY4)	0.74	0.74	0.81	0.81	0.76	0.8	0.83	0.84	0.85	0.87	0.84	0.87	0.89	0.91	0.86	0.96	0.89	0.97	0.92	1						
HSGPA (cum. Y2)	0.69	0.67	0.65	0.65	0.61	0.67	0.64	0.69	0.65	0.66	0.61	0.63	0.67	0.67	0.58	0.66	0.6	0.66	0.62	0.69	1					
HSGPA (cum. Y4)	0.67	0.67	0.64	0.64	0.6	0.66	0.64	0.7	0.62	0.64	0.59	0.61	0.64	0.65	0.58	0.65	0.6	0.66	0.62	0.68	0.95	1				
HSGPA (core cum. Y2)	0.69	0.67	0.65	0.65	0.61	0.66	0.64	0.69	0.65	0.66	0.61	0.63	0.67	0.67	0.58	0.66	0.6	0.66	0.62	0.68	0.99	0.94	1			
HSGPA (core cum. Y4)	0.68	0.67	0.63	0.63	0.61	0.66	0.64	0.7	0.63	0.65	0.6	0.61	0.65	0.66	0.58	0.66	0.6	0.66	0.62	0.68	0.94	0.98	0.95	1		
HSGPA (prim. core cum. Y2)	0.67	0.66	0.64	0.64	0.61	0.66	0.64	0.68	0.64	0.65	0.61	0.62	0.66	0.66	0.57	0.64	0.6	0.66	0.62	0.68	0.96	0.91	0.97	0.92	1	
HSGPA (prim. core cum. Y4)	0.67	0.66	0.63	0.63	0.61	0.66	0.64	0.69	0.63	0.64	0.6	0.61	0.65	0.65	0.58	0.64	0.6	0.65	0.62	0.68	0.92	0.96	0.93	0.98	0.94	1

Note. Correlations are based on all students in the HSY2 study sample who had nonmissing data for the measures included for a particular correlation coefficient. HSGPA = high school grade point average; HSY = high school year; PARCC = Partnership for Assessment of Readiness for College and Careers. For HSGPA, cum. is the overall cumulative HSGPA, core cum. is the cumulative HSGPA for core academic courses, and prim. core cum. is the cumulative HSGPA for primary core academic courses.

I.3. Measures of College and Career Success

In evaluating the interim and proposed measures of college and career readiness, we examined multiple potential definitions of postsecondary progress and career success. The measures of postsecondary progress discussed in the main report are a subset of all the measures we considered in our analysis. In this section of this appendix, we present a list of all possible measures of postsecondary progress and career success and information on the percentage of students from each group and pathway that met each of these measures. Exhibit I.3.1 lists all the measures considered in our analysis, along with descriptions of the measure and the timing of when outcomes were measured. Exhibits I.3.2 through I.3.5 show the percentage of students who achieved each of the four focal postsecondary progress benchmarks, broken down by initial postsecondary pathway, student characteristics, geographic region, and cohort.

Exhibit I.3.1 Postsecondary Progress Measures and Workforce Outcomes for Predictive Validity Analysis

Measure	Description	Measurement time point(s)
Credit accumulation[a]	Cumulative number of postsecondary credits applicable toward a recognized postsecondary credential (e.g., certificate, degree) awarded to a student by the postsecondary pathway institution. Credit accumulation includes postsecondary credits earned while in high school (e.g., dual enrollment, Advanced Placement), summer enrollment immediately following high school graduation, and postsecondary enrollment at multiple institutions (e.g., taking one course at a community college while predominantly enrolled at a 4-year university), with the assumption that students submit their outside postsecondary credits earned to their postsecondary pathway institution. Credit accumulation values are reported by postsecondary institutions in the MLDS Center data files, not derived by AIR.	• PSY1 fall term (cumulative) • PSY1 spring term (cumulative)
Subject course passing	Whether a student passed at least one credit-bearing, college-level (i.e., non-developmental) course in math, English, or science, conditional on enrolling in at least one subject-specific course, respectively. Because conceptions or "first-year" or "gateway" courses can vary substantially by individual student circumstance (e.g., advanced academic standing, college major), we assume that postsecondary courses attempted at any time through a student's first year of college are a suitable proxy for "entry-level" courses. Due to differences in course coding systems across institutions, math courses include three unique subject codes (e.g., MATH, MTH), English courses include three unique codes (e.g., ENGL, ENG), and science courses include 20 unique codes (e.g., BIO, CHEM).	• Any time through PSY1 summer term, including while in high school

Measure	Description	Measurement time point(s)
Postsecondary GPA[a]	The cumulative GPA as defined by the postsecondary institution and recorded at the end of the reporting period. Postsecondary GPA values are reported by postsecondary institutions in the MLDS Center data files, not derived by AIR. Due to the timing of when postsecondary GPA data are reported (e.g., not all term coursework may be included), variation in institution-specific methodology in calculating GPA (e.g., scale range, incorporating binary pass/fail outcome), and the lack of transparency in course grade and course credit values included in the calculation, this measure is likely limited.	• PSY1 fall term (cumulative) • PSY1 spring term (cumulative)
Retention[b]	Whether a student remained continuously enrolled at their initial postsecondary pathway intuition.	• PSY1 fall to PSY1 spring • PSY1 fall to PSY1 spring to PSY2 fall
Persistence[b]	Whether a student remained continuously enrolled at any postsecondary institution after their initial postsecondary pathway institution. Given the less restrictive parameters of the persistence measure (i.e., students may transfer between institutions), persistence is more commonly observed than retention.	• PSY1 fall to PSY1 spring • PSY1 fall to PSY1 spring to PSY2 fall
Consistent employment and any earnings[c]	Whether a student is employed in three consecutive quarters within the first four quarters after HS graduation (summer, fall, winter, spring). We consider a student to be employed in a given quarter if they have an employment record that indicates any amount of employment in that three-month period.	• July after high school through the following June
Consistent employment and earning at least minimum wage[c]	Whether a student is employed and earns the equivalent of a minimum wage in three consecutive quarters within the first four quarters after HS graduation (summer, fall, winter, spring). The minimum wage equivalent is defined as the minimum wage in that quarter times 520 (the equivalent to working 40 hours per week for 12 weeks [4x12=520]). We use the minimum wage for each quarter based on the changes in minimum wage reported by the Maryland Department of Labor (MDOL, n.d.).	• July after high school through the following June
Consistent employment and earning at least living wage[c]	Whether a student is employed and earns the equivalent of a living wage in three consecutive quarters within the first four quarters after HS graduation (summer, fall, winter, spring). A living wage equivalent is defined as the living wage in that quarter times 520 (the equivalent to working 40 hours per week for 12 weeks [4x12=520]). The living wage for each quarter is based on the living wage required for employees of contractors and subcontractors in Tier 1 areas of the state. Beginning on September 28, 2022 the Tier 1 living wage was $15.13 per hour (MDOL, n.d.).	• July after high school through the following June

Note. PSY = postsecondary year.

[a] At the time of data collection for this study, credit accumulation and postsecondary GPA data were not available in the MLDS Center's source files for spring 2022. Therefore, for the 2021 cohort, values for these two measures of postsecondary progress are available only for students' first fall term (i.e., fall 2021).
[b] Given the additional time required to measure retention and persistence after the first year, outcomes at the second time point are not available for the Class of 2021 cohort. Enrollment data for the 2021–22 academic year were not available at the time data were collected for this study.
[c] We examine these workforce outcomes only for students in the "no college" postsecondary pathway group (i.e., those who did not attend college in the fall term after on-time high school graduation).

Exhibit I.3.2. Percentage of Students Who Met the Focal Postsecondary Progress Benchmarks, by Initial Postsecondary Pathway

	Earned Credits ≥ 12 (PSY1F)	Earned English Credits (PSY1)	Earned Math Credits (PSY1)	Earned Science Credits (PSY1)
Any MD institution of higher ed	64%	80%	66%	87%
MD community college	43%	73%	52%	80%
MD Public 4-year institution	85%	90%	83%	93%
MD state-aided independent	87%	n/a	n/a	n/a

Note. MD = Maryland; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester; n/a = not available.

Exhibit I.3.3. Percentage of Students Who Met the Focal Postsecondary Progress Benchmarks, by Student Characteristics

	Earned Credits ≥ 12 (PSY1F)	Earned English Credits (PSY1)	Earned Math Credits (PSY1)	Earned Science Credits (PSY1)
All students	64%	80%	66%	87%
Female students	67%	82%	67%	88%
Male students	61%	78%	66%	87%
Asian students	81%	91%	85%	94%
Black students	51%	75%	52%	82%
Hispanic students	53%	78%	61%	84%
White students	73%	83%	74%	89%
English learners (current)	39%	76%	57%	81%
English learners (recent exit)	63%	82%	71%	87%
Students with disabilities	28%	65%	37%	73%
FARMS-eligible students	49%	73%	53%	81%

Note. MD = Maryland; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester.

Exhibit I.3.4. Percentage of Students Who Met the Focal Postsecondary Progress Benchmarks, by Geographic Region

	Earned Credits ≥ 12 (PSY1F)	Earned English Credits (PSY1)	Earned Math Credits (PSY1)	Earned Science Credits (PSY1)
Anne Arundel County	62%	81%	63%	86%
Baltimore City	47%	71%	40%	76%
Baltimore County	61%	80%	60%	85%
Frederick County	72%	76%	81%	88%
Lower Shore Region	61%	72%	60%	78%
Mid Maryland Region	75%	84%	74%	92%
Montgomery County	66%	87%	77%	91%
Prince George's County	56%	76%	60%	86%
Southern Maryland Region	63%	76%	64%	88%
Susquehanna Region	66%	77%	71%	88%
Upper Shore Region	64%	79%	62%	86%
Western Maryland Region	71%	74%	62%	83%

Note. MD =Maryland; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester.

Exhibit I.3.5. Percentage of Students Who Met the Focal Postsecondary Progress Benchmarks, by Cohort

	Earned Credits ≥ 12 (PSY1F)	Earned English Credits (PSY1)	Earned Math Credits (PSY1)	Earned Science Credits (PSY1)
Class of 2017	62%	83%	65%	88%
Class of 2018	64%	83%	66%	88%
Class of 2019	64%	81%	68%	88%
Class of 2020	66%	79%	71%	87%
Class of 2021	65%	73%	62%	83%

Note. MD = Maryland; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester.

I.4. Specifications of the CCR Standard Tested in the Predictive Validity Analysis

To examine whether there are ways to improve the predictive validity of the interim CCR standard, we assessed the validity of the interim CCR standard and 13 alternative CCR standards. For each specification, we defined two version: one based on measures at the end of a student's second year of high school (HSY2) and another based on measures at the end of a student's fourth year of high school (HSY4). Each CCR standard specification is described in Exhibit I.4.1.

Exhibit I.4.1. Definition of Each CCR Standard Specification Tested in the Predictive Validity Analysis

Internal Index	Name	Description
0.1	Interim CCR standard*	Students are classified as college and career ready if they score in the met or exceeded expectations performance level on the English 10 state assessment (a score of at least 750 on the PARCC English 10 test) and score in the met or exceeded expectations performance level on the Algebra 1, or Algebra 2, or Geometry state assessment (a score of at least 750 on the PARCC test) or score at least 520 on the SAT math test.
0.2	Inclusive interim CCR standard*	Includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready (the approximate threshold for the approaching expectations performance level) instead of having to score at or above 750.
1.1	Interim or PSAT 1000	Students are classified as college and career ready if they meet the interim CCR standard or have a composite PSAT score ≥ 1000.
1.2	Inclusive or PSAT 430/480	Students are classified as college and career ready if they meet the inclusive interim CCR standard or have a reading PSAT score ≥ 430 and a math PSAT score ≥ 480.
2.1	Interim or HSGPA 3.00*	Students are classified as college and career ready if they meet the interim CCR standard or have an overall HSGPA ≥ 3.00.
2.2	Inclusive or HSGPA 3.00	Students are classified as college and career ready if they meet the inclusive interim CCR standard or have an overall HSGPA ≥ 3.00.
2.3	Inclusive and HSGPA 2.75*	Students are classified as college and career ready if they meet the inclusive interim CCR standard and have an overall HSGPA ≥ 2.75.
3.1	Interim or PSAT 1000 or HSGPA 3.00	Students are classified as college and career ready if they meet the interim CCR standard or have a composite PSAT score ≥ 1000 or have an overall HSGPA ≥ 3.00.
3.2	Inclusive or PSAT 1000 or HSGPA 3.00	Students are classified as college and career ready if they meet the inclusive interim CCR standard or have a composite PSAT score ≥ 1000 or have an overall HSGPA ≥ 3.00.

Internal Index	Name	Description
4.1	Interim or Adv. Course	Students are classified as college and career ready if they meet the interim CCR standard or pass at least 2 AP/IB courses or pass at least 3 CTE courses or are in a dual enrollment program.
4.2	Inclusive or Adv. Course	Students are classified as college and career ready if they meet the inclusive interim CCR standard or pass at least 2 AP/IB courses or pass at least 3 CTE courses or are in a dual enrollment program.
5.1	Interim or HSGPA 3.00 or Adv. Crs.	Students are classified as college and career ready if they meet the interim CCR standard or have an overall HSGPA ≥ 3.00 or pass at least 2 AP/IB courses or pass at least 3 CTE courses or are in a dual enrollment program.
5.2	Inclusive or HSGPA 3.00 or Adv. Crs.	Students are classified as college and career ready if they meet the inclusive interim CCR standard or have an overall HSGPA ≥ 3.00 or pass at least 2 AP/IB courses or pass at least 3 CTE courses or are in a dual enrollment program.
5.3	Interim or Inclusive and HSGPA 3.00 or Adv. Course	Students are classified as college and career ready if they meet the interim CCR standard or meet the inclusive interim CCR standard and have an overall HSGPA ≥ 2.75 or meet the inclusive interim CCR standard and pass at least 2 AP/IB courses or pass at least 3 CTE courses or are in a dual enrollment program.

Note. We use the internal index to organize and track the 14 different specifications for the CCR standard. HSGPA = high school grade point average.

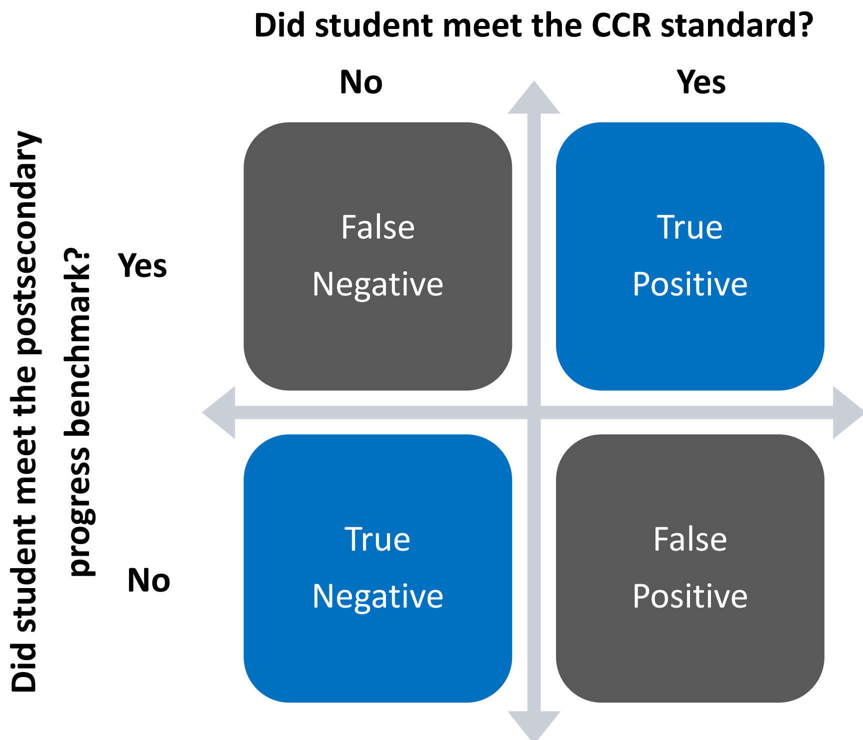
* Focal standard for the predictive validity analysis

I.5. Classification Accuracy Approach

We primarily used a classification approach to assess the predictive validity of the interim CCR standard and alternative specifications of the standard. Under this approach, we categorized students into one of four conditions (Exhibit I.5.1) based on whether they met the CCR standard by the end of HSY2 and whether they achieved postsecondary progress benchmarks:

- A **true positive (TP**) prediction is when the standard indicates a student is ready and the student did meet the postsecondary progress benchmark (i.e., the standard correctly predicted postsecondary progress).
- A **true negative (TN)** prediction is when the standard indicates that a student is not ready and the student did not meet the postsecondary progress benchmark (i.e., the standard correctly predicted a postsecondary delay).
- A **false positive (FP)** prediction is when the standard indicates that a student is ready, but the student did not meet the postsecondary progress benchmark (i.e., the standard incorrectly predicted postsecondary progress).
- A **false negative (FN)** prediction is when the standard indicates that a student is not ready, but the student did meet the postsecondary progress benchmark (i.e., the standard incorrectly predicted a postsecondary delay).

Exhibit I.5.1. The Classification Approach for a Dichotomous CCR Standard and a Dichotomous Postsecondary Progress Benchmark



The predictive validity metrics we focused on are summary statistics based on the four classification types:

- The **accuracy rate** is the probability of correctly identifying a student as ready or not ready to make postsecondary progress: $\frac{TP + TN}{TP + TN + FP + FN}$
- The **sensitivity rate** is the probability of correctly identifying students who are truly ready to make postsecondary progress: $\frac{TP}{TP + FN}$
- The **specificity rate** is the probability of correctly identifying students who are truly not ready to make postsecondary progress: $\frac{TN}{TN + FP}$

Appendix J. Exploratory Correlational Analysis between CCR Measures and Outcomes

J.1. Relationship Between CCR Measures and Postsecondary Progress

To gauge the extent to which the focal high school measures of CCR are predictive of postsecondary progress, we estimated the strength of the relationship (R^2) between each individual CCR measure and our primary measure of postsecondary progress: college credits awarded in the fall of the first postsecondary year. In this section, we focus on the following measures of CCR, both in isolation and in combination:

- PARCC English 10 score
- PARCC Algebra 1 score
- PSAT composite score (best score in the first two years of high school)
- High School GPA (at the end of the second year of high school)
- Dual Enrollment (whether or not a student passed one or more dual enrollment courses in the first four years of high school)
- Advanced Courses Passed (the number of AP or IB courses passed in the first four years of high school)
- CTE Courses Passed (the number of CTE courses passed in the first four years of high school)

To illustrate how the relationship between CCR measures and outcomes do or do not vary across groups of students, we present the R^2 values for (1) students separated by initial postsecondary pathway and (2) students from various demographic groups. The reported percentages represent the degree to which scores on one of the high school measures of CCR can predict performance on a measure of postsecondary progress, with higher values indicating a stronger relationship. To guide interpretation of the percentages, the following percentage ranges and corresponding descriptions can be used:

- < 10% is no meaningful relationship
- ≥ 10% and < 25% is a weak relationship
- ≥ 25% and < 50% is a moderate relationship
- ≥ 50% is a strong relationship

Exhibit J.1.1 presents the strength of the relationship between units awarded and each CCR measure in isolation, for all students and broken out by initial postsecondary pathway. Exhibit J.1.2 shows the same metrics, instead separating students into various demographic groups. In all cases, the reported R^2 comes from a linear regression with one independent/predictor variable using only students from the pathway or student group designated in that cell.

Overall, the results show HS GPA and PSAT Composite score to be the two readiness measures most predictive of PSY1 credits awarded. For every student group and pathway, one of these two measures explains the greatest amount of variation in credits awarded (i.e., has the largest R^2 value). Scores on the two PARCC tests provide the second highest predictive power of the explored CCR metrics. In a few cases, the number of advanced courses passed explains almost as much variation as one of the PARCC tests. However, these results suggest that for all student groups and pathways, all three of the CCR measures related to course taking (i.e., dual enrollment, advanced courses, or CTE) provide the least predictive power for college credits awarded.

Exhibit J.1.1. Strength of the Relationship Between High School Measures of College and Career Readiness and College Credits Awarded in First Postsecondary Semester, by Initial Postsecondary Pathway

	PARCC English 10	PARCC Algebra 1	PSAT composite	HSGPA overall	Dual enrollment	Advanced courses	CTE courses
Any MD college	26%	27%	36%	30%	5%	21%	0%
MD Community College	16%	15%	16%	21%	10%	7%	0%
MD Public 4-year Institution	24%	27%	39%	26%	2%	20%	0%
MD State-Aided Independent	15%	15%	19%	16%	5%	4%	0%

Note. HSGPA = high school grade point average; MD = Maryland; PARCC = Partnership for Assessment of Readiness for College and Careers. PSY1F = postsecondary first-year fall term. Percentages reported in the table represent the percentage of variation (R^2) in the number of college credits awarded during a student's fall semester after expected high school graduation associated with a particular high school measure of readiness at the end of the student's second year of high school. Lighter versus darker color shading in the exhibit distinguishes between lower versus higher percentages.

Exhibit J.1.2. Strength of Relationship Between High School Measures of College and Career Readiness and College Credits Awarded in First Postsecondary Semester, by Student Characteristics

	PARCC English 10	PARCC Algebra 1	PSAT composite	HSGPA overall	Dual enrollment	Advanced courses	CTE courses
All students	26%	27%	36%	30%	5%	21%	0%
Female students	25%	26%	34%	29%	5%	17%	1%
Male students	27%	29%	40%	32%	4%	26%	0%
Asian students	29%	34%	46%	29%	2%	25%	0%
Black students	18%	14%	19%	22%	8%	7%	0%
Hispanic students	21%	20%	26%	23%	7%	14%	0%
White students	23%	23%	32%	30%	4%	22%	0%
English learners (current)	10%	13%	13%	15%	2%	4%	1%
English learners (reclassified)	22%	26%	33%	24%	8%	16%	0%
Students with disabilities	18%	14%	19%	18%	4%	14%	0%
FARMS-eligible students	19%	17%	22%	23%	9%	9%	0%

Note. FARMS = free and reduced-price meal services; HSGPA = high school grade point average; PARCC = Partnership for Assessment of Readiness for College and Careers. Percentages reported in the table represent the percentage of variation (R^2) in the number of college credits awarded during a student's fall semester after expected high school graduation associated with a particular high school measure of readiness at the end of the student's second year of high school. Lighter versus darker color shading in the exhibit distinguishes between lower versus higher percentages.

J.2. Variability in High School GPA

HSGPA explains more than student demographics

The exploratory correlational analysis in Appendix J.1 suggests that the addition of HSGPA to the interim readiness metric provides the largest improvement in the strength of the relationship between high school and measures of postsecondary progress. Still, there may be concern that the improvement in the strength of relationship is driven by a correlation between HSGPA and student specific characteristics, such as race/ethnicity, low-income status, disability, or English learner status. While research has established a correlation between HSGPA and these student factors, there is reason to believe HSGPA does capture useful information about student performance and preparation, even when controlling for student factors (Easton et al., 2017; Brookhart et al., 2016). To illustrate this in the context of the Maryland high school students in our study, we present the coefficient on HSGPA for a series of regression models where we regress HSGPA against a series of postsecondary outcomes, first with, then without a collection of controls for student factors. These factors include gender, race, FARMS eligibility, and EL status. We use these factors to model the following postsecondary outcomes: PSY1F GPA, PSY1S GPA, PSY1F credits awarded, PSY1S credits awarded, and whether the student earned credits in a college-level English course, math course, or science course within PSY1.

The coefficients from these estimated equations are presented in Exhibit J.2.1. The first column shows the coefficients for models that include HSGPA as the only predictor of the postsecondary outcome. The last column shows the coefficients for models that include both HSGPA and the following student factors tested. If the relationships between HSGPA and postsecondary outcomes are driven mostly by the relationship between student characteristics and postsecondary outcomes, then the coefficients on HSGPA in the first column will be overestimated and the inclusion of student factors into the model will dramatically reduce the magnitude of the coefficient on HSGPA. Exhibit J.2.1 shows that across all models, both the coefficient on HSGPA changes very little and, in a few cases, remains essentially unchanged. Overall, this suggests that there is a meaningful relationship between HSGPA and postsecondary outcomes that captures something other than student characteristics such as race, gender, income, and English learning status.

Exhibit J.2.1. Effect of Student Characteristics on Coefficient on HSGPA

Postsecondary progress measure	Coefficient of HSGPA	
	Without controlling for student characteristics	Controlling for student characteristics
PSY1F GPA	0.95	0.90
PSY1S GPA	0.86	0.80
PSY1F Credits Awarded	10.41	9.66
PSY1S Credits Awarded	15.40	14.26
Passed postsecondary English	0.21	0.21
Passed postsecondary Math	0.37	0.34
Passed postsecondary Science	0.18	0.18

Note. Student characteristics include gender, race, FARMS eligibility, and ELL status. PSY1F = postsecondary year 1 fall term; PSY1S = postsecondary year 1 spring term.

Variability in HSGPA and the potential of grade inflation

One concern about HSGPA is that it is not a standardized measure like a state assessment: the underlying meaning (or construct validity) of HSGPA could differ across teachers, schools, LEAs, and time. As a result, the predictive validity of HSGPA could be better under some conditions than others. To examine this concern, we examined how the predictive power of HSGPA differed across cohorts, geographic regions, and schools. In addition, we looked at whether variability in the predictive power of HSGPA differed from the variability in the predictive power of state assessments.

For this analysis we focused on how well three high school measures (at the end of a student's second year of high school) predicted whether a student earned at least 12 credits during the first fall after expected on-time high school graduation (PSY1F):

- Overall HSGPA
- Score on the English 10 state test
- Score on the Algebra 1 state test

The analysis was restricted to students who attended a Maryland institution of higher education during PSY1F.

We used the following logistic regression model to estimate the relationship between a high school measure and earning at least 12 credits in PSY1F:

$$logit(Y) = \beta_0 + \beta_1 X + \boldsymbol{Z}'\boldsymbol{\beta_z} \, ,$$

where *Y* represents the binary indicator for whether a student earned at least 12 credits (*Y* = 1) or not (*Y* = 0), *X* represents a focal high school measures (HSGPA, English test score, or Algebra 1 test score), and $\boldsymbol{Z}'$ is a vector of student characteristics centered at the state mean. The student characteristics include student sex, race/ethnicity, English learner status, student with disability status, and FARM-eligible status. Each focal high school measure was converted to a z-score based on the statewide mean and standard deviation so that the magnitude of the estimated β_1 coefficient could be compared across measures. With this model, β_1 indicates how much the log-odds of earning at least 12 college credits changes when an average student in the state has an *X* value one standard deviation higher than the statewide average. Higher values indicate a stronger relationship between *X* and *Y*, controlling for student characteristics.

To examine how differences in the relationship between *X* and *Y* differ over time and geographic region, we estimated separate models for each student cohort and each geographic region.

To aid interpretation, we focus the presentation of results on how much the predicted probability of earning at least 12 college credits differs between a student with an *X* value one standard deviation below the mean and a student with an *X* value one standard deviation above the mean (controlling for student characteristics):

$$\Delta_{\text{pp}} = \frac{e^{\beta_0+\beta_1}}{1+e^{\beta_0+\beta_1}} - \frac{e^{\beta_0-\beta_1}}{1+e^{\beta_0-\beta_1}}$$

This metric can be interpreted as the percentage-point difference in the predicted probability between a student who is approximately at the 16th percentile versus the 84th percentile of *X*. A higher percentage-point difference indicates a stronger relationship between *X* and *Y* than a lower percentage-point difference.

To examine the extent to which the relationship between *X* and *Y* varies across schools, we estimated a multilevel logistic regression model that parallels the single-level model but allows β_0 and β_1 to vary across schools. For this model, the parameter of primary interest is the estimated between-school variance for β_1. Schools were defined as the high school a student attended at the end of their second year in high school.

How do relationships differ over time? Exhibit J.2.2 presents the results from the analysis that looks at how the relationships differ across student cohorts. Overall, the estimated relationships are similar across cohorts, suggesting that any notion of “grade inflation” for HSGPA has not had a meaningful effect on how well HSGPA predicts postsecondary progress. In addition, any changes across time in the predictive power of HSGPA are similar to changes in the predictive power of state test scores.

Exhibit J.2.2. Estimated Strength of the Relationship Between a High School Measure and Earning At Least 12 College Credits, by Cohort

Cohort	HSGPA			English 10 Test Score			Algebra 1 Test Score		
	β_1	SE(β_1)	Δ_{pp}	β_1	SE(β_1)	Δ_{pp}	β_1	SE(β_1)	Δ_{pp}
2017	1.395	0.022	54.0	0.966	0.019	37.3	1.006	0.020	44.6
2018	1.420	0.022	54.8	0.996	0.019	39.9	0.991	0.019	41.4
2019	1.427	0.023	56.6	1.150	0.022	47.3	1.004	0.021	40.1
2020	1.304	0.022	53.9	1.005	0.022	42.8	0.956	0.023	39.4
2021	1.184	0.021	50.1	0.972	0.022	42.9	0.990	0.024	41.9

How do relationships differ across geographic regions? Exhibit J.2.3 presents the results from the analysis that looks at how the relationships differ across geographic regions. Overall, the estimated relationships indicate that there is some meaningful variation in the predictive power of HSGPA across geographic regions. For example, the difference in the predicted probability between a high (+1 SD) and low (-1 SD) HSGPA student is 63.7 percentage points in Western Maryland and only 32.6 percentage points in Baltimore City. In addition, geographic variation in the predictive power of HSGPA is about twice as great as it is for the state assessments. This raises some concerns about the subjectivity of HSGPA and how it is operationalized across the state.

Exhibit J.2.3. Estimated Strength of the Relationship Between a High School Measure and Earning At Least 12 College Credits, by Geographic Region

Region	HSGPA			English 10 Test Score			Algebra 1 Test Score		
	β_1	SE(β_1)	Δ_{pp}	β_1	SE(β_1)	Δ_{pp}	β_1	SE(β_1)	Δ_{pp}
Anne Arundel County	1.408	0.033	58.7%	0.924	0.028	41.3%	1.008	0.031	45.0%
Baltimore City	0.860	0.032	32.6%	0.893	0.035	36.5%	0.780	0.036	32.8%
Baltimore County	1.462	0.028	54.7%	1.111	0.026	46.2%	1.089	0.028	43.0%
Frederick County	1.562	0.048	62.5%	1.109	0.042	44.9%	1.062	0.043	44.6%
Lower Shore Region	1.464	0.064	61.7%	1.062	0.060	46.6%	0.989	0.059	44.8%
Mid Maryland Region	1.472	0.031	51.7%	0.859	0.026	32.2%	0.910	0.028	36.6%
Montgomery County	1.489	0.025	60.3%	0.887	0.020	35.8%	1.037	0.022	41.8%
Prince George's County	1.206	0.024	49.9%	1.038	0.026	44.1%	1.051	0.027	42.9%
Southern Maryland Region	1.374	0.036	56.7%	0.838	0.032	37.2%	0.830	0.033	37.7%
Susquehanna Region	1.534	0.043	60.0%	1.103	0.040	47.2%	1.003	0.038	44.5%
Upper Shore Region	1.400	0.068	59.4%	0.884	0.055	39.1%	1.031	0.063	45.0%
Western Maryland Region	1.564	0.097	63.7%	0.989	0.049	39.0%	0.874	0.047	34.1%

Note. The MLDS Center defines Maryland regions, where larger LEAs constitute their own region (e.g., Baltimore County) and smaller LEAs are grouped into the following regions: Lower Shore (Somerset, Wicomico, and Worcester Counties), Mid Maryland (Carroll and Howard Counties), Southern Maryland (Calvert, Charles, and St. Mary's Counties), Susquehanna (Cecil and Harford Counties), Upper Shore (Caroline, Dorchester, Kent, Queen Anne's, and Talbot Counties), and Western Maryland (Allegany, Garrett, and Washington Counties). For the predictive validity analysis, students were assigned a region on the basis of the LEA they attended at the end of their second year of high school.

How do relationships differ across schools? To further investigate the extent to which the predictive power of HSGPA could differ across context, we estimated the amount of between-school variation in the relationship (τ_{β_1}). Exhibit J.2.4 presents the results from the multilevel logistic regression. The estimated between-school variance in the *X-Y* relationship (controlling for student characteristics) was about twice as large for HSGPA than the test score measures. This suggests that the predictive power of HSGPA differs across schools more than test scores and provides further evidence that the subjectivity of HSGPA may affect how well HSGPA will be as a predictor of college and career readiness in some schools.

Exhibit J.2.4. Between-School Variation in the Estimated Strength of the Relationship Between a High School Measure and Earning At Least 12 College Credits

High School Measure	β_1	SE(β_1)	τ_{β_1}	Δ_{pp} Low	Δ_{pp} Mean	Δ_{pp} High
HSGPA	1.404	0.020	0.054	49.4%	57.2%	64.2%
English 10 test score	0.971	0.016	0.027	34.6%	41.1%	47.2%
Algebra 1 test score	0.952	0.015	0.020	35.3%	40.8%	46.1%

Note. Δ_{pp} Low = percentage-point change for a school where the strength of the *X-Y* relationship is one standard deviation lower than the average school; Δ_{pp} Mean = percentage-point change for a school where the strength of the *X-Y* relationship is the same as the average school; Δ_{pp} High = percentage-point change for a school where the strength of the *X-Y* relationship is one standard deviation higher than the average school.

Appendix K. Results from Machine Learning Analyses

K.1. Machine Learning Approach

In addition to the classification analysis to assess how well specifications of the CCR standard predict measures of postsecondary progress, we also employed machine learning approaches, including random forest and classification and regression tree (CART) methods, to augment our primary findings. The measures of postsecondary progress we examined for these analyses were credit accumulation, postsecondary GPA, and passing a college-level English, math, or science course (see Appendix I.3).

We began this supplemental examination with a random forest analysis because random forest models are less likely to overfit the data than CART analyses and, therefore, results are more likely to be generalizable to out of sample predictions. We included in the random forest analysis the standard CCR measures (i.e., Grade 10 PARCC and SAT Math) and additional readiness indicators such as HSGPA, PSAT English and Math, advanced course/CTE course passing, and cumulative attendance (see Appendix I.2). Overall, we included 11 high school measures in the random forest analysis. We also included dummy indicators of missing data for each predictor to account for any associations with missingness.

We evaluated the random forest models primarily using variable importance to determine which variables best predict each postsecondary outcome. The variables with the highest variable importance scores were then used in CART analyses to determine what scores on the important predictors were most predictive of postsecondary success. Variable importance was defined in terms of a variable’s influence on overall accuracy (i.e., percentage of students correctly categorized as ready or not ready by the standard) and within-group similarity of subgroups created by splitting a variable at certain cut scores (i.e., also known as node purity, which is measured by the Gini index). We did not include student demographic characteristics or statuses (e.g., special education, English learner) in these models. Instead, these variables were used to determine if the alternative readiness indicator is biased for any subgroup of students (e.g., did accuracy rates differ for Hispanic students compared to for students overall?). Although the random forest approach is preferable for making predictions of postsecondary progress for students outside of our sample, the method does not provide the specific cut of values of the predictors that differentiate between levels of postsecondary progress, which is one of the main questions this study aimed to address.

The next step in the machine learning analyses was to take those variables that were most important in predicting the postsecondary progress benchmarks and include them in CART analyses to examine predictor cut scores. CART analyses are prone to overfitting the data, meaning that the resulting model fits the data from the students used in the analysis well, but it may not fit data for other students. To ensure the findings are generalizable, we limited the minimum size of the demographic groups of students so that predictor cut scores that produce small groups were omitted (i.e., pruning). This approach also ensured that the results align with the data suppression requirements of the MLDS. We split the data to a train-test (70% vs 30%) and estimated the model using the training data. Test data was used to evaluate the fit of the model on unseen data.

K.2. Machine Learning Results for Postsecondary Credits Earned

For the two postsecondary progress benchmarks we examined based on credits earned, the random forest models provided accuracy rates of 77% (at least 12 credits benchmark) and 75% (at least 15 credits benchmark). HSGPA was the primary variable that best predicted postsecondary credits earned, based on both model accuracy and node purity. Specifically, Exhibit K.2.1 shows that removing HSGPA from the random forest analyses resulted in substantially larger decreases in overall accuracy and the Gini index than any other variable included in the models. Further, an HSGPA cut point near 3.0 yields the greatest predictive power (see Exhibit K.2.2). Beyond HSGPA, other consistent but less strong predictors included PARCC English and math scores, and PSAT English and math scores. Of these additional predictors, PARCC English was the most important variable in terms of accuracy and node purity. Approximate cut points that yield the best predictive power are 750 for PARCC English and math for both credit thresholds, 450 for PSAT English and math for the 12-credit threshold, and 490 for PSAT English and math for the 15-credit threshold. In general, increasing the postsecondary criteria threshold (i.e., 12 credits earned vs. 15 credits earned) increased the cut scores for the predictors that yielded the highest predictive power. SAT Math scores, advanced course passing, CTE course passing, and cumulative attendance did not meaningfully increase the predictive power of the models, with the notable exception that cumulative attendance demonstrated relatively better predictive ability for postsecondary core course passing.

Exhibit K.2.1 Variable Importance Results for Random Forest Analysis of 12 and 15 Postsecondary Credits Earned

Predictor Variable	PSY1F Credits Awarded ≥ 12		PSY1F Credits Awarded ≥ 15	
	Accuracy Decrease	Gini Decrease	Accuracy Decrease	Gini Decrease
High School GPA	0.0708	5,137	0.0755	5,244
PARCC English 10 score	0.0232	2,846	0.0221	2,942
PSAT Reading score	0.0203	1,987	0.0221	2,334

Predictor Variable	PSY1F Credits Awarded ≥ 12		PSY1F Credits Awarded ≥ 15	
	Accuracy Decrease	Gini Decrease	Accuracy Decrease	Gini Decrease
PSAT Math score	0.0196	1,563	0.0253	2,157
PARCC Algebra 1 score	0.0129	1,992	0.0133	2,064
Advanced Courses Passed	0.0089	794	0.0091	1,077
Cumulative Attendance	0.0042	1,361	0.0039	1,300
SAT Math score	0.0011	77	0.0019	130
CTE Courses Passed	0.0005	165	0.0005	394

Exhibit K.2.2 Predictor Cut Scores for CART Analysis of 12 and 15 Postsecondary Credits Earned

Predictor Variable	PSY1F Credits Awarded ≥ 12		PSY1F Credits Awarded ≥ 15	
	Improvement	Cut Score	Improvement	Cut Score
High School GPA	7,153	2.97	7,888	3.21
PARCC English 10 score	5,288	751.5	6,162	762.5
PSAT Reading score	4,514	455.0	5,719	495.0
PSAT Math score	4,268	455.0	5,497	475.0
PARCC Algebra 1 score	4,132	744.5	5,029	753.5

K.3. Machine Learning Results for Postsecondary GPA

For the three postsecondary progress benchmarks we examined based on postsecondary GPA, the random forest models provided accuracy rates of 77% (at least a 2.0 GPA), 72% (at least a 2.5 GPA), and 70% (at least a 3.0 GPA). Results for postsecondary GPA were similar to those for postsecondary credits earned. Again, HSGPA was the strongest predictor of postsecondary GPA, based on both model accuracy and node purity. Notably, removing HSGPA from the random forest analyses resulted in substantially larger decreases in overall accuracy and the Gini index than any other variable included in the models (see Exhibit K.3.1). Similar to the results when predicting postsecondary credits earned, an HSGPA cut point near 3.0 yielded the greatest predictive power when predicting postsecondary GPA of 2.0 or greater (see Exhibit K.3.2). This HSGPA cut point increased to 3.12 and 3.27 as we increased the postsecondary success metric to a PSY1F GPA of 2.5 and 3.0, respectively. The other consistent but less strong predictors were PARCC English and math scores, and PSAT English and math scores, where again PARCC English was the most important variable in terms of accuracy and node purity. Approximate cut points that yielded the best predictive power were 750 for PARCC English and math for GPA thresholds, 450 for PSAT English and math for the 2.0 GPA threshold, 475 for PSAT English and math for the 2.5 GPA threshold, and 490 for PSAT English and math for the 3.0 GPA threshold. Finally, SAT Math scores, advanced course passing, CTE course passing, and cumulative attendance again did not meaningfully increase the predictive power of the models.

Exhibit K.3.1 Variable Importance Results for Random Forest Analysis of Postsecondary GPA of 2.0, 2.5, and 3.0

Predictor Variable	PSY1F GPA ≥ 2.0		PSY1F GPA ≥ 2.5		PSY1F GPA ≥ 3.0	
	Accuracy Decrease	Gini Decrease	Accuracy Decrease	Gini Decrease	Accuracy Decrease	Gini Decrease
High School GPA	0.0378	3,370	0.0768	4,800	0.0980	5,025
PSAT Reading score	0.0145	975	0.0138	1,252	0.0162	1,535
PSAT Math score	0.0127	841	0.0129	1,157	0.0136	1,190
PARCC English 10 score	0.0087	1,568	0.0154	2,080	0.0195	2,355
PARCC Algebra 1 score	0.0039	1,057	0.0053	1,395	0.0078	1,618
Advanced Courses Passed	0.0025	447	0.0052	602	0.0062	758
Cumulative Attendance	0.0022	1,050	0.0028	1,275	0.0028	1,347
SAT Math score	0.0010	48	0.0006	68	0.0005	88
CTE Courses Passed	0.0005	315	0.0005	385	0.0003	423

Exhibit K.3.2 Predictor Cut Scores for CART Analysis of Postsecondary GPA of 2.0, 2.5, and 3.0

Predictor Variable	PSY1F GPA ≥ 2.0		PSY1F GPA ≥ 2.5		PSY1F GPA ≥ 3.0	
	Improvement	Cut Score	Improvement	Cut Score	Improvement	Cut Score
High School GPA	3,588	3.08	5,478	3.12	6,151	3.27
PARCC English 10 score	1,949	754.5	3,043	760.5	3,633	773.5
PSAT Reading score	1,527	445.0	2,384	475.0	2,833	495.0
PARCC Algebra 1 score	1,445	741.5	2,207	753.5	2,612	753.5
PSAT Math score	1,362	455.0	2,154	475.0	2,544	485.0

K.4. Machine Learning Results for English, Math, and Science Courses

For the three postsecondary progress benchmarks we examined based on subject-specific credits earned (English, math, and science), the random forest models provided accuracy rates of 81% (English credits benchmark), 78% (math credits benchmark), and 87% (science credits benchmark). Results for passing core English, math, and science courses were generally similar to those for postsecondary credits awarded and postsecondary GPA. Again, HSGPA was the strongest predictor of passing English, math, and science courses based on both model accuracy and node purity. Specifically, removing HSGPA from the random forest analyses resulted in the largest decreases in overall accuracy and the Gini index (see Exhibit K.4.1). Also, like postsecondary credits earned, an HSGPA cut point near 3.0 yielded the greatest predictive power for each outcome (see Exhibit K.4.2). Random forest analyses showed that the other consistent but less strong predictors were PARCC English and math scores, and PSAT reading and math scores, where PSAT reading and math were more important variables in terms of accuracy and PARCC English and math were more important in terms of node purity. In addition, cumulative attendance showed relatively greater importance for predicting course passing outcomes in terms of node purity but did not substantially improve overall accuracy of predictions. However, it is important to note that although variable importance scores in terms of accuracy and node purity for passing math courses were comparable to importance scores for postsecondary credits earned and GPA outcomes, scores were lower for passing English and science courses. That is, Grade 10 variables were substantially less predictive of passing English and science courses than for other postsecondary outcomes. For the passing math outcome, approximate cut points in the CART analysis that yielded the best predictive power were approximately 750 for PARCC English and math, and approximately 460 for PSAT reading and math. However, a cut score of 425 for PSAT reading was the only other variable that when split yielded a meaningful improvement in prediction in the CART analysis for the passing core English course outcome, and no other variable meaningfully improved prediction for the passing core science course outcome beyond HSGPA. Finally, like the other postsecondary outcomes, SAT math scores, advanced course passing, CTE course passing, and cumulative attendance did not meaningfully increase the predictive power of the models.

Exhibit K.4.1 Variable Importance Results for Random Forest Analysis of Passing Postsecondary Core English, Math, Science Courses

Predictor Variable	Passed English		Passed Math		Passed Science	
	Accuracy Decrease	Gini Decrease	Accuracy Decrease	Gini Decrease	Accuracy Decrease	Gini Decrease
High School GPA	0.0202	1,690	0.0678	3,514	0.0091	673
PSAT Reading score	0.0142	567	0.0153	1,008	0.0128	291
PSAT Math score	0.0133	505	0.0222	1,314	0.0098	268
PARCC English 10 score	0.0055	804	0.0173	1,644	0.0037	369
PARCC Algebra 1 score	0.0032	601	0.0166	1,588	0.0023	334
Cumulative Attendance	0.0025	721	0.0042	968	0.0011	362
Advanced Courses Passed	0.0014	234	0.0058	512	0.0020	116
CTE Courses Passed	0.0005	199	0.0004	260	0.0006	114
SAT Math score	0.0004	25	0.0007	46	0.0008	18

Exhibit K.4.2 Predictor Cut Scores for CART Analysis of Passing Postsecondary Core English, Math, Science Courses

Predictor Variable	Passed English		Passed Math		Passed Science	
	Improvement	Cut Score	Improvement	Cut Score	Improvement	Cut Score
High School GPA	1,875	2.83	4,737	2.92	1,321	2.98
PSAT Reading score	750	425	2,846	465	--	--
PARCC English 10 score	--	--	2,928	752.5	--	--
PARCC Algebra 1 score	--	--	2,905	750.5	--	--
PSAT Math score	--	--	2,554	455	--	--

Note. Empty cells indicate that there were no splits on the predictor that yielded meaningful improvements in the predictive power of the CART model.

Appendix L. Results from the Supplemental Predictive Validity Analysis

In this section, we provide additional results from the predictive validity analysis, including: (1) detailed estimates of the accuracy, sensitivity, and specificity for the different CCR standards we tested; (2) results based on college GPA and additional credit accumulation benchmarks as measures of postsecondary progress; (3) results broken down by student cohort; (4) results based on college retention and persistence as the postsecondary progress benchmarks; (5) results for high school graduates; (6) results for students who did not attend college based on employment benchmarks; and (7) results for students who delayed college enrollment. In addition to Appendix L, we created a supplemental document that contains complete reporting on the percentages of students who met each of the different definitions of the CCR standard and postsecondary progress benchmarks examined for this study, along with the related predicative validity metrics between each high school CCR standard specification and postsecondary progress benchmark. All results are broken out by initial postsecondary pathway, student cohort, geographic region, and student characteristics.

L.1. Accuracy, Sensitivity, and Specificity Rates for All CCR Standards Tested and the Four Focal Postsecondary Benchmarks

This section provides estimates of the accuracy, sensitivity, and specificity rates for the interim CCR standard and the 13 alternative CCR standards examined for the predictive validity analysis. In addition, exhibits displaying the classification groups for the interim CCR standard and the focal alternative standards are provided to further help understand how well these standards predict the college course credit postsecondary benchmarks. Classification rates for specific student groups are also provided for the interim CCR standard and the alternative standard that includes the HSGPA option.

Relying solely on the accuracy rate masks some differences in performance between the interim CCR standard and the alternative standards. It is important to also consider the sensitivity rate (how well the standard correctly identifies students making progress) and the specificity rate (how well the standard correctly identifies students not making progress) to understand differences in predictive validity across alternative CCR standards. Ideally, a quality CCR standard should have both sensitivity and specificity rates of at least 70%.

Exhibit L.1.1. Accuracy, Sensitivity, and Specificity Rates for the Interim and Alternative CCR Standards (Postsecondary Progress Benchmark = Earned At Least 12 Credits)

CCR Standard	Accuracy	Sensitivity	Specificity
(HSY2) 0.1: Interim CCR standard	65%	54%	83%
(HSY2) 0.2: Inclusive Interim CCR standard*	71%	81%	53%
(HSY2) 1.1: Interim or PSAT 1000	68%	62%	79%
(HSY2) 1.2: Inclusive or PSAT 430/480	73%	84%	51%
(HSY2) 2.1: Interim or HSGPA 3.00*	75%	81%	64%
(HSY2) 2.2: Inclusive or HSGPA 3.00	74%	90%	44%
(HSY2) 2.3: Inclusive and HSGPA 2.75*	72%	71%	73%
(HSY2) 3.1: Interim or PSAT 1000 or HSGPA 3.00	75%	83%	62%
(HSY2) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	74%	91%	43%
(HSY2) 4.1: Interim or Adv. Crs.	69%	68%	70%
(HSY2) 4.2: Inclusive or Adv. Crs.	72%	86%	46%
(HSY2) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	74%	85%	55%
(HSY2) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	73%	92%	39%
(HSY2) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	73%	76%	65%
(HSY4) 0.1: Interim CCR standard	69%	63%	79%
(HSY4) 0.2: Inclusive interim CCR standard*	72%	85%	48%
(HSY4) 1.1: Interim or PSAT 1000	72%	71%	73%
(HSY4) 1.2: Inclusive or PSAT 430/480	73%	88%	45%
(HSY4) 2.1: Interim or HSGPA 3.00*	76%	87%	58%
(HSY4) 2.2: Inclusive or HSGPA 3.00	74%	93%	38%
(HSY4) 2.3: Inclusive and HSGPA 2.75*	74%	78%	69%
(HSY4) 3.1: Interim or PSAT 1000 or HSGPA 3.00	76%	88%	55%
(HSY4) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	73%	94%	36%
(HSY4) 4.1: Interim or Adv. Crs.	70%	92%	30%
(HSY4) 4.2: Inclusive or Adv. Crs.	69%	96%	20%
(HSY4) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	70%	96%	25%
(HSY4) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	69%	98%	17%
(HSY4) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	73%	84%	54%

Note. Student sample includes 117,819 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland institution of higher education the fall after expected

high school graduation (PSY1F). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; HSY# = high school year; Adv. Crs. = Advanced Courses.
* Focal standard for the predictive validity analysis.

Exhibit L.1.2. Accuracy, Sensitivity, and Specificity Rates for the Interim and Alternative CCR Standards (Postsecondary Progress Benchmark = Earned English Credits)

CCR Standard	Accuracy	Sensitivity	Specificity
(HSY2) 0.1: Interim CCR standard	47%	39%	81%
(HSY2) 0.2: Inclusive interim CCR standard*	66%	69%	52%
(HSY2) 1.1: Interim or PSAT 1000	52%	46%	77%
(HSY2) 1.2: Inclusive or PSAT 430/480	68%	73%	50%
(HSY2) 2.1: Interim or HSGPA 3.00*	67%	67%	67%
(HSY2) 2.2: Inclusive or HSGPA 3.00	73%	80%	46%
(HSY2) 2.3: Inclusive and HSGPA 2.75*	60%	56%	75%
(HSY2) 3.1: Interim or PSAT 1000 or HSGPA 3.00	68%	69%	64%
(HSY2) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	74%	81%	44%
(HSY2) 4.1: Interim or Adv. Crs.	57%	54%	69%
(HSY2) 4.2: Inclusive or Adv. Crs.	70%	76%	46%
(HSY2) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	70%	73%	58%
(HSY2) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	75%	84%	41%
(HSY2) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	63%	62%	66%
(HSY4) 0.1: Interim CCR standard	53%	47%	76%
(HSY4) 0.2: Inclusive interim CCR standard*	69%	74%	47%
(HSY4) 1.1: Interim or PSAT 1000	58%	55%	71%
(HSY4) 1.2: Inclusive or PSAT 430/480	71%	78%	44%
(HSY4) 2.1: Interim or HSGPA 3.00*	71%	73%	63%
(HSY4) 2.2: Inclusive or HSGPA 3.00	76%	85%	41%
(HSY4) 2.3: Inclusive and HSGPA 2.75*	65%	63%	73%
(HSY4) 3.1: Interim or PSAT 1000 or HSGPA 3.00	72%	76%	58%
(HSY4) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	77%	86%	38%
(HSY4) 4.1: Interim or Adv. Crs.	75%	86%	32%
(HSY4) 4.2: Inclusive or Adv. Crs.	78%	92%	21%
(HSY4) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	78%	91%	28%
(HSY4) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	79%	94%	19%

CCR Standard	Accuracy	Sensitivity	Specificity
(HSY4) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	68%	72%	54%

Note. Student sample includes 80,739 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college English course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; HSY# = high school year; Adv. Crs. = Advanced Courses.
* Focal standard for the predictive validity analysis.

Exhibit L.1.3. Accuracy, Sensitivity, and Specificity Rates for the Interim and Alternative CCR Standards (Postsecondary Progress Benchmark = Earned Math Credits)

CCR Standard	Accuracy	Sensitivity	Specificity
(HSY2) 0.1: Interim CCR standard	63%	53%	84%
(HSY2) 0.2: Inclusive interim CCR standard*	71%	80%	53%
(HSY2) 1.1: Interim or PSAT 1000	67%	61%	80%
(HSY2) 1.2: Inclusive or PSAT 430/480	73%	84%	51%
(HSY2) 2.1: Interim or HSGPA 3.00*	75%	81%	65%
(HSY2) 2.2: Inclusive or HSGPA 3.00	75%	90%	44%
(HSY2) 2.3: Inclusive and HSGPA 2.75*	71%	70%	74%
(HSY2) 3.1: Interim or PSAT 1000 or HSGPA 3.00	76%	82%	63%
(HSY2) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	75%	91%	43%
(HSY2) 4.1: Interim or Adv. Crs.	68%	67%	70%
(HSY2) 4.2: Inclusive or Adv. Crs.	72%	85%	45%
(HSY2) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	75%	85%	56%
(HSY2) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	74%	92%	38%
(HSY2) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	72%	75%	66%
(HSY4) 0.1: Interim CCR standard	68%	62%	80%
(HSY4) 0.2: Inclusive interim CCR standard*	72%	85%	48%
(HSY4) 1.1: Interim or PSAT 1000	72%	71%	74%
(HSY4) 1.2: Inclusive or PSAT 430/480	73%	88%	45%
(HSY4) 2.1: Interim or HSGPA 3.00*	77%	86%	59%
(HSY4) 2.2: Inclusive or HSGPA 3.00	75%	93%	38%
(HSY4) 2.3: Inclusive and HSGPA 2.75*	74%	77%	69%
(HSY4) 3.1: Interim or PSAT 1000 or HSGPA 3.00	77%	88%	56%
(HSY4) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	75%	94%	36%
(HSY4) 4.1: Interim or Adv. Crs.	71%	92%	29%
(HSY4) 4.2: Inclusive or Adv. Crs.	70%	96%	19%

CCR Standard	Accuracy	Sensitivity	Specificity
(HSY4) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	72%	96%	25%
(HSY4) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	71%	98%	17%
(HSY4) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	74%	84%	54%

Note. Student sample includes 80,017 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college math course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; HSY# = high school year; Adv. Crs. = Advanced Courses.
* Focal standard for the predictive validity analysis.

Exhibit L.1.4. Accuracy, Sensitivity, and Specificity Rates for the Interim and Alternative CCR Standards (Postsecondary Progress Benchmark = Earned Science Credits)

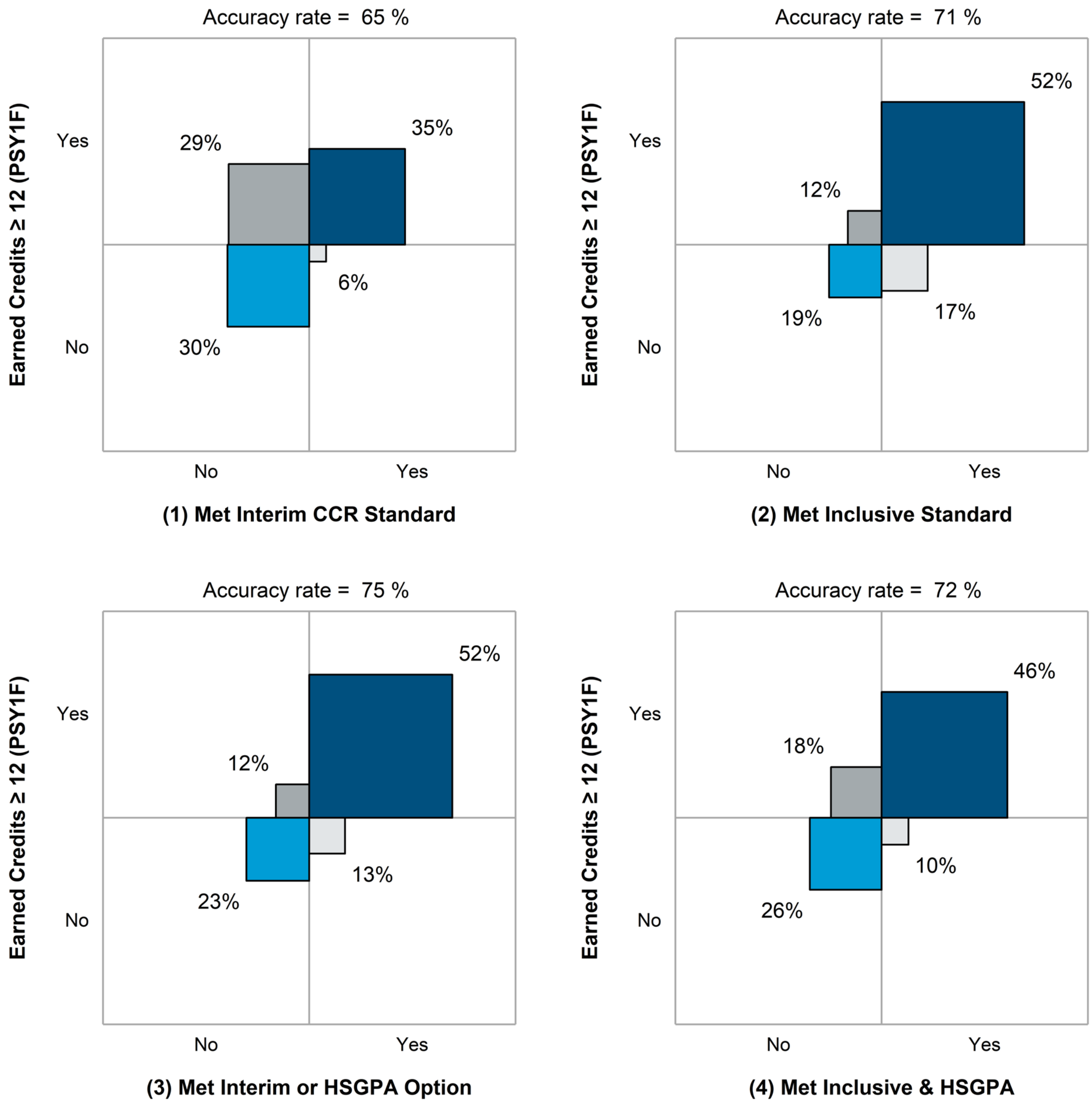
CCR Standard	Accuracy	Sensitivity	Specificity
(HSY2) 0.1: Interim CCR standard	57%	54%	75%
(HSY2) 0.2: Inclusive interim CCR standard*	75%	80%	41%
(HSY2) 1.1: Interim or PSAT 1000	63%	62%	69%
(HSY2) 1.2: Inclusive or PSAT 430/480	78%	84%	38%
(HSY2) 2.1: Interim or HSGPA 3.00*	77%	81%	52%
(HSY2) 2.2: Inclusive or HSGPA 3.00	82%	90%	32%
(HSY2) 2.3: Inclusive and HSGPA 2.75*	69%	70%	62%
(HSY2) 3.1: Interim or PSAT 1000 or HSGPA 3.00	78%	82%	49%
(HSY2) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	83%	91%	30%
(HSY2) 4.1: Interim or Adv. Crs.	67%	68%	60%
(HSY2) 4.2: Inclusive or Adv. Crs.	79%	85%	34%
(HSY2) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	79%	85%	43%
(HSY2) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	83%	92%	27%
(HSY2) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	73%	76%	53%
(HSY4) 0.1: Interim CCR standard	64%	63%	69%
(HSY4) 0.2: Inclusive interim CCR standard*	79%	85%	35%
(HSY4) 1.1: Interim or PSAT 1000	70%	71%	62%
(HSY4) 1.2: Inclusive or PSAT 430/480	81%	88%	32%
(HSY4) 2.1: Interim or HSGPA 3.00*	81%	86%	45%
(HSY4) 2.2: Inclusive or HSGPA 3.00	84%	93%	26%
(HSY4) 2.3: Inclusive and HSGPA 2.75*	74%	76%	57%
(HSY4) 3.1: Interim or PSAT 1000 or HSGPA 3.00	82%	88%	41%
(HSY4) 3.2: Inclusive or PSAT 1000 or HSGPA 3.00	85%	94%	24%

CCR Standard	Accuracy	Sensitivity	Specificity
(HSY4) 4.1: Interim or Adv. Crs.	83%	92%	22%
(HSY4) 4.2: Inclusive or Adv. Crs.	85%	96%	13%
(HSY4) 5.1: Interim or HSGPA 3.00 or Adv. Crs.	85%	95%	17%
(HSY4) 5.2: Inclusive or HSGPA 3.00 or Adv. Crs.	86%	97%	10%
(HSY4) 5.3: Interim or Inclusive and HSGPA 3.00 or Adv. Crs.	78%	83%	41%

Note. Student sample includes 48,035 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college science course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; HSY# = high school year; Adv. Crs. = Advanced Courses.

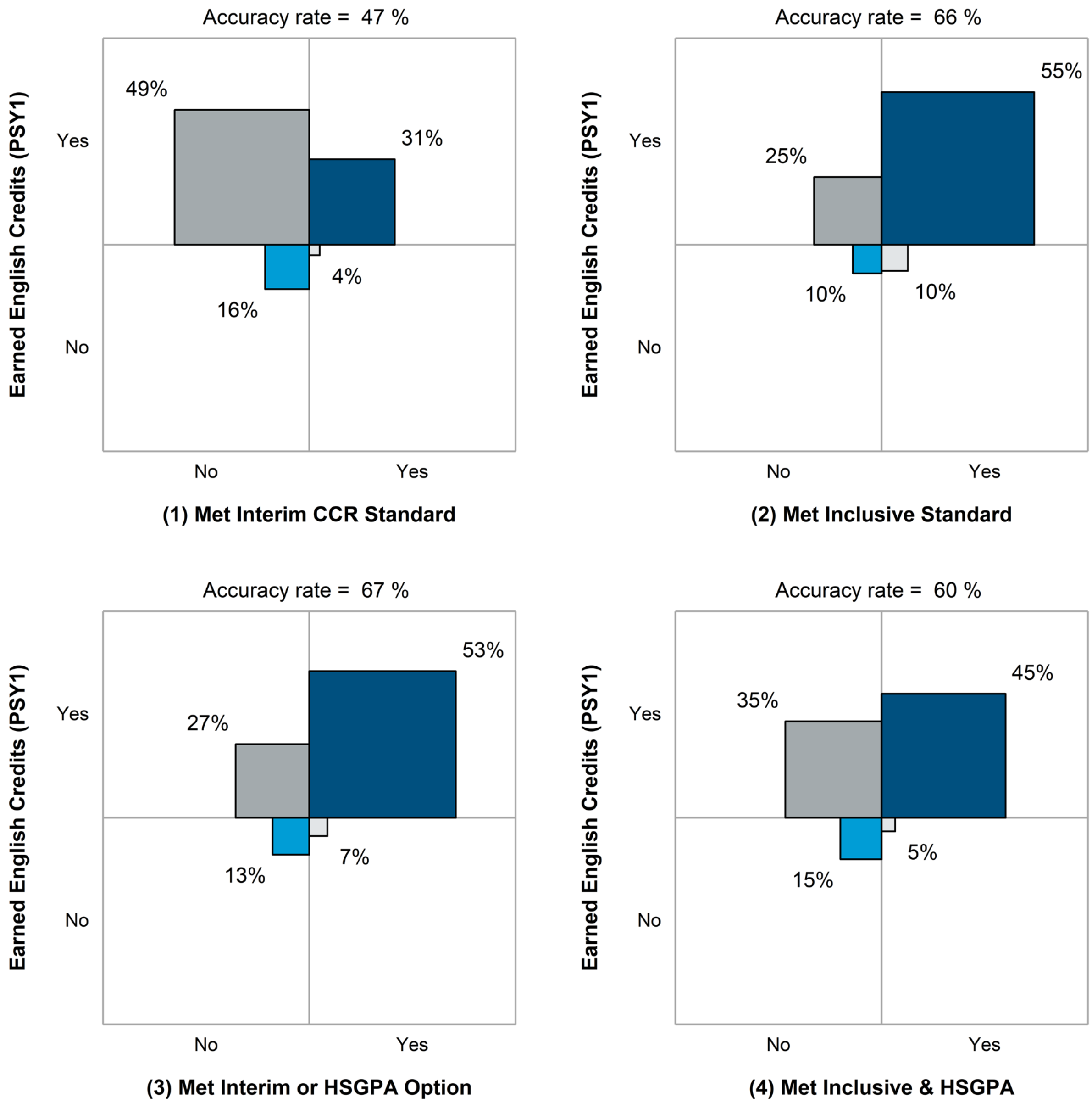
* Focal standard for the predictive validity analysis.

Exhibit L.1.5. Classification Groups for the Interim and Focal Alternative CCR Standards (Postsecondary Progress Benchmark = Earned At Least 12 Credits)



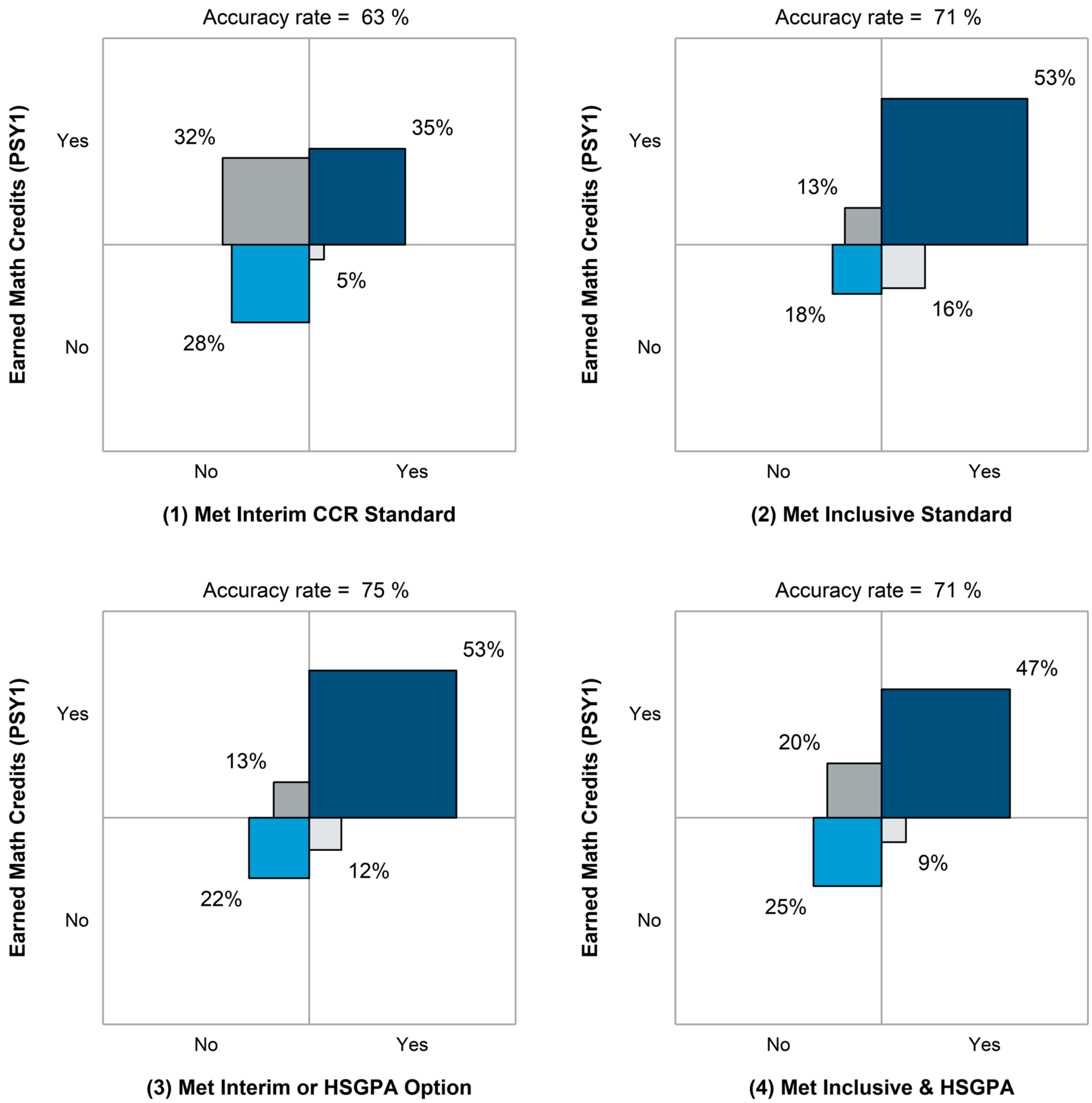
Note. Student sample includes 117,819 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland institution of higher education the fall after expected high school graduation (PSY1F). See Exhibit I.4.1. for definitions of each CCR standard.

Exhibit L.1.6. Classification Groups for the Interim and Focal Alternative CCR Standards (Postsecondary Progress Benchmark = Earned English Credits)



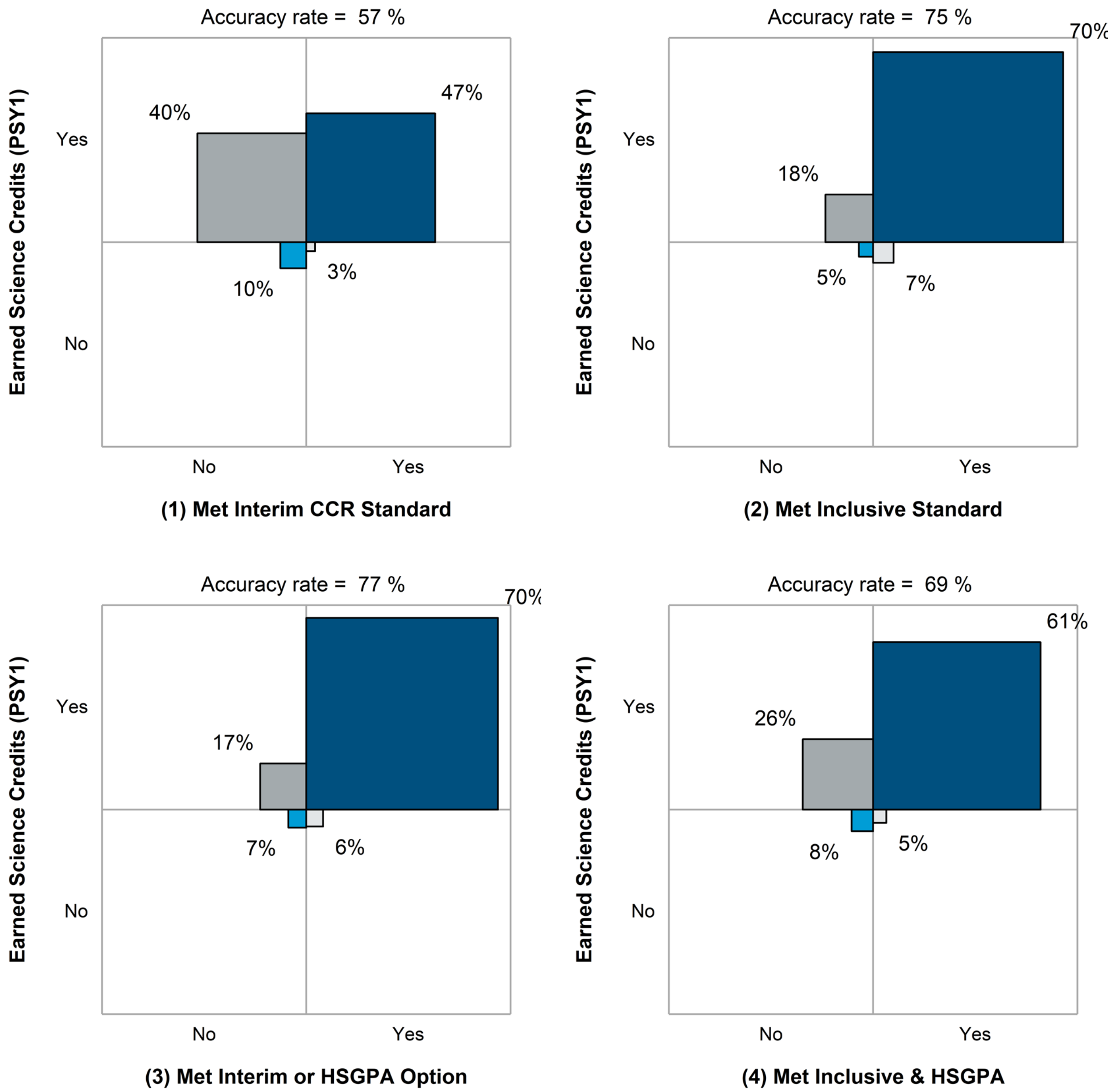
Note. Student sample includes 80,739 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college English course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard.

Exhibit L.1.7. Classification Groups for the Interim and Focal Alternative CCR Standards (Postsecondary Progress Benchmark = Earned Math Credits)



Note. Student sample includes 80,017 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college math course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard.

Exhibit L.1.8. Classification Groups for the Interim and Focal Alternative CCR Standards (Postsecondary Progress Benchmark = Earned Science Credits)



Note. Student sample includes 48,035 students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college science course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard.

Exhibit L.1.9. Classification Groups for the Interim CCR Standard and the Alternative with an HSGPA Option, by Initial Postsecondary Pathway and Student Characteristics (Postsecondary Progress Benchmark = Earned At Least 12 Credits)

Student Group		Classifications using the interim CCR standard				Classifications using the CCR standard with interim or HSGPA			
	N	TP	TN	FP	FN	TP	TN	FP	FN
All students	117,819	35%	30%	6%	29%	52%	23%	13%	12%
By initial postsecondary pathway									
MD community college	59,209	19%	48%	9%	25%	32%	38%	19%	12%
MD public 4-year institution	50,533	52%	11%	4%	33%	73%	8%	7%	12%
By student characteristic									
Female students	63,618	35%	28%	5%	32%	55%	21%	13%	12%
Male students	54,199	35%	32%	7%	26%	48%	26%	14%	13%
Asian students	13,201	55%	14%	5%	26%	75%	8%	11%	6%
Black students	37,232	15%	45%	4%	36%	32%	38%	11%	19%
Hispanic students	13,381	23%	41%	6%	30%	41%	29%	18%	12%
White students	49,007	47%	19%	8%	26%	63%	14%	13%	9%
Multiracial	4,583	40%	26%	7%	27%	55%	20%	14%	11%
English learners (current)	2,532	-	-	-	-	31%	34%	27%	8%
English learners (recent exit)	6,420	31%	31%	5%	33%	55%	19%	18%	9%
Students with disabilities	6,016	6%	69%	3%	22%	16%	55%	18%	11%
FARMS-eligible students	33,491	18%	45%	5%	32%	34%	36%	15%	15%

Note. Student sample includes students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland institution of higher education the fall after expected high school graduation (PSY1F). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; N = total number of students; TP = true-positive rate (correctly classified as college and career ready); TN = true-negative rate (correctly classified as not college and career ready); FP = false-positive rate (misclassified as college and career ready); FN = false-negative rate (misclassified as not college and career ready).

- Results are suppressed due to small sample size for at least one of the cells.

Exhibit L.1.10. Classification Groups for the Interim CCR Standard and the Alternative with an HSGPA Option, by Initial Postsecondary Pathway and Student Characteristics (Postsecondary Progress Benchmark = Earned English Credits)

Student Group		Classifications using the interim CCR standard				Classifications using the CCR standard with interim or HSGPA			
	N	TP	TN	FP	FN	TP	TN	FP	FN
All students	80,739	31%	16%	4%	49%	53%	13%	7%	27%
By initial postsecondary pathway									
MD community college	47,143	21%	22%	5%	52%	42%	19%	8%	31%
MD public 4-year institution	33,431	45%	7%	3%	45%	69%	5%	4%	21%
By student characteristic									
Female students	42,902	31%	15%	3%	52%	56%	12%	6%	26%
Male students	37,837	32%	18%	5%	46%	50%	15%	7%	28%
Asian students	8,283	49%	6%	3%	42%	76%	4%	6%	14%
Black students	28,223	15%	23%	2%	59%	36%	21%	5%	38%
Hispanic students	9,738	22%	18%	4%	56%	49%	14%	8%	29%
White students	31,117	43%	12%	6%	40%	64%	9%	8%	19%
Multiracial	3,090	36%	15%	5%	44%	57%	13%	7%	23%
English learners (current)	1,881	-	-	-	-	52%	15%	9%	25%
English learners (recent exit)	4,279	26%	14%	3%	56%	61%	10%	8%	21%
Students with disabilities	4,363	7%	34%	2%	58%	28%	29%	7%	36%
FARMS-eligible students	24,890	17%	23%	3%	56%	40%	20%	7%	34%

Note. Student sample includes students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college English course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; N = total number of students; TP = true-positive rate (correctly classified as college and career ready); TN = true-negative rate (correctly classified as not college and career ready); FP = false-positive rate (misclassified as college and career ready); FN = false-negative rate (misclassified as not college and career ready).

- Results are suppressed due to small sample size for at least one of the cells.

Exhibit L.1.11. Classification Groups for the Interim CCR Standard and the Alternative with an HSGPA Option, by Initial Postsecondary Pathway and Student Characteristics (Postsecondary Progress Benchmark = Earned Math Credits)

Student Group		Classifications using the interim CCR standard				Classifications using the CCR standard with interim or HSGPA			
	N	TP	TN	FP	FN	TP	TN	FP	FN
All students	82,017	35%	28%	5%	32%	53%	22%	12%	13%
By initial postsecondary pathway									
MD community college	43,131	21%	41%	7%	31%	38%	33%	15%	14%
MD public 4-year institution	38,686	50%	14%	4%	32%	71%	10%	8%	12%
By student characteristic									
Female students	43,013	33%	28%	5%	34%	55%	21%	12%	12%
Male students	39,003	36%	28%	6%	29%	52%	23%	11%	14%
Asian students	9,731	55%	11%	4%	30%	78%	7%	8%	8%
Black students	26,818	16%	44%	4%	36%	34%	37%	11%	18%
Hispanic students	9,125	25%	33%	5%	36%	46%	23%	15%	15%
White students	32,890	46%	19%	7%	27%	64%	14%	12%	10%
Multiracial	3,153	40%	26%	6%	28%	56%	20%	12%	11%
English learners (current)	1,664	-	-	-	-	45%	24%	19%	12%
English learners (recent exit)	4,491	32%	25%	4%	39%	60%	14%	15%	11%
Students with disabilities	3,701	7%	60%	2%	30%	23%	49%	14%	14%
FARMS-eligible students	23,457	18%	43%	5%	34%	37%	34%	13%	16%

Note. Student sample includes students who attended a Maryland public high school at the end of their second year of high school (HSY2) and enrolled in a Maryland community college or public 4-year institution the fall after expected high school graduation (PSY1F) and enrolled in a college English course during their first year of college (PSY1). See Exhibit I.4.1. for definitions of each CCR standard. CCR = college and career ready; N = total number of students; TP = true-positive rate (correctly classified as college and career ready); TN = true-negative rate (correctly classified as not college and career ready); FP = false-positive rate (misclassified as college and career ready); FN = false-negative rate (misclassified as not college and career ready).

- Results are suppressed due to small sample size for at least one of the cells.

L.2. Results for Postsecondary GPA and Additional Credit Accumulation Benchmarks

Analytic approach

In addition to the primary focal measures of postsecondary progress included in the main report—earning at least 12 college credits in the fall of the first postsecondary year (PSY1F) and subject course passing in the first postsecondary year (PSY1)—we conducted supplemental predictive validity analyses testing alternative postsecondary outcomes. Using the same primary analytic sample of Grade 10 students on a Maryland college pathway in the fall term after expected on-time high school graduation, we first examined college GPA as an additional measure of postsecondary progress.

We used students' cumulative GPA in PSY1F as defined and reported by their postsecondary institution to the MLDS Center; AIR did not derive this measure. Due to the timing of when college GPA data are reported (e.g., not all term coursework may be included), variation in institution-specific grading policy (e.g., no grades assigned in the first semester) and methodology in calculating GPA (e.g., scale range), and the lack of transparency in course grade and course credit values included in the calculation, this measure of college GPA may be limited in its validity and comparability across students and pathways.

For college GPA, which is measured on a continuous scale, we selected benchmarks of a cumulative GPA of 2.0, 2.5, and 3.0 to develop binary indicators of whether students met these benchmarks. We started with a 2.0 GPA benchmark because students are typically required to maintain at least a 2.0 GPA to meet Satisfactory Academic Progress requirements to remain eligible to receive federal financial aid. We considered more stringent GPA benchmarks up to 3.0 (B average) because many of the related studies of CCR used a 3.0 college GPA as a marker for postsecondary success.

Second, we examined additional credit accumulation benchmarks including earning at least 15 credits in PSY1F and 24 and 30 credits in PSY1S. We used 15 and 30 credits for fall and spring terms, respectively, as an alternative to the 12 and 24 credit benchmarks because they correspond with the average number of credits a student typically must earn per term to obtain an associate's degree in 2 years (60 credits in 4 semesters) or a bachelor's degree in 4 years (120 credits in eight semesters). Credits for the spring term represent the cumulative number of credits for the entire first year, not just the spring term.

Findings

Despite the known limitations of the college GPA measure, results for this outcome mirror the results of the primary analysis. The accuracy rates presented in Exhibit L.2.1 show that accuracy rates are higher for alternative standards and accuracy rates are highest for standards with the HSGPA option. Accuracy rates for alternative specifications of the CCR standards tested are higher for students enrolled at Maryland 4-year institutions compared to those enrolled at community colleges.

In contrast to predictive validity results using college GPA as the outcome, accuracy rates for predicting students' meeting different credit accumulation benchmarks (Exhibit L.2.2) are not uniformly improved when using alternative standards that include the HSGPA option, and results vary by initial postsecondary pathway. Including the HSGPA option improves accuracy rates among the lower credit benchmarks tested (i.e., 12 and 24 college credits in the fall and spring terms, respectively), but only for students on the Maryland public 4-year postsecondary pathway. Using alternative standards that include the HSGPA option does not substantively improve predictive accuracy for meeting credit accumulation benchmarks for students on the Maryland community college pathway.

Exhibit L.2.1 Accuracy Rates for Each CCR Standard Predicting First-Year College GPA, by Postsecondary Benchmark and Initial Postsecondary Pathway

Students in Any MD Institution of Higher Ed	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
College GPA ≥ 2.0 (PSY1F)	56%	69%	72%	66%
College GPA ≥ 2.5 (PSY1F)	61%	67%	71%	68%
College GPA ≥ 3.0 (PSY1F)	64%	61%	67%	66%

Students in MD Community College	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
College GPA ≥ 2.0 (PSY1F)	51%	62%	64%	60%
College GPA ≥ 2.5 (PSY1F)	58%	61%	66%	64%
College GPA ≥ 3.0 (PSY1F)	63%	57%	64%	65%

Students in MD Public 4-Year Institution	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
College GPA ≥ 2.0 (PSY1F)	62%	77%	79%	73%
College GPA ≥ 2.5 (PSY1F)	64%	73%	77%	72%
College GPA ≥ 3.0 (PSY1F)	65%	65%	69%	67%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light grey), between 70% and 75% (light blue), and ≥ 75% (darker blue). CCR = college and career ready; MD = Maryland; PSY1F = postsecondary year 1 fall semester.

Exhibit L.2.2. Accuracy Rates for Each CCR Standard Predicting Total College Credits Earned, by Postsecondary Benchmark and Initial Postsecondary Pathway

Students in Any MD Institution of Higher Ed	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Earned Credits ≥ 12 (PSY1F)	65%	71%	75%	72%
Earned Credits ≥ 15 (PSY1F)	70%	65%	70%	70%
Earned Credits ≥ 24 (PSY1S)	65%	71%	75%	72%
Earned Credits ≥ 30 (PSY1S)	71%	64%	69%	70%

Students in MD Community College	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Earned Credits ≥ 12 (PSY1F)	67%	64%	69%	69%
Earned Credits ≥ 15 (PSY1F)	72%	58%	65%	69%
Earned Credits ≥ 24 (PSY1S)	68%	65%	69%	70%
Earned Credits ≥ 30 (PSY1S)	74%	57%	63%	68%

Students in MD Public 4-Year Institution	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Earned Credits ≥ 12 (PSY1F)	64%	78%	81%	75%
Earned Credits ≥ 15 (PSY1F)	68%	72%	76%	72%
Earned Credits ≥ 24 (PSY1S)	64%	78%	82%	75%
Earned Credits ≥ 30 (PSY1S)	69%	71%	75%	73%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to be classified as college and career ready. Students can meet Standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light gray), between 70% and 75% (light blue), and ≥ 75% (darker blue). CCR = college and career ready; MD = Maryland; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester; PSY1S = postsecondary year 1 spring semester.

L.3. Results Separated by Student Cohort

This appendix section shows how results from our primary predictive validity analysis presented in the main report vary by student cohort, as defined by their expected year of high school graduation at the end of Grade 10.

Exhibit L.3.1. Percentage of Students Who Met the Alternative CCR Standards at the end of Grade 10, by Student Cohort

	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Class of 2017	26%	46%	44%	34%
Class of 2018	28%	48%	46%	36%
Class of 2019	30%	51%	49%	40%
Class of 2020	31%	54%	51%	42%
Class of 2021	34%	60%	53%	45%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. CCR = college and career ready.

Exhibit L.3.2. Average Accuracy Rate for Each CCR Standard Across Postsecondary Benchmarks for First-Year College Credits Earned, by Student Cohort

	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Class of 2017	55%	68%	71%	65%
Class of 2018	57%	70%	73%	67%
Class of 2019	58%	72%	74%	69%
Class of 2020	58%	72%	75%	70%
Class of 2021	62%	71%	74%	71%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light grey), between 70% and 75% (light blue), and ≥ 75% (darker blue). CCR = college and career ready.

L.4. Results for Retention and Persistence Benchmarks

Analytic approach

Our focal measures of postsecondary progress included credits awarded and subject course passing. To test whether results from the primary analysis would change if we used alternative measures of postsecondary progress, we replicated the predictive validity analysis using retention and persistence as outcomes. Retention is operationalized as continuous enrollment at *the same postsecondary institution* as a student's initial postsecondary pathway (i.e., the fall-enrolled college or university after expected on-time high school graduation). Persistence is more broadly operationalized to include continuous enrollment at *any postsecondary institution*. Given the less restrictive parameters of this outcome (i.e., students may transfer between postsecondary institutions[15]), persistence rates are necessarily higher than retention

[15] For example, persistence would include students who "vertical transfer" from a 2-year to a 4-year college in their first year and, conversely, those who "reverse transfer" from a 4-year to a 2-year college.

rates.[16] Because retention and persistence measures are based solely on enrollment records and do not require course-level data, these measures include a larger portion of the Grade 10 (HSY2) student sample, including those who attend a non-Maryland college. Exhibit L.4.1 provides a breakdown of the student characteristics for this retention and persistence sample, which includes students who enrolled at an out-of-state 4-year institution in addition to the primary analytic sample of students enrolled at a Maryland institution of higher education.

Retention and persistence can provide a more comprehensive view of students' progress through the broader higher education system, which often includes transferring between postsecondary institutions (e.g., moving from a community college to a 4-year university, initially enrolling at an out-of-state university but returning to Maryland after one semester). In addition, these measures may serve as more meaningful measures of postsecondary progress (i.e., continued enrollment regardless of number of credits earned) for students unable to enroll full-time due to work and family obligations, particularly community college students.

Exhibit L.4.1. Student Characteristics for the Retention and Persistence Sample

Student characteristic	Retention and persistence sample
Total number of students (% of Grade 10 Sample)	169,839 (53%)
Sex/gender (%)	
Female	55%
Male	45%
Race/ethnicity (%)[a]	
Asian	10%
Black/African American	30%
Hispanic/Latinx	10%
White	46%
Multiracial	4%
Percentage English learners, current[b]	2%
Percentage English learners, recent exit[b]	5%
Percentage students with disabilities	5%
Percentage FARMS eligible	25%

Note. Student characteristics were defined based on a student's status as of the end of their HSY2. The retention and persistence analysis does not include students who attended a 2-year non-Maryland college because less than 1% of students had this as their initial postsecondary pathway. FARMS = free and reduced-price meals services; HSY = high school year.

[a] Less than 1% of students were classified as American Indian, Alaska Native, Native Hawaiian, or Pacific Islander.

[16] Fewer than 400 students were reported as attaining a postsecondary credential, typically a certificate, within their first year of postsecondary enrollment. This small share of students is coded as both retained and persisted given that continuous enrollment is no longer necessary after initial attainment is achieved.

[b] For the purposes of our analysis, students were considered a current English learner if they were classified as an English learner at the end of their HSY2. English learners were considered a recent exit if they were reclassified within 2 years prior to the end of their HSY2.

Findings

The accuracy rates presented in Exhibit L.4.2 mirror the results from the primary analysis: accuracy rates are higher for alternative standards, particularly the alternative specification that includes the HSGPA ≥ 3.0 option in addition to meeting the interim standard's test score benchmarks. Accuracy rates are highest and comparable for students who attend a Maryland public 4-year institution and a non-Maryland (i.e., out-of-state) 4-year institution. In contrast, accuracy rates are relatively low for students who attend a Maryland community college across all CCR specifications tested, though including HSGPA does improve predictive accuracy for students on this pathway.

Exhibit L.4.2. Accuracy Rates for Each CCR Standard Predicting College Persistence and Retention, by Postsecondary Benchmark and Initial Postsecondary Pathway

Students in MD Community College	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Persistence: PSY1F to PSY1S	40%	59%	57%	50%
Retention: PSY1F to PSY1S	41%	58%	56%	50%
Persistence: PSY1F to PSY2F	48%	59%	60%	56%
Retention: PSY1F to PSY2F	51%	57%	59%	56%

Students in MD Public 4-Year Institution	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Persistence: PSY1F to PSY1S	57%	79%	80%	72%
Retention: PSY1F to PSY1S	58%	78%	79%	72%
Persistence: PSY1F to PSY2F	59%	77%	80%	72%
Retention: PSY1F to PSY2F	60%	74%	77%	70%

Students in MD State-Aided Independent	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Persistence: PSY1F to PSY1S	49%	76%	77%	67%
Retention: PSY1F to PSY1S	50%	74%	76%	67%
Persistence: PSY1F to PSY2F	50%	73%	75%	67%
Retention: PSY1F to PSY2F	54%	69%	72%	65%

Students in Non-MD 4-Year Institution	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Persistence: PSY1F to PSY1S	60%	79%	82%	73%
Retention: PSY1F to PSY1S	60%	77%	80%	72%
Persistence: PSY1F to PSY2F	59%	76%	80%	71%
Retention: PSY1F to PSY2F	61%	72%	76%	69%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light grey), between 70% and 75% (light blue), and ≥ 75% (darker blue). CCR = college and career ready; MD = Maryland; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester; PSY1S = postsecondary year 1 spring semester; PSY2F = postsecondary year 2 fall semester.

L.5. Results for High School Graduates

Analytic approach

Our primary analysis is based on all students in a Maryland public high school at the end of their second year of high school, regardless of whether they ended up graduating from high school on time. To determine whether results from the primary analysis would change if we included only on-time high school graduates in the study, we replicated the predictive validity analysis for students who graduated from high school within four years. About 85% of our primary student sample graduated from high school within four years. Exhibit L.5.1 provides a breakdown of the student characteristics for this high school graduate sample.

Exhibit L.5.1. Student Characteristics for the High School Graduate Sample

Student characteristic	High school graduate sample
Total number of students (% of Grade 10 Sample)	272,012 (85%)
Sex/gender (%)	
Female	51%
Male	49%
Race/ethnicity (%)[a]	
Asian	7%
Black/African American	33%
Hispanic/Latinx	14%
White	42%
Multiracial	4%
Percentage English learners, current[b]	4%
Percentage English learners, recent exit[b]	5%
Percentage students with disabilities	8%
Percentage FARMS eligible	34%

Note. Student characteristics were defined based on a student's status as of the end of their HSY2. FARMS = free and reduced-price meals services; HSY = high school year.

[a] Less than 1% of students were classified as American Indian, Alaska Native, Native Hawaiian, or Pacific Islander.

[b] For the purposes of our analysis, students were considered a current English learner if they were classified as an English learner at the end of their HSY2. English learners were considered a recent exit if they were reclassified within 2 years prior to the end of their HSY2.

Findings

For the high school graduate sample, we calculated accuracy rates based on (1) CCR standards defined at the end of HSY2 and (2) CCR standards defined at the end of HSY4. The accuracy rates are presented in Exhibit L.5.2. Results mirror the results from the primary analysis: accuracy rates are higher for alternative standards and accuracy rates were highest for standard with HSGPA option. In addition, results are similar whether defining the standard at the end of HSY2 or HSY4.

Exhibit L.5.2. Accuracy Rates for Each CCR Standard Predicting First-Year College Credits Earned for Students with On-Time High School Graduation, by Postsecondary Benchmark

HS Graduates CCR Standard Defined at HSY2	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Earned Credits ≥ 12 (PSY1F)	65%	71%	75%	72%
Earned English Credits (PSY1)	47%	66%	67%	60%
Earned Math Credits (PSY1)	63%	71%	75%	71%
Earned Science Credits (PSY1)	57%	75%	77%	69%

HS Graduates CCR Standard Defined at HSY4	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Earned Credits ≥ 12 (PSY1F)	69%	72%	76%	74%
Earned English Credits (PSY1)	53%	69%	71%	65%
Earned Math Credits (PSY1)	68%	73%	77%	74%
Earned Science Credits (PSY1)	64%	79%	81%	74%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light grey), between 70% and 75% (light blue), and ≥ 75% (darker blue). CCR = college and career ready; HSY = high school year; PSY1 = postsecondary year 1; PSY1F = postsecondary year 1 fall semester.

L.6. Results for Students Who did not Attend College

Analytic approach

To assess the relationship between career readiness metrics and career success outcomes, we limited our analysis to the population of Maryland high school graduates that do not attend college in the fall term after expected on-time high school graduation (i.e., "no enrollment" pathway). To identify success in the career pathway, we rely on Maryland's Quarterly Census of Employment and Wages (QCEW). These data provide information on earnings in each fiscal quarter for all employed workers in the state of Maryland, excluding self-employed workers, military servicemembers, railroad workers, elected officials, religious organization workers, and agricultural workers where the cash wages are less than $20,000 or the operation has fewer than 10 employees (MDOL, n.d.). These data also do not cover employment of Maryland residents who are employed in another state, such as Pennsylvania, Virginia, or the District of Columbia. In each quarter, workers have one record per employer for whom they worked in that quarter. Because of these limitations, MLDS refers to this measure as “wage visibility” instead of employment (MLDSC, n.d.). We use the term employment here for simplicity.

Our primary measure of workforce success is operationalized as being employed for three consecutive quarters in the 12 months following expected on-time high school graduation (i.e., summer/fall/winter or fall/winter/spring). We consider a student to be employed in a given quarter if they have an employment record that indicates any amount of employment in that three-month period, even if they earn only one dollar. Because the employment data used for these analyses do not include hours worked, we are unable to impose a minimum number of hours worked as part of the definition of employed. We also note that the data exclude cases where people are self-employed, in the military, or employed in a state other than Maryland. Of the students in our sample who did not attend college, 37% were employed for at least three consecutive quarters in the year after high school.

Our second measure of success in the workforce is earning an income greater than or equal to working a full-time job at Maryland’s minimum wage threshold for three consecutive quarters. Specifically, we define earning an equivalent to a minimum wage income in a given quarter if someone’s recorded earnings for that quarter equal or exceed the minimum wage in that quarter times 520 (the equivalent to working 40 hours per week for 12 weeks [4x12=520]). We use the minimum wage for each quarter based on the changes in minimum wage reported by the Maryland Department of Labor (MDOL, n.d.). In cases where someone worked all four quarters after high school graduation (i.e., summer, fall, winter, and spring), we consider them as having earned the minimum wage if they earned the equivalent to the minimum wage in any three consecutive quarters in the first four quarters following high school graduation. Because this measurement of earnings relies on being employed for three consecutive quarters, those who achieve this measure of success will be a subset of those who achieve our primary measure of being employed for three consecutive quarters. Of the students in our sample who did not attend college, 6% earned the equivalent of a minimum wage for at least three consecutive quarters in the year after high school.

Our third measure of success in the workforce is earning an income greater than or equal to working a full-time job at Maryland’s living wage threshold for three consecutive quarters. Specifically, we define earning an equivalent to a living wage income in a given quarter if someone’s recorded earnings for that quarter equal or exceed the living wage in that quarter times 520 (the equivalent to working 40 hours per week for 12 weeks [4x12=520]). The living]wage for each quarter is based on the living wage required for employees of contractors and subcontractors in Tier 1 areas of the state. Beginning on September 28, 2022, the Tier 1 living wage was $15.13 per hour (MDOL, n.d.). This living wage was then applied retroactively to previous quarters, adjusting for inflation using the BLS Inflation Calculator (BLS, n.d.). In cases where someone worked all four quarters after high school graduation (i.e., summer, fall, winter, and spring), we consider them as having earned a living wage if they earned the equivalent to the living wage in any three consecutive quarters in the first four quarters following high school graduation. Because this measurement of earnings relies on being employed for three consecutive quarters, those who achieve this measure of success will be a subset of those who achieve our primary measure of being employed for three consecutive quarters. Of the students in our sample who did not attend college, 3% earned the equivalent of a minimum wage for at least three consecutive quarters in the year after high school.

We also considered engagement in apprenticeships and completion of non-credit certifications as potential markers of success in the workforce. Data on apprenticeship participation came from the Maryland Apprenticeship Program and include information on start and end date of apprenticeships. However, evaluation of these data suggested that end date information was incomplete for many of the cases, making it difficult to assess how long the individual engaged in the apprenticeship. Information on non-credit certifications came from the Noncredit Workforce Completer System. These data cover students who “successfully completed a course or series of courses that qualifies students for identifiable occupations or that provides a comprehensive body of knowledge leading to career advancement” (MHEC, 2020). However, data are available only for students in our cohorts of 2020 and 2021 high school graduates. In all cases, apprenticeships and non-credit certifications were held by less than 0.5% of non-college going high school graduates from the cohorts where data were available. Moreover, of those with an apprenticeship or certification in their first year after on-time high school graduation, over half also achieved success in the workforce based on our metric of three consecutive quarters of employment. Given these limitations, we elected not to include apprenticeships or non-credit certifications as workforce outcomes for the non-college-going sample.

Exhibit L.6.1. Student Characteristics for the Workforce (No College Enrollment) Sample

Student characteristic	Workforce sample
Total number of students (% of Grade 10 Sample)	146,756 (46%)
Sex/gender (%)	
Female	42%
Male	58%
Race/ethnicity (%)[a]	
Asian	3%
Black/African American	38%
Hispanic/Latinx	23%
White	33%
Multiracial	4%
Percentage English learners, current[b]	12%
Percentage English learners, recent exit[b]	4%
Percentage students with disabilities	17%
Percentage FARMS eligible	53%

Note. Student characteristics were defined based on a student's status as of the end of their HSY2. FARMS = free and reduced-price meals services; HSY = high school year.

[a] Less than 1% of students were classified as American Indian, Alaska Native, Native Hawaiian, or Pacific Islander.

[b] For the purposes of our analysis, students were considered a current English learner if they were classified as an English learner at the end of their HSY2. English learners were considered a recent exit if they were reclassified within 2 years prior to the end of their HSY2.

Findings

Unlike the results from our primary analysis, results for employment and earnings-related outcomes differ because accuracy rates are higher for the interim standard than the alternative standards tested. Because so few students meet the employment benchmarks, one should be cautious to not over interpret the accuracy rate findings. A more stringent standard will tend to have higher accuracy rates than a less stringent standard when few students meet the employment benchmarks.

Exhibit L.6.2. Accuracy Rates for Each CCR Standard Predicting First-Year Employment for Students Who Did Not Enroll in Postsecondary Education in Fall After Expected High School Graduation, by Postsecondary Benchmark

Students in the No College Initial Pathway	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Consistent employment: Any earnings (PSY1)	60%	58%	55%	59%
Consistent employment: at least minimum wage (PSY1)	84%	69%	73%	81%
Consistent employment: at least living wage (PSY1)	86%	70%	74%	82%

Note. Consistent employment is defined as at least three consecutive quarters of employment in the first four quarters after high school graduation. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light grey), between 70% and 75% (light blue), and ≥ 75% (darker blue). PSY1 = postsecondary year 1.

L.7. Results for Students who Delayed College Enrollment

Analytic approach

Among students in the Grade 10 (HSY2) sample who enrolled in college at any time within two years of expected on-time high school graduation (N = 190,819), 90% did so in the fall term after four years of high school, which is our primary college-going sample and defined by initial postsecondary pathways. In this appendix section, we extend our primary analysis by examining the subset of students who delayed their postsecondary enrollment by either one semester (i.e., PSY1S entrant) or by one year (i.e., PSY2F entrant), which includes approximately 14,300 delayed collegegoers or 7% of the total college-going sample.

For the delayed college enrollment sample, we examined credits earned and cumulative GPA as measures of postsecondary progress, which are readily available in MLDS Center enrollment records for students attending a Maryland college or university affiliated with the Maryland Higher Education Commission. For each postsecondary progress measure, we specified multiple benchmarks, including earning at least 12 or 15 credits in the first term and a college GPA of at least 2.0, 2.5, or 3.0 in the first term. Given that delayed collegegoers enrolled in either PSY1S or PSY2F, the timing of outcome measurement is not uniform and instead reflects students' first term of enrollment.[17]

Exhibit L.7.1. Student Characteristics for the Delayed College Enrollment Sample

Student characteristic	Delayed college enrollment sample
Total number of students (% of Grade 10 Sample)	9,601 (3%)
Sex/gender (%)	
Female	51%
Male	49%
Race/ethnicity (%)[a]	
Asian	5%
Black/African American	37%
Hispanic/Latinx	19%
White	34%
Multiracial	4%
Percentage English learners, current[b]	5%
Percentage English learners, recent exit[b]	4%
Percentage students with disabilities	10%
Percentage FARMS eligible	44%

Note. Student characteristics were defined based on a student's status as of the end of their HSY2. FARMS = free and reduced-price meals services; HSY = high school year.

[a] Less than 1% of students were classified as American Indian, Alaska Native, Native Hawaiian, or Pacific Islander.

[b] For the purposes of our analysis, students were considered a current English learner if they were classified as an English learner at the end of their HSY2. English learners were considered a recent exit if they were reclassified within 2 years prior to the end of their HSY2.

Findings

Accuracy rates for the delayed-college group (Exhibit L.7.2) are not consistent with primary analysis results. For example, when looking at credit accumulation outcomes, the accuracy rates are not improved by adding HSGPA into the interim CCR standard. And rates are lower when using a more inclusive threshold on the state assessments (i.e., score of 725 instead of 750), also in contrast to our main findings. When looking at subject course passing outcomes, alternative CCR standards that add an HSGPA option improved accuracy rates only modestly,

[17] Among the delayed college enrollment sample (N = 14,254), 57% first enrolled in PSY1S and 43% in PSY2F.

yet all CCR standards tested yielded relatively low accuracy rates. Given that delayed collegegoers reflect only a small portion of total college enrollees (7%), it may be unsurprising that their CCR measures do not appear to align with measures of postsecondary progress in the same ways as the vast majority of collegegoers (90%) who enroll in the fall term immediately following high school.

Exhibit L.7.2. Accuracy Rates for Each CCR Standard Predicting First-Term College Credits Earned and GPA for Students who Delayed College Enrollment, by Postsecondary Benchmark

Students with Delayed Enrollment in Any MD Institution of Higher Ed	(1) Interim Standard	(2) Inclusive Standard	(3) Interim or HSGPA	(4) Inclusive & HSGPA
Earned Credits ≥ 12	72%	64%	70%	73%
Earned Credits ≥ 15	76%	63%	69%	75%
College GPA ≥ 2.0	51%	58%	60%	57%
College GPA ≥ 2.5	60%	60%	64%	64%
College GPA ≥ 3.0	65%	59%	65%	67%

Note. Standard 1 is the interim CCR standard where students must score at or above 750 on the state assessments. Standard 2 includes the same measures as the interim CCR standard but students can score at or above 725 on the state assessments to get classified as college and career ready. Students can meet standard 3 based on the interim CCR standard or with an overall high school grade point average (HSGPA) ≥ 3.0. Standard 4 requires students to meet the 725 version of the interim CCR standard and have an HSGPA ≥ 2.75. Color shading in the exhibit distinguishes between rates < 70% (light grey), between 70% and 75% (light blue), and ≥ 75% (darker blue). Students in the analytic sample delayed college enrollment by either one term (spring entrant) or by one year (second year fall entrant); therefore, the timing of outcome measurement is not uniform and instead reflects students' first term of enrollment. CCR = college and career ready; MD = Maryland.

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