California Diploma Project Technical Report I: Crosswalk Study

Crosswalk of the Intersegmental Committee for the Academic Senate Statements of Competencies to the Common Core State Standards

Prepared for
Policy Analysis for California Education (PACE)
by the
Educational Policy Improvement Center (EPIC) and WestEd

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Introduction

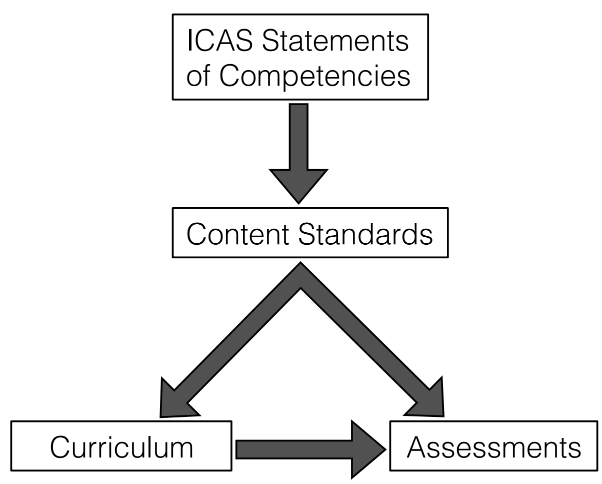
The Educational Policy Improvement Center (EPIC) conducted an investigation of the Intersegmental Committee for the Academic Senates (ICAS) Statements of Competencies for Mathematics and Academic Literacy. The purpose of this work is to understand how the ICAS competencies relate to college and career readiness, as represented by the augmented Common Core State Standards (CCSS) adopted by the California State Board of Education (SBE) on August 2, 2010. This study investigated a crosswalk analysis between (a) the Academic Literacy (ELA) ICAS competencies and the CCSS ELA Anchor Standards and (b) the mathematics ICAS competencies and the CCSS Standards for Mathematical Practice and the High School Mathematics Standards at the cluster level.

The ICAS competencies and the augmented CCSS were created for different purposes, but both represent the knowledge and skills that students need to be successful in entry-level college coursework. The stated goal of the ICAS competencies is to provide a clear and coherent message about what students need to know and be able to do in order to be successful in college. The ICAS competencies represent the expectations faculty members from California's system of higher education have for the critical reading, writing, thinking abilities, and mathematical ability of their entering students in order to be successful.[1,2]

The purpose of the CCSS is to provide a consistent and clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills needed for success in college and careers. The belief is, if American students are fully prepared for the future, the country will be best positioned to compete successfully in the global economy.[3]

In addition, the ICAS competency statements and the augmented CCSS differ by the source and methodology used to develop the standards. The development of the ICAS competencies is based on faculty responses from the University of California, the California State University, and the California Community College systems. For the CCSS, the Council of Chief State School Officers (CCSSO) and the National Governors Association (NGA) worked with representatives from participating states, a wide range of educators, content experts, researchers, national organizations, and community groups to develop the standards. ICAS competencies seek to advise California high school students and their families what kind of intellectual preparation is necessary for success in California higher education, no matter which segment a student may elect to attend. The ICAS represent competencies identified by faculty for students to be successful in public institutions of higher education in California, and the CCSS represent standards identified by a national group of educational stakeholders for students to be college and career ready.

Figure 1. Role of Competencies and Content Standards in the Education System



According to an article defining the characteristics of educational competencies, "What distinguishes a

[1]Intersegmental Committee of the Academic Senates of the California Community Colleges, the California State University, and the University of California. (2002). *Academic Literacy: Statement of Competencies Expected of Students Entering California's Public Colleges and Universities.* Retrieved from http://icas-ca.org/competencies

[2]Intersegmental Committee of the Academic Senates of the California Community Colleges, the California State University, and the University of California. (2010). *Statement of Competencies in Mathematics Expected of Entering College Students*. Retrieved from http://icas-ca.org/competencies

[3]Common Core State Standards Initiative. (2011). Mission Statement. Retrieved from http://www.corestandards.org/

competency from a goal or objective is that it focuses on the end-product of the instructional process, rather than on the instructional process itself, or that it embraces the larger picture rather than the content of a single course…Competencies are used to set performance standards that must be met."[4] As previously stated, the CCSS provide a grade-specific (or grade-span) understanding of what students are expected to learn to be ready for postsecondary success. As demonstrated in Figure 1, the ICAS represent the objectives of the educational process, and the CCSS represent the math and literacy content standards.

For this investigation, a crosswalk methodology was used. A crosswalk is a means to examine relationships by arraying two sets of statements orthogonally in a matrix format and then examining the intersection of each element of each statement in a unique cell. The relationship represented by that cell is then coded based on a categorization system designed to produce insight into how two sets of statements interact with one another. The two types of statements analyzed were statements of competencies (ICAS) and content standards (CCSS). The coding scale used for the examination of the ICAS competencies and the CCSS included codes that explicitly reference a content relationship (described in Table 5).

Overall, the study finds that the ICAS competencies do relate to the augmented Common Core State Standards. This study also reveals the absence of certain "habits of mind" and English as a Second Language (ESL) standards in the CCSS ELA standards, and the absence of discrete mathematics and calculus in the augmented CCSS mathematics standards. The ICAS framework is broader than the CCSS ELA standards in addressing additional components related to supporting ESL students and includes key cognitive strategies all students need to be successful in postsecondary settings. The results of this study also raise the issue of the level of desired preparation in mathematics for high school graduates in California. The CCSS mathematics standards strongly relate to the ICAS competencies identified as *essential* for all students, but have gaps with the ICAS competencies deemed *desirable* for all students.

[4] Albanese, M., Mejicano, G., Mullan, P., Kokotailo, P., & Gruppen, L. (2008) Defining characteristics of educational competencies. *Medical Education* 2008, 42(3): 248–255.

Methodology

The investigation was a crosswalk between (a) the Academic Literacy ICAS competencies and the augmented CCSS English Language Arts Anchor Standards and (b) the Mathematics ICAS competencies and the Standards for Mathematical Practice and the high school cluster level CCSS. The augmented CCSS describe both content and performance expectations that students need to meet in order to be prepared to succeed beyond high school. The ICAS competencies are, by definition, a statement of the expectations that college faculty in California have for the critical reading, writing, thinking, and mathematical abilities necessary for their entering students to possess in order to be successful. Therefore, the crosswalk yields insight into the ways in which the augmented CCSS can support and enhance learning and retention of the ICAS by a wide range of students.

The ICAS competencies for Academic Literacy are organized into two levels, and the second level (the competencies) were reviewed in this study. The ICAS competencies for Mathematics are organized into four levels, and the fourth level (competency level) was used. The CCSS for ELA and literacy are organized into five levels: strands, topics, anchor standards, grade-level/span standards, and substandards. The CCSS for mathematics are organized into five levels: conceptual categories, domains, clusters, standards, and substandards. The CCSS also stipulates Standards for Mathematical Practice that are used in every grade and conceptual category.

For this study, the augmented CCSS English Language Arts Anchor Standards were selected as the level of analysis (i.e., grain size) to examine the relationship with the Academic Literacy ICAS competencies. In mathematics, both the CCSS Standards for Mathematical Practice and the high school mathematics standards at the cluster level were selected. The augmented CCSS were selected to be analyzed at these leve[5]ls to provide a comparable level of detail to the ICAS (see Tables 1–4). For example, the individual mathematics CCSS at the lowest granularity consist primarily of distinct topical areas of mathematics and specific techniques, concepts, and algorithms associated with each area. The Standards for Mathematical Practice, however, identify the cognitive domains that are expected to be taught and mastered at all grade levels, which represent a more comparable level of specificity to the ICAS. Thus, this crosswalk is able to reveal the nature of the relationship between the ICAS and the critical college and career readiness standards driving the CCSS. For clarification, because of the level of standards (grain size) chosen for this study, the augmentations to the CCSS adopted by the SBE did not affect any of the ELA anchor standards used—they are identical with the original CCSS. In one instance, a mathematics cluster level was added and therefore was also used in the study (Graph polar coordinates and curves). Also important to note is that the augmented version of the math CCSS includes Advanced Placement Probability and Statistics and Calculus Standards, but these were not written in the same structure or format as the rest of the CCSS and were therefore not included in this study.

Table 1. Categories and Number of ICAS Competencies Rated

Academic Literacy Competency	Number of Statements
Habits of Mind	27
Reading/Writing Connection[a]	9
Reading	31
Writing	26
Listening and Speaking	15
Listening and Speaking for ESL Students	4
Technology	19
Total	131

Table 2. Common Core Categories and Number of Anchor Standards Rated

ELA Anchor Standard	Number of Statements
Reading	10
Writing	10
Speaking and Listening	6
Language	6
Total	32

[a] Within the ICAS competencies for Academic Literacy, 9 competency statements are duplicated in the Reading/Writing Connection and Reading sections. Consistent with the organization of the ICAS, each duplicated competency was rated twice, once for each section.

Table 3. Categories and Number of ICAS Competencies Rated

Mathematics Competency	Number of Statements
Dispositions towards Mathematics	8
Aspects of Instruction	8
Subject Matter Essential for All Students	6
Subject Matter Desirable for All Students	4
Subject Matter Essential for Quantitative Majors	4
Subject Matter Desirable for Quantitative Majors	5
Mathematical Skills	12
Total	**47**

Table 4. Common Core Categories and Number of Cluster Headings Rated

Mathematics Standards	Number of Statements
Mathematical Practices	8
Number and Quantity	9
Algebra	11
Functions	10
Geometry	16
Statistics and Probability	9
Total	**63**

For the investigation, each relationship "intersection" was coded into one of five potential categories (see Table 5). The categories suggest the intensity and depth of the connection between each ICAS competency and each CCSS included in the crosswalk. The categories consider degree of alignment, whether the ICAS builds upon and is enhanced by the CCSS, and the degree to which the CCSS is a necessary or important factor in teaching the ICAS. Because every intersection between every competency and every standard was reviewed, a high percentage of no matches would be expected. What is of interest is the frequency and intensity of the matches within each competency.

This crosswalk methodology and the scale selected had intentional directionality, examining the content of the CCSS that is required by the ICAS, but not the inverse. This enabled the analysis to explore the relationship of the CCSS in preparing students to master the ICAS competencies. The use of a partial match code without specifying the exact elements that do or do not match does not clarify the specific aspects of a standard or competency that are only partially aligned. To address these limitations, further studies employing a multidirectional and annotated coding system could more deeply specify the relationship between the CCSS and the ICAS competencies.

For this study, the crosswalks between the CCSS and the ICAS competencies were conducted by two postsecondary content experts (one each in ELA and Mathematics) who have significant experience working with the CCSS and with standards statements in general. Both were trained in the use of the crosswalk rating scale and in the content and intended usage of the ICAS competencies. The Mathematics expert rated the ICAS Mathematics Competencies to CCSS Mathematics Standards matches, while the ELA expert rated the ICAS Academic Literacy to CCSS ELA Anchor Standards, using the scale and decision criteria described in Table 5. For better understanding of the relationships represented in the scale, see examples of actual standards coded at each point on the scale in Tables 6 and 7.

Table 5. Crosswalk Codes

Code	Description	Definition	Decision Criterion
ACR (Aligned)	Aligned Content Relationship	There is a direct alignment between the CCSS statement and the ICAS; mastery of the ICAS requires the CCSS.	Content matter in the CCSS is stated in the same or equivalent terms in the ICAS.
PACR (Partial)	Partially Aligned Content Relationship	There is a partial direct match between the CCSS and the ICAS; mastery of the ICAS requires the CCSS, but the CCSS alone is not sufficient for mastery of the ICAS.	Content matter in the ICAS is, as part of a larger description, included in the same or equivalent terms in the CCSS or stated in a way that is related to the CCSS (but not exactly the same).
PCR (Prerequisite)	Prerequisite Content Relationship	Mastery on the ICAS does not require the CCSS, although possessing the CCSS is expected to significantly increase mastery of the ICAS.	It is clear that the content required by the CCSS would precede the content required by the ICAS, based on the general learning progression of the subject area.
CTLR (Consistent)	Consistent Teaching/ Learning Relationship	The CCSS would be expected to be found when the ICAS was taught or learned.	This relationship would be expected to exist in the majority of instances in which this ICAS was taught.
ITLR (Inconsistent)	Inconsistent Teaching/ Learning Relationship	The CCSS may or may not be expected to be found when the ICAS was taught or learned.	This relationship would be expected to be found in less than a majority of instances in which this ICAS was taught.

Table 6. ELA Examples of Coded Matches

Scale	Common Core ELA and Literacy Standard	Academic Literacy ICAS Competency
ACR (Aligned)	Read and comprehend complex literary and informational texts independently and proficiently.	read texts of complexity without instruction and guidance
ACR (Aligned)	Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.	decipher the meaning of vocabulary from the context
PACR (Partial)	Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.	identify key ideas of speakers in lectures or discussion, identifying the evidence which supports, confutes, or contradicts the thesis
PACR (Partial)	Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.	edit or proofread to eliminate errors in grammar, mechanics, and spelling, using standard English conventions
PCR (Prerequisite)	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	synthesize information from reading and incorporate it into a writing assignment
PCR (Prerequisite)	Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.	synthesize information from assigned reading

CTLR (Consistent)	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.	sustain and support arguments with evidence
CTLR (Consistent)	Draw evidence from literary or informational texts to support analysis, reflection, and research.	prepare and ask provocative questions
ITLR (Inconsistent)	Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.	read a variety of texts, including news articles, textbooks, essays, research of others, Internet resources
ITLR (Inconsistent)	Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.	read skeptically

Table 7. Mathematics Examples of Coded Matches

Scale	Common Core Mathematics Standard/Math Practice	Math ICAS Competency
ACR (Aligned)	Make sense of problems and persevere in solving them.	Solving Problems
PACR (Partial)	Attend to precision.	Becoming Fluent in Mathematics
PCR (Prerequisite)	Understand solving equations as a process of reasoning and explain the reasoning	Developing Analytic Ability and Logic
CTLR (Consistent)	Construct viable arguments and critique the reasoning of others.	Experiencing Mathematics in Depth
ITLR (Inconsistent)	Model with mathematics.	Communicating

English Language Arts Results

Results from the English/Language Arts crosswalk show that whereas few standards are directly aligned (ACR [Aligned] column in Table 8), 120 of the 131 ICAS academic literacy competencies (92 %) were reviewed as having some relationship (at least one match) with the Common Core State Standards. This includes standards rated with the first four categories of the scale: Aligned Content Relationship (ACR), Partially Aligned Content Relationship (PACR), Prerequisite Content Relationship (PCR), or Consistent Teaching/Learning Relationship (CTLR). The distribution of responses in each of these categories is represented in Figure 2. Frequency of matches ranged from 1–29 per competency statement.

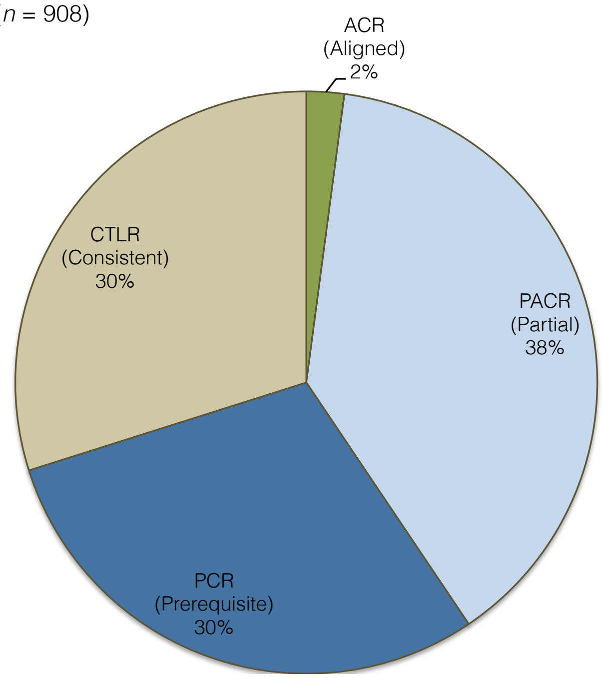
Table 8. Crosswalk Analysis of Academic Literacy Competencies and ELA Anchor Standards

ICAS Academic Literacy Competency	% ACR	% PACR	% PCR	% CTLR	% ITLR
Habits of Mind	0.1	6.0	7.3	10.1	76.5
Reading/Writing Connection	0.7	13.9	22.6	4.2	58.7
Reading	1.0	15.7	14.0	2.1	67.1
Writing	0.6	7.9	0.1	11.3	80.0
Listening and Speaking	0.0	4.1	0.0	2.5	93.4
Listening and Speaking for ESL Students	0.0	0.0	0.0	3.1	96.9
Technology	0.2	3.1	0.0	6.9	89.8

ACR = Aligned, PACR = Partial, PCR = Prerequisite, CTLR = Consistent, ITLR = Inconsistent

Overall, the ELA content expert evaluated 4192 total intersections. Of those intersections, 908 were coded as ACR (Aligned), PACR (Partial), PCR (Prerequisite), or CTLR (Consistent). Two percent of the 908 ratings indicated a directly aligned relationship of the ICAS with the CCSS (mastery of the ICAS requires the CCSS). Thirty-eight percent were at the PACR (Partial) level, which stipulates that there is a partial direct match between the CCSS and the ICAS (mastery of the ICAS requires the CCSS, but the CCSS alone is not sufficient for mastery of the ICAS). The PCR (Prerequisite) and CTLR (Consistent) levels each account for 30% of the aligned intersections. The PCR (Prerequisite) relationship states that mastery of the ICAS does not require the CCSS, although possessing the CCSS is expected to significantly increase mastery of the ICAS, or it is clear that the content required by the CCSS would precede the content required by the ICAS, based on the general learning progression of the subject area. The CTLR (Consistent) category describes that the CCSS would be expected to be found in a majority of cases where the ICAS was taught or learned.

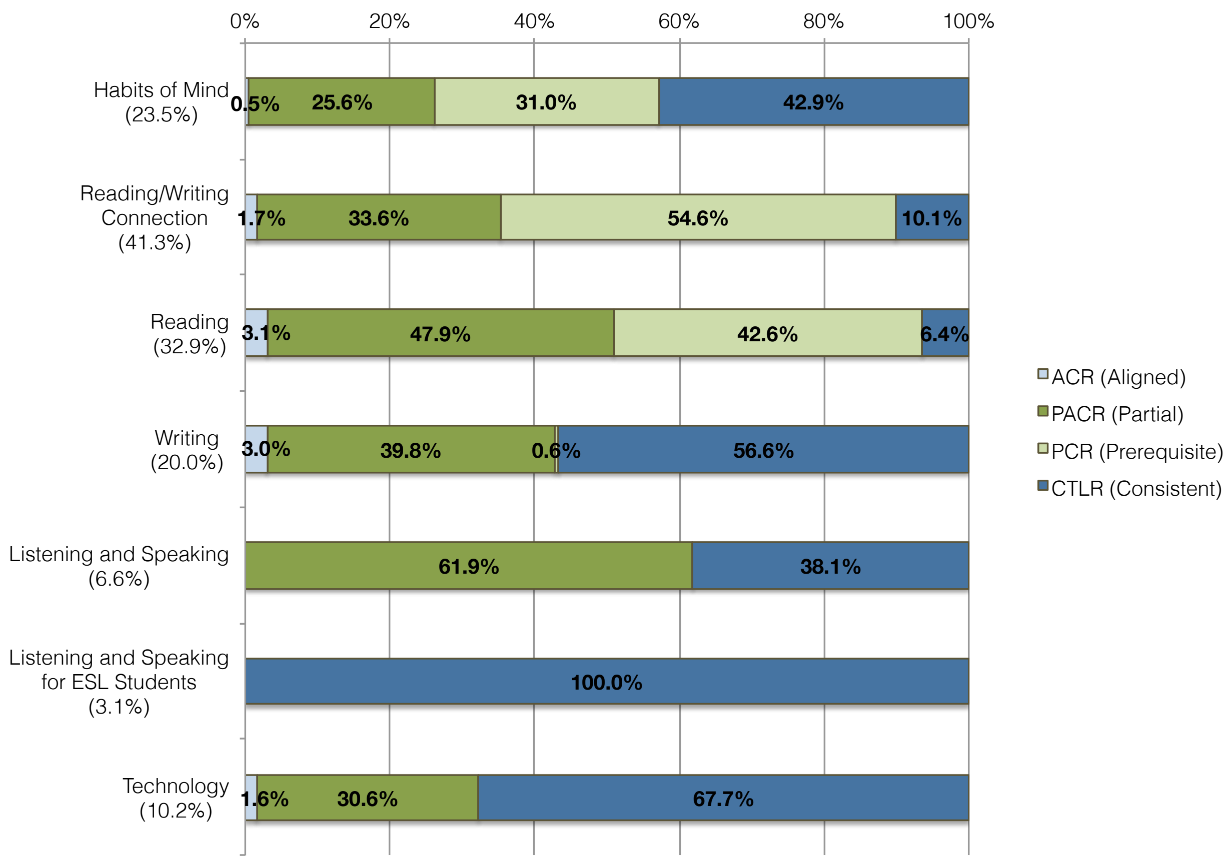
Figure 2. ELA Distribution of Responses Indicating a Significant Relationship to the Common Core State Standards
(*n* = 908)



Note: The figure above represents the distribution of all of those matches indicating a significant relationship; it does not include those matches coded as ITLR (Inconsistent).

Figure 3 shows the distribution of the ratings by ICAS categories. While the first three categories (Habits of Mind, Reading/Writing Connection, and Reading) show a large percentage of the total matches at the Prerequisite Content Relationship level, the last three categories (Writing, Listening and Speaking, and Technology) show that when alignment occurs it is generally within the Partially Aligned Content Relationship or the Consistent Teaching/Learning Relationship levels. This reveals the variance in the relationships between categories. For example, over half of the ratings for Reading/Writing Connection competencies indicate the CCSS standard was prerequisite to the ICAS competency, compared to none of the bottom four categories having a prerequisite relationship. As noted by the expert content reviewer, Listening and Speaking varied from the other categories in that the CCSS tended to be broader and the ICAS competencies more specific. Due to the unidirectionality of the scale, this variance made it difficult to align at the ACR (Aligned) level, but the relationship of the standards were generally rated at the CTLR (Consistent) level instead.

Figure 3. ELA Percent Distribution of Ratings Indicating a Relationship to Common Core State Standards, by ICAS Category (% of total intersections rated as having a significant relationship)



Note: The figure above represents the distribution of all of those matches indicating a significant relationship; it does not include those matches coded as ITLR (Inconsistent).

The specific competencies with the most matches to the Common Core State Standards in the first four categories are:

- Habits of Mind: identify and use rhetorics of argumentation and interrogation in different disciplines, for different purposes, and for diverse audiences (29 matches).
- Habits of Mind: sustain and support arguments with evidence (24 matches).

These results indicate significant overlap with these ICAS competencies and the Common Core State Standards.

ICAS competencies with direct full alignment to CCSS in ELA

Fifteen of the ICAS had direct alignment to the CCSS in ELA, with the most frequent direct alignment in Reading. The following list identifies the ICAS with the strongest direct relationship to the CCSS in ELA:

- Habits of Mind: embrace the value of research to explore new ideas through reading and writing
- Reading/Writing Connection and Reading Comprehension and Retention and Reading: read texts of complexity without instruction and guidance
- Reading/Writing Connection and Reading Comprehension and Retention: summarize information
- Reading Comprehension and Retention: determine major and subordinate ideas in passages
- Reading Comprehension and Retention: identify the main idea of a text
- Reading Comprehension and Retention: summarize reading
- Reading Comprehension and Retention: decipher the meaning of vocabulary from the context
- Reading Comprehension and Retention: analyze information and argument
- Reading: use vocabulary appropriate to college-level work and the discipline
- Writing Invention: duly consider audience, purpose
- Writing Arrangement: use revision techniques to improve focus, support, and organization
- Writing: correctly document research materials to avoid plagiarism
- Writing: critically assess the authority and value of research materials that have been located
- Writing: write well-organized, well-developed essays
- Technology: present material in Web format or media such as PowerPoint

ICAS competencies with no significant relationship to CCSS

Eleven competencies (8%) of the ICAS competencies were reviewed as having only an inconsistent teaching/learning relationship with the Common Core State Standards. The scale defines this relationship as being expected to be found in less than a majority of instances in which this ICAS was taught. In other words, no CCSS statement would be expected to be found a majority of the time when those 11 competencies were taught. These ICAS competencies have no significant relationship to the CCSS, thus identifying gaps between the two systems. Overall, the largest gap occurs with the ICAS competencies related to the Habits of Mind and the Listening and Speaking for ESL students not being addressed in the CCSS in ELA. (See Table 9 for the percent of competencies with no relationship to the CCSS by category.) The list of ICAS competencies with no significant relationship to the CCSS in ELA are:

- Habits of Mind: interrogate own beliefs
- Habits of Mind: meet deadlines for assignments
- Habits of Mind: demonstrate initiative and develop ownership of their education
- Habits of Mind: gain attention appropriately
- Habits of Mind: be attentive in class
- Habits of Mind: exercise civility
- Habits of Mind: engage in self-advocacy
- Reading: have patience

- Writing: reasons, and logic
- Listening and Speaking for ESL students: identify nuances of meaning indicated by shifts in vocal inflection and non-verbal cues, such as facial expressions or body language
- Listening and Speaking for ESL students: demonstrate a full range of pronunciation skills including phonemic control mastery of stress and intonation patterns of English

Table 9. Percent of ICAS Competencies That Had No Significant Relationship With the CCSS by Category.

Academic Literacy Competency	Number of competencies in section	Number of competencies with no significant relationship with CCSS	Percent of ICAS competencies with no significant relationship to the CCSS
Habits of Mind	27	7	25.9%
Reading/Writing Connection	9	0	0.0%
Reading	31	1	3.2%
Writing	26	1	3.8%
Listening and Speaking	15	0	0.0%
Listening and Speaking for ESL Students	4	2	50.0%
Technology	19	0	0.0%

CCSS with no significant relationship to ICAS competencies

All CCSS anchor standards have at least one match to an ICAS competency. Therefore, a student learning all ICAS competencies should also have the opportunity to learn all CCSS in ELA at some level as identified by the rating scale. However, as noted, the inverse is not necessarily true, and a student prepared in the CCSS may not be fully prepared to meet the 11 ICAS competencies identified above as having an inconsistent teaching and learning relationship. Further clarification is necessary to determine if and/or how the additional "habits of mind" should be addressed in California classrooms, and further specification in meeting the needs of ESL students is needed.

Mathematics Results

Results from the mathematics crosswalk show that whereas there was little direct alignment, 46 of the 47 ICAS mathematics competencies (98%) were reviewed as having a relationship (at least one match) with the Common Core State Standards. This result includes matches in the first four categories of the scale: Aligned Content Relationship (ACR), Partially Aligned Content Relationship (PACR), Prerequisite Content Relationship (PCR), or Consistent Teaching/Learning Relationship (CTLR). The total distribution in each of these categories is represented in Figure 4. Frequency of matches ranged from 1–18 per competency statement.

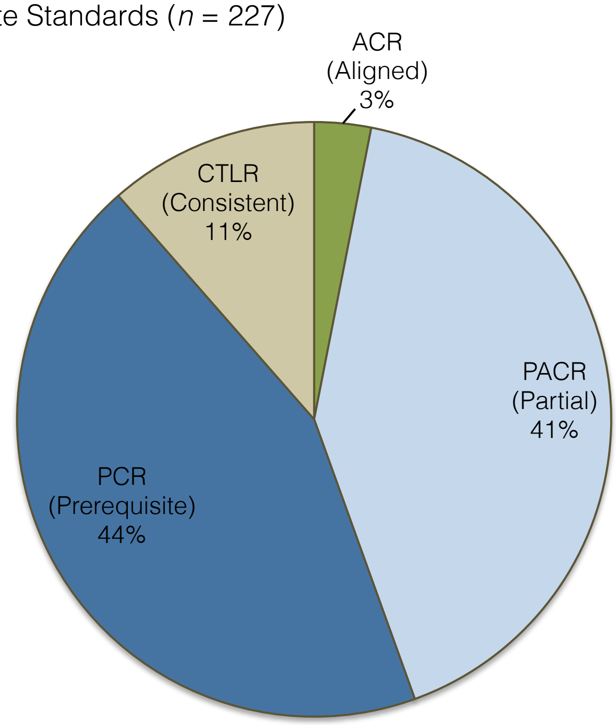
Table 10. Crosswalk Analysis of ICAS Competencies in Mathematics and CCRS Mathematics Clusters and Standards for Mathematical Practice

Mathematics Competency	% ACR	% PACR	% PCR	% CTLR	% ITLR
Dispositions towards Mathematics	1.2	1.8%	6.2%	2.4%	88.5%
Aspects of Instruction	0.2	4.8%	5.4%	1.2%	88.5%
Subject Matter Essential for All Students	0.0	7.1%	4.8%	0.0%	88.1%
Subject Matter Desirable for All Students	0.0	2.8%	0.8%	0.0%	96.4%
Subject Matter Essential for Quantitative Majors	0.0	8.3%	2.0%	0.0%	89.7%
Subject Matter Desirable for Quantitative Majors	0.0	1.9%	1.3%	0.0%	96.8%
Mathematical Skills	0.0	0.0%	1.7%	1.1%	97.2%

ACR = Aligned, PACR = Partial, PCR = Prerequisite, CTLR = Consistent, ITLR = Inconsistent

Overall, there were 2961 intersections evaluated by the expert Mathematics reviewer. Of those, 227 were coded as ACR (Aligned), PACR (Partial), PCR (Prerequisite), or CTLR (Consistent). Three percent of the 227 responses with some relationship were directly aligned with the Common Core State Standard, or the mastery of the ICAS requires the CCSS. Forty-one percent were at the PACR (Partial) level, which stipulates that there is a partial direct match between the CCSS and the ICAS; mastery of the ICAS requires the CCSS, but the CCSS alone is not sufficient for mastery of the ICAS. Another 44 percent of those aligned are at the PCR (Prerequisite) level. The PCR (Prerequisite) relationship states that mastery of the ICAS does not require the CCSS, although possessing the CCSS is expected to significantly increase mastery of the ICAS, or it is clear that the content required by the CCSS would precede the content required by the ICAS, based on the general learning progression of the subject area. And finally, 11 percent are at the CTLR (Consistent) level of alignment. The CTLR (Consistent) category describes that the CCSS would be expected to be found in a majority of cases where the ICAS was taught or learned.

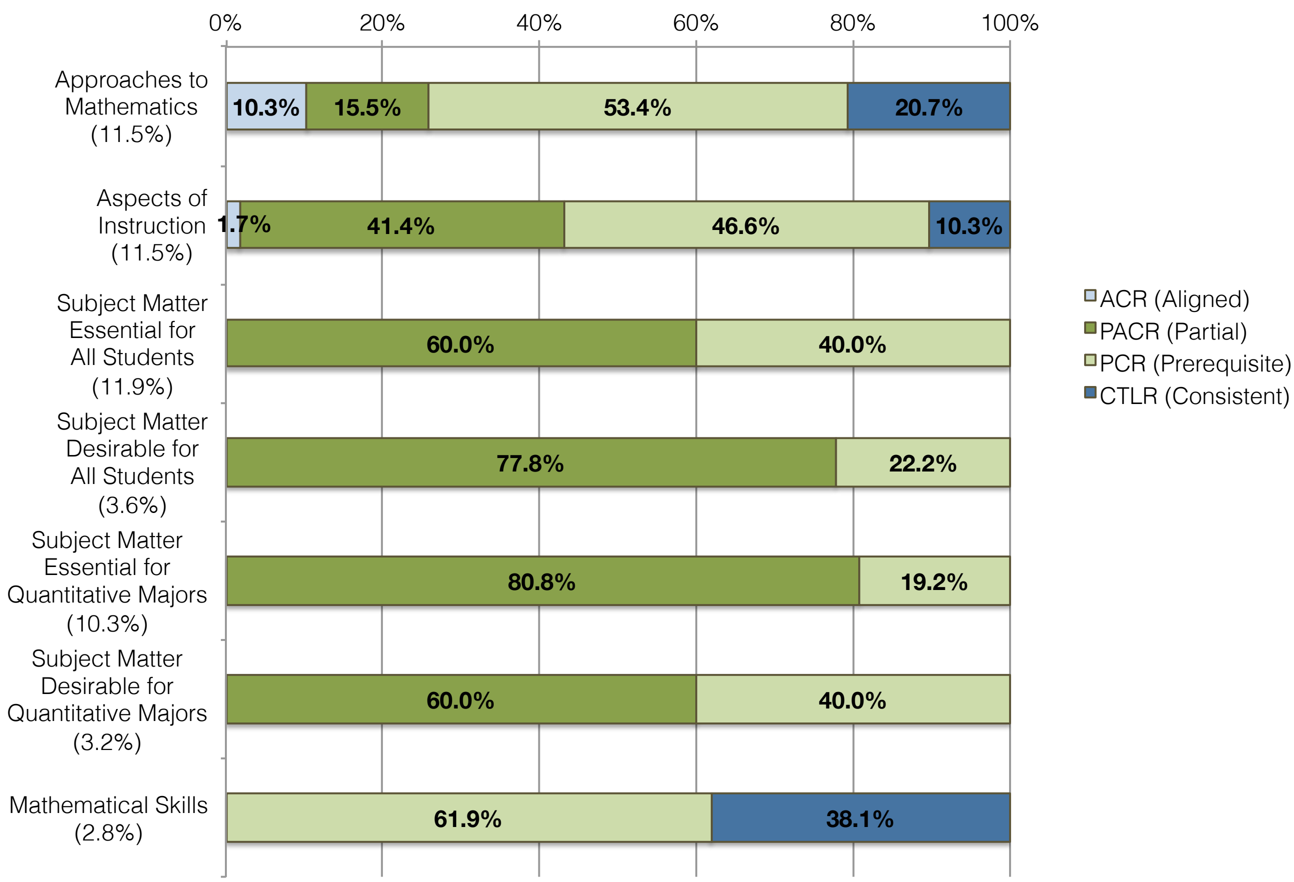
Figure 4. Mathematics Distribution of Responses Indicating a Relationship to the Common Core State Standards (*n* = 227)



Note: The figure above represents the distribution of all of those matches indicating a significant relationship, it does not include those matches coded as ITLR (Inconsistent).

Figure 5 shows the distribution of the ratings by ICAS categories indicating some relationship to the CCSS. While the first category, Dispositions towards Mathematics, has a representation from all four levels of alignment, the majority of the ratings were at the Prerequisite Content Relationship (PCR) level. In Aspects of Instruction, all four levels are represented, but nearly 88 percent are at the PACR (Partial) or PCR (Prerequisite) levels. All areas having to do with subject matter or content had a majority of the ratings at the PACR (Partial) level. Finally, the skills section is rated almost entirely at the PCR (Prerequisite) level, indicating that the Common Core State Standards that are aligned are generally prerequisite knowledge for the ICAS.

Figure 5. Mathematics Percent Distribution of Ratings Indicating a Relationship to Common Core State Standards, by ICAS Category (% of total intersections rated as having a significant relationship)



Note: The figure above represents the distribution of all of those matches indicating a significant relationship; it does not include those matches coded as ITLR (Inconsistent).

The individual mathematics competencies with the most matches to the Common Core State Standards in the first four categories are:

- Aspects of Mathematics Instruction: Becoming Fluent in Mathematics (18 matches).
- Dispositions towards Mathematics: An ease in using their mathematical knowledge to solve unfamiliar problems in both concrete and abstract situations—students should be able to find patterns, make conjectures, and test those conjectures; they should recognize that abstraction and generalization are important sources of the power of mathematics; they should understand that mathematical structures are useful as representations of phenomena in the physical world; they should consistently verify that their solutions to problems are reasonable (17 matches).

These results indicate significant overlap with these ICAS competencies and the Common Core State Standards.

ICAS competencies with direct full alignment to CCSS

Five of the ICAS had direct alignment to the CCSS in mathematics, with all but one within the Dispositions towards Mathematics category. The following list identifies the ICAS with the strongest direct relationship to the CCSS in mathematics:

- Dispositions towards Mathematics: An ease in using their mathematical knowledge to solve unfamiliar problems in both concrete and abstract situations—students should be able to find patterns, make conjectures, and test those conjectures; they should recognize that abstraction and generalization are important sources of the power of mathematics; they should understand that mathematical structures are useful as representations of phenomena in the physical world; they should consistently verify that their solutions to problems are reasonable.
- Dispositions towards Mathematics: A willingness to work on mathematical problems requiring time and thought, problems that are not solved by merely mimicking examples that have already been seen—students should have enough genuine success in solving such problems to be confident, and thus to be tenacious, in their approach to new ones.
- Dispositions towards Mathematics: The understanding that assertions require justification based on persuasive arguments, and an ability to supply appropriate justifications—students should habitually ask "Why?" and should have a familiarity with reasoning at a variety of levels of formality, ranging from concrete examples through informal arguments using words and pictures to precise structured presentations of convincing arguments.
- Dispositions towards Mathematics: While proficiency in the use of technology is not a substitute for mathematical competency, students should be familiar with and confident in the use of computational devices and software to manage and display data, to explore functions, and to formulate and investigate mathematical conjectures.
- Aspects of Mathematics Instruction: Solving Problems

ICAS competencies with no significant relationship to CCSS

One ICAS competency (2%) was reviewed as having only an Inconsistent Teaching/Learning Relationship (ITLR) with the Common Core State Standards. The scale defines this relationship as being expected to be found in less than a majority of instances in which this ICAS competency was taught. In other words, no Common Core State Standards statement would be expected to be found a majority of the time when the following competency is taught or learned. (See Table 11 for the percent of competencies with no relationship to the CCSS by category.)

- Discrete Mathematics: Topics such as set theory, graph theory, coding theory, voting systems, game theory, and decision theory.

Table 11. Percent of ICAS competencies with no significant relationship to the CCSS

Mathematics Competency	Number of competencies in section	Number of competencies with no significant relationship to the CCSS	Percent of ICAS competencies with no significant relationship to the CCSS
Dispositions towards Mathematics	8	0	0.0
Aspects of Instruction	8	0	0.0
Subject Matter Essential for All Students	6	0	0.0
Subject Matter Desirable for All Students	4	1	25.0
Subject Matter Essential for Quantitative Majors	4	0	0.0
Subject Matter Desirable for Quantitative Majors	5	0	0.0
Mathematical Skills	12	0	0.0

CCSS with no significant relationship to ICAS competencies

Three CCSS cluster level standards have no matches to an ICAS competency:

- Functions: Model periodic phenomena with trigonometric functions
- Geometry: Visualize relationships between two-dimensional and three-dimensional objects
- Statistics and Probability: Interpret linear models

Discussion

Overall, the study finds that the ICAS competencies, in general, do relate to the Common Core State Standards. The findings indicate that when the ICAS standards are taught and learned each of the ELA Common Core State Standards will be present in some way (fully covered, partially covered, a prerequisite, or have a consistent teaching/learning relationship). For mathematics, the same is true for almost all of the mathematics Common Core State Standards (save for the three listed on page 16). As for the reverse, if only the CCSS are taught and learned, some gaps were identified with the ICAS competencies. The major gaps include the absence of certain "habits of mind" and English as a Second Language (ESL) standards in the CCSS ELA standards, and the absence of discrete mathematics in the CCSS mathematics standards.

The results indicate that the ICAS framework is broader than the CCSS ELA standards in addressing additional components related to supporting ESL students and including key cognitive strategies all students need to be successful in postsecondary settings. The results also raise the issue of the level of desired preparation in mathematics for high school graduates in California. The CCSS mathematics standards strongly relate to the ICAS competencies identified as *essential* for all students, but have gaps with the ICAS competencies deemed *desirable* for all students. This raises the issue of the level of desired preparation in mathematics for high school graduates in California.

English/Language Arts (ELA)

For ELA, 92 percent of the ICAS competencies are present in some way when the CCSS are taught or learned. The largest area not addressed by CCSS but included in the ICAS competencies are certain "habits of mind" including: interrogate own beliefs; meet deadlines for assignments; demonstrate initiative and develop ownership of their education; gain attention appropriately; be attentive in class; exercise civility; and engage in self-advocacy. In addition, the CCSS do not address English as a Second Language (ESL) as included in the ICAS competencies. Therefore, further clarification is necessary to determine if and/or how the additional "habits of mind" should be addressed in California classrooms, and further specification in meeting the needs of ESL students is needed.

Another issue is the variance in the distribution of the ratings by ICAS categories. This crosswalk methodology revealed that a large percentage of the CCSS in the ICAS ELA areas of Habits of Mind, Reading/Writing Connection, and Reading were rated as prerequisite skills to the ICAS competencies. If students are taught only the CCSS, would this prerequisite knowledge to the ICAS competencies suffice for students to be prepared for California institutions of higher education?

The crosswalk also revealed that the alignment relationship in Writing, Listening and Speaking, and Technology generally occurs within the Partially Aligned Content Relationship or the Consistent Teaching/Learning Relationship levels. The crosswalk methodology employed by this study using the standards statement as a whole as the unit of analysis does not specify the partial relationships within the standards statements. Therefore, further studies would be necessary to not only explore the sufficiency of the CCSS to prepare students for postsecondary success, but also a deeper content analysis to further explore the partial content relationships.

Mathematics

For mathematics, 98 percent of the ICAS competencies are present in some way when the CCSS are taught or learned. The primary difference between the CCSS and the ICAS is between the ICAS competencies deemed essential versus the competencies deemed desirable for all majors. All essential ICAS competencies have a relationship to the CCSS, but there are gaps with the ICAS competencies deemed desirable. Specifically, the ICAS competencies address discrete mathematics and calculus which are not included in the CCSS. In addition, three CCSS have no matches to an ICAS competency, including:

- Functions: Model periodic phenomena with trigonometric functions
- Geometry: Visualize relationships between two-dimensional and three-dimensional objects
- Statistics and Probability: Interpret linear models

Similar to ELA, the mathematics results revealed a variance in the distribution of the ratings by ICAS categories. The largest percentage of ratings demonstrating some sort of a relationship with the CCSS in the ICAS mathematics areas of Dispositions towards Mathematics and Mathematical Skills were rated as prerequisite skills to the ICAS competencies. Further examination at an individual competency level would be necessary to determine whether, if students are only taught the CCSS, this prerequisite knowledge would be sufficient for postsecondary mathematics preparation. The crosswalk also revealed that the alignment relationship in Subject Matter Essential for All Students, Subject Matter Desirable for All Students, Subject Matter Essential for Quantitative Majors, and Subject Matter Desirable for Quantitative Majors generally occurs within the Partially Aligned Content Relationship or the Consistent Teaching/Learning Relationship levels. A deeper content analysis would be necessary to further explore the partial content relationships.

Finally, one additional side note is that the augmented version of the math CCSS include Advanced Placement Probability and Statistics and Calculus Standards; however, these were not written in the same structure or format as the rest of the CCSS. This means that any advanced statistics and probability and calculus CCSS standards would appear to not have any matches in the CCSS in this study, but the augmentation might relate to them. Further revision might be necessary to achieve parallel construction and consistency to increase understanding and ease of implementation.

Appendix A – Standards and Competencies

Common Core State Standards

Table A1. English Language Arts Anchor Standards

Common Core Reading Anchor Standards	Key Ideas and Details	1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
		2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
		3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.
	Craft and Structure	4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
		5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.
		6. Assess how point of view or purpose shapes the content and style of a text.
	Integration of Knowledge and Ideas	7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.*
		8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
		9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.
	Range of Reading and Level of Text Complexity	10. Read and comprehend complex literary and informational texts independently and proficiently.
Common Core Writing Anchor Standards	Text Types and Purposes*	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
		2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
		3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.
	Production and Distribution of Writing	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
		5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
		6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

	Research to Build and Present Knowledge	7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
		8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
		9. Draw evidence from literary or informational texts to support analysis, reflection, and research.
	Range of Writing	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.
Common Core Speaking and Listening Anchor Standards	Comprehen-sion and Collaboration	1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
		2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
		3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.
	Presentation of Knowledge and Ideas	4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
		5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
		6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.
Common Core Language Anchor Standards	Conventions of Standard English	1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
		2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
	Knowledge of Language	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.
	Vocabulary Acquisition and Use	4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.
		5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.
		6. Acquire and use accurately a range of 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.

Table A2. Standards for Mathematical Practice and High School Cluster Level Standards

Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by a star symbol (★).

Common Core Mathematical Practices	Mathematical Practices	Make sense of problems and persevere in solving them
		Reason abstractly and quantitatively
		Construct viable arguments and critique the reasoning of others
		Model with mathematics
		Use appropriate tools strategically
		Attend to precision
		Look for and make use of structure
		Look for and express regularity in repeated reasoning
Common Core Number and Quantity Clusters	The Real Number System N -RN	Extend the properties of exponents to rational exponents
		Use properties of rational and irrational numbers
	Quantities★ N -Q	Reason quantitatively and use units to solve problems
	The Complex Number System N -CN	Perform arithmetic operations with complex numbers
		Represent complex numbers and their operations on the complex plane
		Use complex numbers in polynomial identities and equations
	Vector and Matrix Quantities N -VM	Represent and model with vector quantities
		Perform operations on vectors
		Perform operations on matrices and use matrices in applications
Common Core Algebra Clusters	Seeing Structure in Expressions A-SSE	Interpret the structure of expressions
		Write expressions in equivalent forms to solve problems
	Arithmetic with Polynomials and Rational Expressions A -APR	Perform arithmetic operations on polynomials
		Understand the relationship between zeros and factors of polynomials
		Use polynomial identities to solve problems
		Rewrite rational expressions
	Creating Equations★ A -CED	Create equations that describe numbers or relationships
	Reasoning with Equations and Inequalities A -REI	Understand solving equations as a process of reasoning and explain the reasoning
		Solve equations and inequalities in one variable
		Solve systems of equations
		Represent and solve equations and inequalities graphically
Common Core Functions Clusters	Interpreting Functions F-IF	Understand the concept of a function and use function notation
		Interpret functions that arise in applications in terms of the context
		Analyze functions using different representations

Common Core Functions Clusters	Building Functions F-BF	Build a function that models a relationship between two quantities
		Build new functions from existing functions
	Linear, Quadratic, and Exponential Models★ F -LE	Construct and compare linear, quadratic, and exponential models and solve problems
		Interpret expressions for functions in terms of the situation they model
	Trigonometric Functions F-TF	Extend the domain of trigonometric functions using the unit circle
		Model periodic phenomena with tronometric functions
		Prove and apply trigonometric identities
Common Core Geometry Clusters	Congruence G-CO	Experiment with transformations in the plane
		Understand congruence in terms of rigid motions
		Prove geometric theorems
		Make geometric constructions
	Similarity, Right Triangles, and Trigonometry G-SRT	Understand similarity in terms of similarity transformations
		Prove theorems involving similarity
		Define trigonometric ratios and solve problems involving right triangles
		Apply trigonometry to general triangles
	Circles G-C	Understand and apply theorems about circles
		Find arc lengths and areas of sectors of circles
	Expressing Geometric Properties with Equations G-GPE	Translate between the geometric description and the equation for a conic section
		Use coordinates to prove simple geometric theorems algebraically
	Geometric Measurement and Dimension G-GMD	Explain volume formulas and use them to solve problems
		Visualize relationships between two-dimensional and three dimensional objects
	Modeling with Geometry G-MG	Apply geometric concepts in modeling situations
	Polar Coordinates and Curves	Graph polar coordinates and curves
Common Core Statistics and Probability Clusters	Interpreting Categorical and Quantitative Data S-ID	Summarize, represent, and interpret data on a single count or measurement variable
		Summarize, represent, and interpret data on two categorical and quantitative variables
		Interpret linear models
	Making Inferences and Justifying Conclusions S-IC	Understand and evaluate random processes underlying statistical experiments
		Make inferences and justify conclusions from sample surveys, experiments, and observational studies

	Conditional Probability and the Rules of Probability S-CP	Understand independence and conditional probability and use them to interpret data
		Use the rules of probability to compute probabilities of compound events in a uniform probability model
	Using Probability to Make Decisions S-MD	Calculate expected values and use them to solve problems
		Use probability to evaluate outcomes of decisions

Intersegmental Committee of the Academic Senates of the California Community Colleges, the California Sate University and the University of California Competency Statements

Table A3. Academic Literacy Competencies

ICAS: Fostering Habits of Mind Essential for Success: Academic Literacy and Critical Thinking Students entering colleges and universities will be expected to	sustain and express intellectual curiosity
	experiment with new ideas
	generate hypotheses
	synthesize multiple ideas into a theory
	identify and use rhetorics of argumentation and interrogation in different disciplines, for different purposes, and for diverse audiences
	read skeptically
	prepare and ask provocative questions
	challenge their own beliefs
	engage in intellectual discussions
	manifest interest in and exhibit respect for others' diverse views
	postpone judgment and tolerate ambiguity
	respect principles as well as observations and experiences
	respect facts and information in situations where feelings and intuitions often prevail
	compare and contrast own ideas with others'
	interrogate own beliefs
	sustain and support arguments with evidence
	embrace the value of research to explore new ideas through reading and writing
	enjoy the exchange of ideas
	work collaboratively on reading and writing
	meet deadlines for assignments
	demonstrate initiative and develop ownership of their education
	exercise the stamina and persistence to pursue difficult subjects and tasks
	work collaboratively with others
	gain attention appropriately
	be attentive in class

	exercise civility
	engage in self-advocacy
Making the Reading/Writing Connection Students entering colleges and universities are expected to	read texts of complexity without instruction and guidance
	summarize information
	relate prior knowledge and experience to new information
	make connections to related topics or information
	synthesize information in discussion and written assignments
	synthesize information from reading and incorporate it into a writing assignment
	argue with the text
	anticipate where an argument or narrative is heading
	suspend information while searching for answers to self-generated questions
Reading Competencies Students entering colleges and universities will be expected to	read a variety of texts, including news articles, textbooks, essays, research of others, Internet resources
	read texts of complexity without instruction and guidance
	use vocabulary appropriate to college-level work and the discipline
Students entering colleges and universities will be expected to demonstrate these features of reading: Reading Comprehension and Retention	summarize information
	summarize reading
	analyze information and argument
	retain the information read
	identify the main idea of a text
	determine major and subordinate ideas in passages
	synthesize information from assigned reading
	synthesize information from reading and incorporate it into a writing assignment
	identify appeals made to reader
	use the title of the article/essay/text as an indication of what will come
	predict the intention of the author from extratextual cues
	understand "rules" of various genres
	retain versatility in reading various forms of organization—both essay and paragraph
	read texts of complexity without instruction and guidance
	decipher the meaning of vocabulary from the context
	have strategies for reading convoluted sentences
	reread (either parts or whole) for clarity
Students entering colleges and universities will be expected to demonstrate these features of reading: Reading Depth of Understanding	identify the evidence which supports, confutes, or contradicts a thesis
	argue with the text
	retain information while seeking answers to self-generated questions
	understand separate ideas and then be able to see how these ideas form a whole

Students entering colleges and universities will be expected to demonstrate these features of reading: Reading Depth of Analysis and Interaction with the Text	read with awareness of self and others
	anticipate the direction of an argument or narrative
	suspend information while searching for answers to self-generated questions
	relate prior knowledge and experience to new information
	make connections to related topics or information
	identify appeals made to the reader [pathos, logos, ethos]
	have patience
Students entering colleges and universities will be expected to demonstrate these features of writing: Writing Invention	generate ideas for writing by using texts in addition to past experience or observations
	duly consider audience, purpose
	participate in recursive prewriting process
	develop main point or thesis
Students entering colleges and universities will be expected to demonstrate these features of writing: Writing Arrangement	develop thesis convincingly with well-chosen examples,
	reasons, and logic
	organize information
	structure writing so that it is clearly organized, logically developed, and coherent
	structure writing so that it moves beyond formulaic patterns that discourage critical examination of the topic and issues
	use revision techniques to improve focus, support, and organization
Students entering colleges and universities will be expected to demonstrate these features of writing: Writing Style/Expression	vary sentence structures and word choice as appropriate for audience and purpose
	edit or proofread to eliminate errors in grammar, mechanics, and spelling, using standard English conventions
Students will be assigned writing tasks that require them to do the following:	write to discover and learn new ideas
	critically analyze or evaluate the ideas or arguments of others
	summarize ideas and/or information contained in a text
	write well-organized, well-developed essays
	synthesize ideas from several sources
	provide factual descriptions
	report facts or narrate events
	prepare lab reports using conventions of the discipline
	produce informal writing in and out of class (e.g., journals, “quick-writes”)
	provide short answer responses or essays
	conduct college-level research to develop and support their own opinions and conclusions
	use the library catalog and the Internet to locate relevant sources
	critically assess the authority and value of research materials that have been located
	correctly document research materials to avoid plagiarism

Listening and Speaking Competencies in Academic Settings Students entering colleges and universities will be expected to demonstrate these strategies of Listening	listen and simultaneously take notes
	identify key ideas of speakers in lectures or discussion, identifying the evidence which supports, confutes, or contradicts the thesis
	infer meaning of unfamiliar terms
	identify digressions and illustrations
	identify emotional appeals
	retain information
	participate in class discussions
	produce comprehensible speech
	use the vocabulary of the discipline
	attend to and understand directions for assignments
Listening and Speaking Competencies in Academic Settings Students entering colleges and universities will be expected to demonstrate these strategies of Speaking	ask clearly framed and articulated questions
	engage in intellectual discussions and the serious interrogation of diverse views
	ask questions for clarification
	contribute to class discussions
	employ transitional language to show how various ideas are related
Additional Listening and Speaking Competencies Expected of Students Whose Home Language is Not English In addition to the other competencies noted, L2 Learners should be able to do the following: Speaking/Oral Writing	comprehend English spoken by various speakers whose language styles include a variety of pitches, rates of speech, accents, and regional variations
	identify nuances of meaning indicated by shifts in vocal inflection and non-verbal cues, such as facial expressions or body language
	recognize the spoken form of vocabulary–including idiomatic expressions–previously encountered only in written form
	demonstrate a full range of pronunciation skills including phonemic control mastery of stress and intonation patterns of English
Technology Competencies Students entering college are expected to be able to do the following:	type
	use word-processing software to cut, paste, and format text; spell-check; and save and move files
	navigate e-mail; compose, send, and receive e-mail; and post attachments
	employ e-mail etiquette
	navigate the Internet and the World Wide Web, recognizing the significance of domains (e.g., com, net, edu, org, gov)
	use search engines effectively
	evaluate material found on the Web, including the authenticity of the Website and the author, and the validity of the material
	know how to cite Internet sources
	know what constitutes plagiarism and how to avoid it when using the Internet
	submit drafts and papers electronically
	use electronic handbooks or references
	join a class listserv, a threaded discussion, or mailing list

Technology Competencies In addition, while not yet considered essential, the desirable competencies listed below will enable a student to pursue greater success:	consult experts by e-mail
	present material in Web format or media such as PowerPoint
	use interactive lab-based software
	keep electronic logs or journals
	create multimedia documents; publish work on a Website
	use “chat rooms”
	use video conferencing

Table A4. Mathematics Competency Competencies

ICAS: Approaches to Mathematics Part 1: Dispositions of well-prepared students toward mathematics to their success in college is the way in which students encounter the challenges of new problems and new ideas. From their high school mathematics courses students should have gained certain approaches, attitudes, and perspectives:	A view that mathematics makes sense—students should perceive mathematics as a way of understanding, not as a sequence of algorithms to be memorized and applied.
	An ease in using their mathematical knowledge to solve unfamiliar problems in both concrete and abstract situations—students should be able to find patterns, make conjectures, and test those conjectures; they should recognize that abstraction and generalization are important sources of the power of mathematics; they should understand that mathematical structures are useful as representations of phenomena in the physical world; they should consistently verify that their solutions to problems are reasonable.
	A willingness to work on mathematical problems requiring time and thought, problems that are not solved by merely mimicking examples that have already been seen—students should have enough genuine success in solving such problems to be confident, and thus to be tenacious, in their approach to new ones.
	A readiness to discuss the mathematical ideas involved in a problem with other students and to write clearly and coherently about mathematical topics—students should be able to communicate their understanding of mathematics with peers and teachers using both formal and natural languages correctly and effectively.
	An acceptance of responsibility for their own learning—students should realize that their minds are their most important mathematical resource, and that teachers and other students can help them to learn but can't learn for them.
	The understanding that assertions require justification based on persuasive arguments, and an ability to supply appropriate justifications—students should habitually ask "Why?" and should have a familiarity with reasoning at a variety of levels of formality, ranging from concrete examples through informal arguments using words and pictures to precise structured presentations of convincing arguments.
	While proficiency in the use of technology is not a substitute for mathematical competency, students should be familiar with and confident in the use of computational devices and software to manage and display data, to explore functions, and to formulate and investigate mathematical conjectures.
	A perception of mathematics as a unified field of study—students should see interconnections among various areas of mathematics, which are often perceived as distinct.
ICAS: Approaches to Mathematics Part 2: Aspects of Mathematics Instruction to Foster Student Understanding and Success	Modeling Mathematical Thinking
	Solving Problems
	Developing Analytic Ability and Logic
	Experiencing Mathematics in Depth
	Appreciating the Beauty and Fascination of Mathematics
	Building Confidence
	Communicating
	Becoming Fluent in Mathematics

ICAS: Subject Matter Part 1: Essential areas of focus for all entering college students	Variables, Equations, and Algebraic Expressions: Algebraic symbols and expressions; evaluation of expressions and formulas; translation from words to symbols; solutions of linear equations and inequalities; absolute value; powers and roots; solutions of quadratic equations; solving two linear equations in two unknowns, including the graphical interpretation of a simultaneous solution. Emphasis should be placed on algebra both as a language for describing mathematical relationships and as a means for solving problems; algebra should not merely be the implementation of a set of rules for manipulating symbols.
	Families of Functions and Their Graphs: Applications; linear functions; quadratic and power functions; exponential functions; roots; operations on functions and the corresponding effects on their graphs; interpretation of graphs; function notation; functions in context, as models for data. Emphasis should be placed on various representations of functions—using graphs, tables, variables, and words—and on the interplay among the graphical and other representations; repeated manipulations of algebraic expressions should be minimized.
	Geometric Concepts: Distances, areas, and volumes, and their relationship with dimension; angle measurement; similarity; congruence; lines, triangles, circles, and their properties; symmetry; Pythagorean Theorem; coordinate geometry in the plane, including distance between points, midpoint, equation of a circle; introduction to coordinate geometry in three dimensions. Emphasis should be placed on developing an understanding of geometric concepts sufficient to solve unfamiliar problems and an understanding of the need for compelling geometric arguments; mere memorization of terminology and formulas should receive as little attention as possible.
	Probability: Counting (permutations and combinations, multiplication principle); sample spaces; expected value; conditional probability; independence; area representations of probability. Emphasis should be placed on a conceptual understanding of discrete probability; aspects of probability that involve student memorization and rote application of formulas should be minimized.
	Data Analysis and Statistics: Presentation and analysis of data; measures of center such as mean and median, and measures of spread such as standard deviation and interquartile range; representative samples; using lines to fi t data and make predictions. Emphasis should be placed on organizing and describing data, interpreting summaries of data, and making predictions based on the data, with common sense as a guide; algorithms should be learned with an understanding of the underlying ideas.
	Argumentation and Proof: Logical implication; hypotheses and conclusions; inductive and deductive reasoning. Emphasis should be placed on construction and recognizing valid mathematical arguments; mathematical proofs should not be considered primarily as formal exercises.
ICAS: Part 2: Desirable areas of focus for all entering college students	Discrete Mathematics: Topics such as set theory, graph theory, coding theory, voting systems, game theory, and decision theory.
	Sequences and Series: Geometric and arithmetic sequences and series; the Fibonacci sequence; recursion relations.
	Geometry: Right triangle trigonometry; transformational geometry including dilations; tessellations; solid geometry; three-dimensional coordinate geometry, including lines and planes.

	Number Theory: Prime numbers; prime factorization; rational and irrational numbers; triangular numbers; Pascal's triangle; Pythagorean triples.
ICAS: Part 3: Essential areas of focus for students in quantitative majors	Variables, Equations, and Algebraic Expressions: Solutions to systems of equations, and their geometrical interpretation; solutions to quadratic equations, both algebraic and graphical; complex numbers and their arithmetic; the correspondence between roots and factors of polynomials; rational expressions; the binomial theorem.
	Functions: Rational functions; logarithmic functions, their graphs, and applications; trigonometric functions of real variables, their graphs, properties including periodicity, and applications to right triangle trigonometry; basic trigonometric identities; operations on functions, including addition, subtraction, multiplication, reciprocals, division, composition, and iteration; inverse functions and their graphs; domain and range.
	Geometric Concepts: Two- and three-dimensional coordinate geometry; locus problems; polar coordinates; vectors; parametric representations of curves.
	Argumentation and Proof: Mathematical implication; mathematical induction and formal proof. Attention should be paid to the distinction between plausible or informal reasoning and complete or rigorous demonstrations.
ICAS: Part 4: Desirable areas of focus for students in quantitative majors	Vectors and Matrices: Vectors in the plane; vectors in space; dot product and cross product; matrix operations and applications.
	Probability and Statistics: Distributions as models; discrete distributions, such as the Binomial Distribution; continuous distributions, such as the Normal Distribution; fitting data with curves; correlation, regression; sampling, graphical displays of data.
	Conic Sections: Representations as plane sections of a cone; focus-directrix properties; reflective properties.
	Non-Euclidean Geometry: History of the attempts to prove Euclid's parallel postulate; equivalent forms of the parallel postulate; models in a circle or sphere; seven-point geometry.
	Calculus: A high school calculus course should have the same depth, rigor and content as university calculus courses designed for physical sciences and engineering majors. Prior to taking the course, students should have successfully completed four years of secondary school mathematics. Students completing the course should take one of the College Board's Advanced Placement Calculus examinations.
ICAS: Some Mathematical Skills Necessary for College Work	1. Perform arithmetic with signed numbers, including fractions and percentages.
	2. Combine like terms in algebraic expressions.
	3. Use the distributive law for monomials and binomials.
	4. Factor monomials out of algebraic expressions.
	5. Solve linear equations of one variable.
	6. Solve quadratic equations of one variable.
	7. Apply laws of exponents.
	8. Plot points that are on the graph of a function.
	9. Given the measures of two angles in a triangle, find the measure of the third.
	10. Find areas of right triangles.
	11. Find and use ratios from similar triangles.
	12. Given the lengths of two sides of a right triangle, find the length of the third side.

Appendix B – Competencies and Frequencies of Ratings

Table B1. Academic Literacy Competencies and Frequencies of Ratings

ICAS competencies	ACR (Aligned)	PACR (Partial)	PCR (Prerequisite)	CTLR (Consistent)	ITLR (Inconsistent)
Habits of Mind					
sustain and express intellectual curiosity	0	0	0	11	21
experiment with new ideas	0	1	0	8	23
generate hypotheses	0	0	0	7	25
synthesize multiple ideas into a theory	0	2	2	7	21
identify and use rhetorics of argumentation and interrogation in different disciplines, for different purposes, and for diverse audiences	0	16	9	4	3
read skeptically	0	4	8	0	20
prepare and ask provocative questions	0	0	3	9	20
challenge their own beliefs	0	0	0	3	29
engage in intellectual discussions	0	1	8	4	19
manifest interest in and exhibit respect for others' diverse views	0	1	5	3	23
postpone judgment and tolerate ambiguity	0	0	4	1	27
respect principles as well as observations and experiences	0	0	0	3	29
respect facts and information in situations where feelings and intuitions often prevail	0	0	0	4	28
compare and contrast own ideas with others'	0	2	5	2	23
interrogate own beliefs	0	0	0	0	32
sustain and support arguments with evidence	0	10	5	9	8
embrace the value of research to explore new ideas through reading and writing	1	13	3	5	10
enjoy the exchange of ideas	0	0	4	5	23
work collaboratively on reading and writing	0	1	7	1	23
meet deadlines for assignments	0	0	0	0	32
demonstrate initiative and develop ownership of their education	0	0	0	0	32
exercise the stamina and persistence to pursue difficult subjects and tasks	0	1	0	0	31
work collaboratively with others	0	0	0	1	31
gain attention appropriately	0	0	0	0	32
be attentive in class	0	0	0	0	32
exercise civility	0	0	0	0	32
engage in self-advocacy	0	0	0	0	32
Reading/Writing Connection					
read texts of complexity without instruction and guidance	1	8	5	0	18
summarize information	1	8	5	0	18
relate prior knowledge and experience to new information	0	0	11	0	21
make connections to related topics or information	0	1	10	0	21
synthesize information in discussion and written assignments	0	0	14	6	12
synthesize information from reading and incorporate it into a writing assignment	0	8	5	6	13
argue with the text	0	9	0	0	23
anticipate where an argument or narrative is heading	0	6	3	0	23
suspend information while searching for answers to self-generated questions	0	0	12	0	20
Reading					

read a variety of texts, including news articles, textbooks, essays, research of others, Internet resources	0	11	5	0	16
read texts of complexity without instruction and guidance	1	7	5	0	19
use vocabulary appropriate to college-level work and the discipline	1	5	1	4	21
summarize information	1	9	5	0	17
summarize reading	1	9	5	0	17
analyze information and argument	1	11	3	0	17
retain the information read	0	7	6	0	19
identify the main idea of a text	1	4	6	0	21
determine major and subordinate ideas in passages	1	6	3	0	22
synthesize information from assigned reading	0	0	10	2	20
synthesize information from reading and incorporate it into a writing assignment	0	8	5	6	13
identify appeals made to reader	0	4	5	1	22
use the title of the article/essay/text as an indication of what will come	0	1	0	0	31
predict the intention of the author from extratextual cues	0	1	0	0	31
understand “rules” of various genres	0	8	3	0	21
retain versatility in reading various forms of organization—both essay and paragraph	0	7	3	0	22
read texts of complexity without instruction and guidance	1	8	5	0	18
decipher the meaning of vocabulary from the context	2	5	0	5	20
have strategies for reading convoluted sentences	0	3	0	2	27
reread (either parts or whole) for clarity	0	2	9	0	21
identify the evidence which supports, confutes, or contradicts a thesis	0	7	3	0	22
argue with the text	0	9	0	0	23
retain information while seeking answers to self-generated questions	0	0	12	0	20
understand separate ideas and then be able to see how these ideas form a whole	0	7	2	0	23
read with awareness of self and others	0	6	3	0	23
anticipate the direction of an argument or narrative	0	6	3	0	23
suspend information while searching for answers to self-generated questions	0	0	11	0	21
relate prior knowledge and experience to new information	0	0	11	0	21
make connections to related topics or information	0	1	10	0	21
identify appeals made to the reader [pathos, logos, ethos]	0	4	5	1	22
have patience	0	0	0	0	32
Writing					
generate ideas for writing by using texts in addition to past experience or observations	0	8	1	9	14
duly consider audience, purpose	1	4	0	4	23
participate in recursive prewriting process	0	3	0	6	23
develop main point or thesis	0	1	0	7	24
develop thesis convincingly with well-chosen examples,	0	5	0	5	22
reasons, and logic	0	0	0	0	32

organize information	0	6	0	3	23
structure writing so that it is clearly organized, logically developed, and coherent	0	6	0	3	23
structure writing so that it moves beyond formulaic patterns that discourage critical examination of the topic and issues	0	0	0	8	24
use revision techniques to improve focus, support, and organization	1	0	0	8	23
vary sentence structures and word choice as appropriate for audience and purpose	0	0	0	7	25
edit or proofread to eliminate errors in grammar, mechanics, and spelling, using standard English conventions	0	3	0	8	21
write to discover and learn new ideas	0	0	0	5	27
critically analyze or evaluate the ideas or arguments of others	0	7	0	4	21
summarize ideas and/or information contained in a text	0	2	0	1	29
write well-organized, well-developed essays	1	4	0	3	24
synthesize ideas from several sources	0	4	0	5	23
provide factual descriptions	0	0	0	1	31
report facts or narrate events	0	0	0	2	30
prepare lab reports using conventions of the discipline	0	0	0	3	29
produce informal writing in and out of class (e.g., journals, "quick-writes")	0	1	0	1	30
provide short answer responses or essays	0	1	0	1	30
conduct college-level research to develop and support their own opinions and conclusions	0	3	0	0	29
use the library catalog and the Internet to locate relevant sources	0	4	0	0	28
critically assess the authority and value of research materials that have been located	1	4	0	0	27
correctly document research materials to avoid plagiarism	1	0	0	0	31
Listening and Speaking					
listen and simultaneously take notes	0	0	0	3	29
identify key ideas of speakers in lectures or discussion, identifying the evidence which supports, confutes, or contradicts the thesis	0	2	0	0	30
infer meaning of unfamiliar terms	0	1	0	2	29
identify digressions and illustrations	0	2	0	0	30
identify emotional appeals	0	2	0	0	30
retain information	0	1	0	0	31
participate in class discussions	0	1	0	0	31
produce comprehensible speech	0	2	0	2	28
use the vocabulary of the discipline	0	2	0	0	30
attend to and understand directions for assignments	0	0	0	0	31
ask clearly framed and articulated questions	0	0	0	1	31
engage in intellectual discussions and the serious interrogation of diverse views	0	1	0	1	30
ask questions for clarification	0	0	0	1	31
contribute to class discussions	0	1	0	1	30

employ transitional language to show how various ideas are related	0	1	0	0	31
Listening and Speaking for ESL Students					
comprehend English spoken by various speakers whose language styles include a variety of pitches, rates of speech, accents, and regional variations	0	0	0	2	30
identify nuances of meaning indicated by shifts in vocal inflection and non-verbal cues, such as facial expressions or body language	0	0	0	0	32
recognize the spoken form of vocabulary– including idiomatic expressions– previously encountered only in written form	0	0	0	2	30
demonstrate a full range of pronunciation skills including phonemic control mastery of stress and intonation patterns of English	0	0	0	0	32
Technology					
type	0	0	0	2	30
use word-processing software to cut, paste, and format text; spell-check; and save and move files	0	1	0	2	29
navigate e-mail; compose, send, and receive e-mail; and post attachments	0	1	0	0	31
employ e-mail etiquette	0	1	0	0	31
navigate the Internet and the World Wide Web, recognizing the significance of domains (e.g., com, net, edu, org, gov)	0	2	0	3	27
use search engines effectively	0	2	0	3	27
evaluate material found on the Web, including the authenticity of the Website and the author, and the validity of the material	0	3	0	2	27
know how to cite Internet sources	0	1	0	4	27
know what constitutes plagiarism and how to avoid it when using the Internet	0	1	0	4	27
submit drafts and papers electronically	0	1	0	3	28
use electronic handbooks or references	0	0	0	4	28
join a class listserv, a threaded discussion, or mailing list	0	0	0	1	31
consult experts by e-mail	0	2	0	3	27
present material in Web format or media such as PowerPoint	1	2	0	2	27
use interactive lab-based software	0	0	0	3	29
keep electronic logs or journals	0	0	0	1	31
create multimedia documents; publish work on a Website	0	1	0	1	30
use "chat rooms"	0	0	0	2	30
use video conferencing	0	1	0	2	29
Total	**19**	**349**	**268**	**271**	**3284**

Table B2. Mathematics Competencies and Frequencies of Ratings

ICAS competencies	ACR (Aligned)	PACR (Partial)	PCR (Prerequisite)	CTLR (Consistent)	ITLR (Inconsistent)
Dispositions towards Mathematics					
A view that mathematics makes sense—students should perceive mathematics as a way of understanding, not as a sequence of algorithms to be memorized and applied.	0	1	6	4	51
An ease in using their mathematical knowledge to solve unfamiliar problems in both concrete and abstract situations—students should be able to find patterns, make conjectures, and test those conjectures; they should recognize that abstraction and generalization are important sources of the power of mathematics; they should understand that mathematical structures are useful as representations of phenomena in the physical world; they should consistently verify that their solutions to problems are reasonable.	3	1	11	2	45
A willingness to work on mathematical problems requiring time and thought, problems that are not solved by merely mimicking examples that have already been seen—students should have enough genuine success in solving such problems to be confident, and thus to be tenacious, in their approach to new ones.	1	0	0	2	59
A readiness to discuss the mathematical ideas involved in a problem with other students and to write clearly and coherently about mathematical topics—students should be able to communicate their understanding of mathematics with peers and teachers using both formal and natural languages correctly and effectively.	0	0	4	2	56
An acceptance of responsibility for their own learning—students should realize that their minds are their most important mathematical resource, and that teachers and other students can help them to learn but can't learn for them.	0	0	1	1	60
The understanding that assertions require justification based on persuasive arguments, and an ability to supply appropriate justifications—students should habitually ask "Why?" and should have a familiarity with reasoning at a variety of levels of formality, ranging from concrete examples through informal arguments using words and pictures to precise structured presentations of convincing arguments.	1	4	6	1	50
While proficiency in the use of technology is not a substitute for mathematical competency, students should be familiar with and confident in the use of computational devices and software to manage and display data, to explore functions, and to formulate and investigate mathematical conjectures.	1	0	1	0	60
A perception of mathematics as a unified field of study—students should see interconnections among various areas of mathematics, which are often perceived as distinct.	0	3	2	0	57
Aspects of Instruction					
Modeling Mathematical Thinking	0	1	1	0	60

Solving Problems	1	2	7	0	52
Developing Analytic Ability and Logic	0	5	4	1	52
Experiencing Mathematics in Depth	0	1	2	2	57
Appreciating the Beauty and Fascination of Mathematics	0	0	3	0	60
Building Confidence	0	1	3	0	58
Communicating	0	1	4	1	56
Becoming Fluent in Mathematics	0	13	2	2	45
Subject Matter Essential for All Students					
Variables, Equations, and Algebraic Expressions: Algebraic symbols and expressions; evaluation of expressions and formulas; translation from words to symbols; solutions of linear equations and inequalities; absolute value; powers and roots; solutions of quadratic equations; solving two linear equations in two unknowns, including the graphical interpretation of a simultaneous solution. Emphasis should be placed on algebra both as a language for describing mathematical relationships and as a means for solving problems; algebra should not merely be the implementation of a set of rules for manipulating symbols.	0	10	0	0	52
Families of Functions and Their Graphs: Applications; linear functions; quadratic and power functions; exponential functions; roots; operations on functions and the corresponding effects on their graphs; interpretation of graphs; function notation; functions in context, as models for data. Emphasis should be placed on various representations of functions—using graphs, tables, variables, and words—and on the interplay among the graphical and other representations; repeated manipulations of algebraic expressions should be minimized.	0	7	2	0	54
Geometric Concepts: Distances, areas, and volumes, and their relationship with dimension; angle measurement; similarity; congruence; lines, triangles, circles, and their properties; symmetry; Pythagorean Theorem; coordinate geometry in the plane, including distance between points, midpoint, equation of a circle; introduction to coordinate geometry in three dimensions. Emphasis should be placed on developing an understanding of geometric concepts sufficient to solve unfamiliar problems and an understanding of the need for compelling geometric arguments; mere memorization of terminology and formulas should receive as little attention as possible.	0	2	9	0	52

Probability: Counting (permutations and combinations, multiplication principle); sample spaces; expected value; conditional probability; independence; area representations of probability. Emphasis should be placed on a conceptual understanding of discrete probability; aspects of probability that involve student memorization and rote application of formulas should be minimized.	0	2	1	0	59
Data Analysis and Statistics: Presentation and analysis of data; measures of center such as mean and median, and measures of spread such as standard deviation and interquartile range; representative samples; using lines to fi t data and make predictions. Emphasis should be placed on organizing and describing data, interpreting summaries of data, and making predictions based on the data, with common sense as a guide; algorithms should be learned with an understanding of the underlying ideas.	0	3	3	0	56
Argumentation and Proof: Logical implication; hypotheses and conclusions; inductive and deductive reasoning. Emphasis should be placed on construction and recognizing valid mathematical arguments; mathematical proofs should not be considered primarily as formal exercises.	0	3	3	0	56
Subject Matter Desirable for All Students					
Discrete Mathematics: Topics such as set theory, graph theory, coding theory, voting systems, game theory, and decision theory.	0	0	0	0	62
Sequences and Series: Geometric and arithmetic sequences and series; the Fibonacci sequence; recursion relations.	0	0	1	0	61
Geometry: Right triangle trigonometry; transformational geometry including dilations; tessellations; solid geometry; three-dimensional coordinate geometry, including lines and planes.	0	6	1	0	56
Number Theory: Prime numbers; prime factorization; rational and irrational numbers; triangular numbers; Pascal's triangle; Pythagorean triples.	0	1	0	0	61
Subject Matter Essential for Quantitative Majors					
Variables, Equations, and Algebraic Expressions: Solutions to systems of equations, and their geometrical interpretation; solutions to quadratic equations, both algebraic and graphical; complex numbers and their arithmetic; the correspondence between roots and factors of polynomials; rational expressions; the binomial theorem.	0	7	2	0	53
Functions: Rational functions; logarithmic functions, their graphs, and applications; trigonometric functions of real variables, their	0	7	2	0	54

graphs, properties including periodicity, and applications to right triangle trigonometry; basic trigonometric identities; operations on functions, including addition, subtraction, multiplication, reciprocals, division, composition, and iteration; inverse functions and their graphs; domain and range.					
Geometric Concepts: Two- and three-dimensional coordinate geometry; locus problems; polar coordinates; vectors; parametric representations of curves.	0	3	0	0	60
Argumentation and Proof: Mathematical implication; mathematical induction and formal proof. Attention should be paid to the distinction between plausible or informal reasoning and complete or rigorous demonstrations.	0	4	1	0	57
Subject Matter Desirable for Quantitative Majors					
Vectors and Matrices: Vectors in the plane; vectors in space; dot product and cross product; matrix operations and applications.	0	3	0	0	59
Probability and Statistics: Distributions as models; discrete distributions, such as the Binomial Distribution; continuous distributions, such as the Normal Distribution; fitting data with curves; correlation, regression; sampling, graphical displays of data.	0	2	2	0	58
Conic Sections: Representations as plane sections of a cone; focus-directrix properties; reflective properties.	0	0	1	0	61
Non-Euclidean Geometry: History of the attempts to prove Euclid's parallel postulate; equivalent forms of the parallel postulate; models in a circle or sphere; seven-point geometry.	0	1	0	0	61
Calculus: A high school calculus course should have the same depth, rigor and content as university calculus courses designed for physical sciences and engineering majors. Prior to taking the course, students should have successfully completed four years of secondary school mathematics. Students completing the course should take one of the College Board's Advanced Placement Calculus examinations.	0	0	1	0	62
Mathematical Skills					
1. Perform arithmetic with signed numbers, including fractions and percentages.	0	0	0	2	61
2. Combine like terms in algebraic expressions.	0	0	2	0	60
3. Use the distributive law for monomials and binomials.	0	0	2	0	60
4. Factor monomials out of algebraic expressions.	0	0	2	0	60
5. Solve linear equations of one variable.	0	0	1	0	61
6. Solve quadratic equations of one variable.	0	0	1	0	61
7. Apply laws of exponents.	0	0	2	1	60
8. Plot points that are on the graph of a function.	0	0	1	1	61
9. Given the measures of two angles in a triangle, find the measure of the third.	0	0	0	1	61
10. Find areas of right triangles.	0	0	0	1	61
11. Find and use ratios from similar triangles.	0	0	1	1	61

12. Given the lengths of two sides of a right triangle, find the length of the third side.	0	0	1	1	61
Total	**7**	**94**	**100**	**26**	**2734**