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BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS (BOARS)
Barbara Knowlton, Chair
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Assembly of the Academic Senate
1111 Franklin Street, 12th Floor
Oakland, CA 94607-5200

February 21, 2024

HAN MI YOON-WU, ASSOCIATE VICE PROVOST &
EXECUTIVE DIRECTOR
UNDERGRADUATE ADMISSIONS

RE: BOARS' Area C Workgroup Phase One Report and Recommendations

Dear Han Mi,

Attached please find the initial Stage 1 report from the Area C Workgroup. The report has been endorsed by BOARS. The workgroup focused on the criteria by which courses can validate the Algebra II/Math III requirement for UC admission, and appropriate level of courses applicants are recommended to take for a 4th year of math. The report makes two specific recommendations:

1. The workgroup recommends that only courses that require knowledge of advanced algebra should validate the Algebra II/ Math III course. Thus, courses in statistics should not be used to substitute for a foundational course in advanced algebra. As a thorough knowledge of algebra is foundational for a wide range of quantitative methods, requiring a course in advanced algebra will best prepare students for the widest variety of college majors.
2. Applicants are currently recommended to take a 4th year of math in addition to the three foundational courses (Algebra I-Geometry-Algebra II or Math I-II-III). The Workgroup recommended that this 4th year course should extend math knowledge past the content of the foundational courses. Thus, for some categories within Area C, the Workgroup recommends differentiating between higher math courses and foundational or math elective courses. By encouraging applicants to take the most rigorous high school math courses available, BOARS believes they will be better prepared for college-level quantitative coursework.

I request that the UC Undergraduate Admissions Office work to implement these policy recommendations as soon as reasonable and to communicate these changes with relevant constituent groups. In Stage 2 of their deliberations, the Workgroup intends to provide more clarity on UC's recommended 4th year math courses. I encourage your team to continue communicating

with the Workgroup on current K-12 math curriculum standards and Area C course criteria for math content areas.

Thank you,

Barbara Knowlton
BOARS Chair

cc: Provost and Executive Vice President Newman
Senate Chair Steintrager
Vice President and Vice Provost Gullatt
Members of BOARS
Members of the Area C Workgroup
Executive Director Lin

UC Board of Admissions and Relations with Schools (BOARS)
Workgroup on Mathematics (Area C) Preparation, 2023-2024

Stage 1 Report
January 5, 2024

Background.

The Area C Workgroup was charged with considering UC undergraduate admissions requirements in Mathematics (Area C), in two stages. For Stage 1 (to be completed December 2023) we were charged with considering *current* UC policy, and providing guidance for how this policy should be implemented in course development and approval. The subsequent Stage 2 Report (to be completed by May 2024) may or may not recommend *changes* to UC policy; such changes would require systemwide review for approval.

One particular focus of Stage 1 was the process by which “more advanced” courses can be used to substitute for (“validate”) courses that cover the Mathematics content required for UC admission. Across campuses, there has been substantial faculty concern that in recent years this validation process has not been appropriately applied *(see campus reports in BOARS minutes, 2022-2023)*. Specifically, a number of elementary courses labeled as "data science" have been allowed to validate the advanced algebra requirement. In July 2023 BOARS ruled unanimously that existing policy does not allow currently approved courses in "data science" to validate Algebra II, and that this validation should cease without delay.

The Area C Workgroup was convened in October 2023 to provide further, expert guidance about: 1) UC’s definition of advanced mathematics courses; 2) the criteria by which advanced mathematics can validate UC requirements for algebra and geometry coursework; 3) whether data science courses can potentially qualify as advanced mathematics for admission purposes, and if so what content they would need to contain.

On Senate Regulations and Mathematics Standards.

Admissions policy is set by Senate Regulations. Substantial changes in this policy must therefore undergo the Systemwide review process to be valid. For Area C, the relevant Senate Regulations are as follows:

424 A.3.c: Mathematics, 3 units. Four [courses] are recommended. Must include the topics covered in elementary and advanced algebra and two- and three-dimensional geometry.

428. Alternate ways to complete the subject requirements specified in SR 424.A.3 include: Completing more advanced courses with passing grades, as the Board of Admissions and Relations with Schools may determine, provided that such courses assume knowledge acquired in lower-level coursework.

Regulation 424 A.3.c specifies that an essential mathematical foundation for study at UC includes elementary algebra, geometry, and advanced algebra. The Workgroup determined that these correspond to the standard high school course sequence Algebra I -> Geometry -> Algebra II (or the equivalent Math I -> Math II -> Math III). For Area C, these courses together constitute the “lower-level coursework” referred to in Regulation 428.

Regulation 428 defines the process by which “more advanced” courses can validate the lower-level coursework. The Regulation specifies that for admission purposes, "more advanced" courses can be taken as an alternative, provided that they assume knowledge acquired in the lower-level coursework. The Workgroup determined that for this purpose, "more advanced" courses are those that assume *and rely on completion* of the standard lower-level coursework, meaning prior study of the *overwhelming majority* of the content covered in those lower-level course sequences.

On “Advanced Mathematics”.
The Workgroup notes that the term "advanced mathematics" does not appear in the Senate Regulations. We find that this term has caused confusion in the past, as it has been used to refer to two distinct properties of courses: 1) whether they are "more advanced" courses (per SR 428) that might potentially validate lower-level coursework; 2) whether they would be suitable for the recommended 4th year of high school study in Mathematics (per SR 424). As noted below, a course may satisfy the second criterion, but not the first. Therefore to avoid confusion we recommend that the term "advanced mathematics" not be used in public-facing documents or internal UC discussion.

On Validation.
The Workgroup determines that courses may not be considered “more advanced” Mathematics courses for validation purposes unless they have as an enforced prerequisite all of the lower-level coursework (including Algebra II / Math III) and rely on that material. The Workgroup further determines that the assumption or inclusion of a moderate amount of material from Algebra II / Math III is *not* sufficient for a course to count as “more advanced” per SR 428.

The Area C guidance provided on UC websites should be promptly updated to state clearly and simply that UC requires incoming students to have mastered the material

covered in the standard high school mathematics lower-level course sequence, up to and including Algebra II (or Math III). While it is permissible to include additional explanation of this policy, such text may not expand the range of acceptable Mathematics pathways in ways that are not compliant with the Senate Regulations, as described above.

On the Recommended 4th Year of Mathematics.

The Workgroup noted that a 4th year of high school Mathematics is recommended, rather than required. Nonetheless, it is desirable, if possible, for students to continue their growth in mathematical knowledge, abstract thinking, and problem-solving skills, to better ease the transition into college-level coursework.

At the same time the Workgroup determined that appropriate 4th year Mathematics courses include some that do not require *all* of the lower-level content (e.g., AP Statistics), and therefore may not count as “more advanced” courses (per SR 428). The Workgroup further noted that the most suitable 4th year course may depend on the individual student's interests and trajectory. A student intending a STEM major (including Data Science or Computer Science) at the college level is well-advised to take Calculus or Pre-Calculus, whereas others may find courses such as AP Statistics more useful. Overall, a broad range of courses may be suitable for the recommended 4th year - provided that they are Mathematics courses of a level of mathematical challenge appropriate for 12th grade students already familiar with the lower-level required Mathematics coursework.

On "Data Science" Courses.

The Workgroup examined the content of three popular courses labeled "data science" *(Introduction to Data Science, Youcubed, CourseKata*). Per our consultation with the Director of A-G & Transfer Articulation Policy, these courses collectively make up the great majority of courses labeled "data science" recently taken by CA high school students. We compared this content to the Mathematics standards specified above (see Appendix for details of this comparison).

The Workgroup determined that none of these courses labeled as "data science" even come close to meeting the required standard to be a "more advanced" course per SR 428. The Workgroup therefore strongly supports the July 2023 BOARS decision that the three courses above do not validate Algebra II according to current Senate Regulations.

Furthermore, we find these current courses labeled as "data science" are more akin to data literacy courses. While they may be suitable college preparatory courses for some

students, they are not appropriate as recommended 4th year Mathematics courses per SR 424.

The Workgroup certainly believes it is possible for a course in Data Science to be crafted at a level suitable for the recommended 4th year of high school Mathematics study. We encourage the future development of a range of innovative, rigorous 4th year Mathematics courses, including in the area of Data Science. However all courses labeled “data science” or similar should undergo appropriate review to ensure they follow Senate Regulations.

<u>On Faculty Oversight and Public Communication of Policy.</u>
The Workgroup is concerned that in recent years the implementation and communication of Mathematics standards has deviated away from the policies formally set by the Senate Regulations. To address this concern and avoid public confusion:

1) This Stage 1 Report, explaining UC Mathematics standards as defined by Senate Regulations, should immediately be made public.
2) The content of future UC communications regarding Mathematics standards must be consistent with SR 424 and 428, and should be reviewed and approved by the *full* BOARS membership before being made public.
3) Existing public-facing documents, webinars etc regarding UC admission policy should be immediately updated to be in compliance with SR 424 and 428 as discussed above, or removed.
4) Given the prior lack of effective faculty oversight over course approvals we recommend that BOARS institute new procedures for monitoring the implementation of policy re: course approval. These new procedures should include the regular involvement of subject-area faculty experts, nominated by individual UC campuses rather than central UC administration.

Sincerely, the Members of the Area C Workgroup:

(Chair) Ani Adhikari (Berkeley, Statistics)
Alexander Aue (Davis, Statistics)
Josh Berke (San Francisco, School of Medicine; BOARS)
Maribel Bueno Cachadina (Santa Barbara, Mathematics)
Svetlana Jitomirskaya (Irvine / Berkeley, Mathematics)
Todd Kemp (San Diego, Mathematics)
Amit Sahai (Los Angeles, Computer Science)
Bruno Sansó (Santa Cruz, Statistics)
Frank Vahid (Riverside, Computer Science; BOARS)

Appendix A: Curricula Labeled "Data Science"

The workgroup has examined the content of three commonly used curricula labeled "data science": Introduction to Data Science (IDS), CourseKata, and YouCubed. It is important to note that there are no official State of California or UC standards for what constitutes a high school data science course.

The workgroup finds that none of these three curricula validates Algebra 2. In particular, none of them requires the completion of Algebra 2 or prior study of the overwhelming majority of the content of Algebra 2.

The workgroup further determines that none of these three curricula can be considered "more advanced" than Algebra 2 for validation purposes since the assumption or inclusion of a moderate amount of material from Algebra II / Math III is not sufficient for a course to count as "more advanced" per SR 428.

This determination is based on a comparison of the curricula of Algebra 2 and the three curricula labeled "data science".

<u>Algebra 2 Curriculum Outline</u>

A typical Algebra 2 course covers the following topics:

- Algebraic Manipulation
    - Operations with polynomials, rational expressions, and radicals
    - Factoring polynomials
- Functions
    - Understanding and working with various types of functions, including linear, quadratic, exponential, and logarithmic functions
    - Composition and inverse functions
- Trigonometry
    - Basic concepts including trigonometric functions and identities
- Linear Systems
    - Solving systems of linear equations
    - Applications of linear systems
- Conic Sections:
    - Understanding and graphing circles, ellipses, hyperbolas, and parabolas
- Probability and Statistics
    - Basic concepts of probability
    - Descriptive statistics

The following are not part of the official Algebra 2 standards but are listed as additional or "+" standards.

- Matrices and Determinants
    - Basic operations with matrices
    - Determinants and their properties
- Sequences and Series
    - Arithmetic and geometric sequences
    - Series and summation notation

Algebra 2 topics that are not part of the three “data science” curricula include:

- Algebraic manipulation beyond the level of Algebra 1
- Exponential and logarithmic functions
- Inverses of functions
- Systems of equations and inequalities
- Polynomials and factoring
- Trigonometry
- Conic sections or similar geometry

YouCubed uses the least mathematics among all three “data science” curricula, instead relying on multiple technological platforms for visualization and calculation. Though some of the topic headings appear to be advanced mathematics, the content is not. For example, “linear algebra” consists only of representing data as vectors or matrices.

On its website, (https://www.introdatascience.org/wp-content/uploads/California-Common-Core-Mathematics-Standards-addressed-by-IDS.pdf) IDS lists the California Common Core Mathematics Standards addressed by its curriculum. Algebra 2 content is neither required nor mentioned.

CoureKata uses algebraic notation to define some quantities but otherwise hardly uses algebra or other mathematics, relying instead on the statistical system R. Its view of the mathematics involved in introductory statistics is provided in its first chapter: “The mathematics behind basic statistics is simple (it’s mostly adding, subtracting, multiplying, and dividing a bunch of times). The computations are trivial, though labor intensive.”

The focus of the curricula labeled “data science” is on statistical reasoning, applied skills and tools relevant to data analysis, and interpretation of analyses. This does not include the extensive use of topics in Algebra 2 that would be necessary for validation.

“Data Science” Curricular Details

Introduction to Data Science (IDS)
The IDS curriculum is available at https://www.introdatascience.org/wp-content/uploads/IDS_v3.0_Table-of-Contents.pdf . The curriculum overview available at https://www.introdatascience.org/introduction-to-data-science-curriculum has the following units.

- Data and Visualizations
    - Introduces students to fundamental notions of data analysis—such as distribution and multivariate associations and emphasizes creating and interpreting visualizations of real-world processes as captured by data
- Distributions, Probability, and Simulations

    - Students use numerical summaries to describe distributions and introduces probability through the lens of computer simulations for informal inference
- Data Collection Methods: Traditional and Modern
    - Prepares students to learn about the various ways of collecting data, including Participatory Sensing, and the effect that data collection has on their interpretation of the patterns they discover
- Predictions and Models
    - Students learn to make and how to use mathematical and statistical models to predict future observations and how data scientists measure the success of these predictions

CourseKata (High School / Advanced Statistics and Data Science)
The CourseKata curriculum has multiple levels. The workgroup examined the most advanced high school level CourseKata curriculum, available at https://coursekata.org/preview/default/program. It has the following main headings.

Part I: Exploring Variation
1. Welcome to Statistics: A Modeling Approach
2. Understanding Data
3. Examining Distributions
4. Explaining variation

Part II: Modeling Variation
5. A Simple Model
6. Quantifying Error
7. Adding an Explanatory Variable to the Model
8. Digging Deeper into Group Models
9. Models with a Quantitative Explanatory Variable

Part III: Evaluating Models
10. The Logic of Inference
11. Model Comparison with F
12. Parameter Estimation and Confidence Intervals
13. What You Have Learned

YouCubed
The YouCubed high school curriculum is available at https://hsdatascience.youcubed.org/curriculum/ and has the following main headings.

1. Data Tells a Story

- What are variability, data, and models?
- Data ethics
- Data science inquiry: asking questions of data
- Univariate, bivariate and multivariate data

- Creating visual representations
- What is the story I can tell from this data?
- Data cleaning

2. The Data of Our Community

- Using measures of center and spread to model data
- Distributions and normal distributions
- Data representations
- Sampling and variability
- Probabilistic thinking

3. Water in Your Life

- Linear regression and bivariate data
- Using probability to analyze the fit of a regression
- Make connections between the trend and the context to make predictions
- Spurious correlations, confounding and mediating variables and data ethics
- Evaluating claims: spurious correlation vs causality

4. Shuffling Songs

- Algorithmic Thinking
- Basics of Programming
    - Variables
    - Loops
    - If-then statements
- Simulation
- Variability
- Probability
    - Theoretical and Experimental Probability
    - Conditional Probability

5. Skin Tones and Representations

- Pros and cons of different ways of data collecting
- Collecting categorical data
- Two-way tables
- Foundations in Linear Algebra: Working in higher dimensional spaces
- Introduction to clustering
- Probability

6. What's the Best Place for Me?

- Bias
- Data collection and cleaning

- Normalization and weighting of data
- Forming mathematical models
- Sensitivity analysis
- Writing reports and communicating findings

7. Predicting My Preferences

- Predictive modeling
- Machine learning
- Basic programming
- Linear Algebra
- Conditional Probability

8. Being a Data Scientist

- Asking questions
- Gathering and organizing data
- Modeling
- Analyzing and synthesizing
- Communicating