Measuring the Alignment of High School and Community College Math Assessments

Alison R. Shelton
Walnut High School
Walnut Valley Unified School District

Richard S. Brown
Rossier School of Education
University of Southern California

More than 60% of all community college students are placed into remedial, noncredit bearing courses. Concerns over the lack of articulation across the K-12 and postsecondary educational systems have led to concerns over whether students have had the opportunity to learn and demonstrate the skills required for success in college-level classes. To measure the degree to which the expectations across these systems are consistent, the degree of alignment between the examinations at these two levels was explored. The California Community College placement test content was compared to the high school level California Standards Tests in General Mathematics, Algebra 1, and Geometry. Only the General Mathematics was aligned across a substantial number of standards. Taking into consideration past studies, it appears that the major source of misalignment between the two testing systems occurs within the content areas of integers and rationals, trigonometry, and graphing.

Introduction

This study investigates the consistency of high school and community college-level expectations. In California, there is little incentive for state universities, community colleges, and high schools to communicate and work together. This has contributed to high rates of high school graduates needing postsecondary remediation.

The majority of high school graduates who go on to attend California's community colleges need some form of remediation. In general, this means that students take classes they had previously passed in high school (Willett, 2007). Increasing college enrollments and fiscal concerns have brought issues associated with remediation to the forefront of today's educational policy. Educational leaders across the system are looking for ways to reduce the need for students to take remedial courses once they enroll in postsecondary institutions.

High rates of remediation suggest that there is a pervasive lack of preparation for college among recent high school graduates. The low proficiency rates on high school standardized tests support this claim (California Department of Education, 2008). However, low performance is not necessarily the issue for every remedial college student. For instance, the mean GPA of California State University remedial math students is well over 3.0 (California State University, 2006). This indicates that students who are earning A's and B's in high school, and meet the minimum course requirements for university admission, are still being placed into remedial courses. Furthermore, there is evidence that many students who are placed in remedial classes could have been successful in college-level courses (Armstrong, 1999, 2000). This suggests that the remediation problem is more complex than just the lack of preparedness of high school graduates. To get an accurate picture of the issue necessitates looking beyond preparation to other issues such as motivation, school quality, and the appropriateness of the tests themselves.

In addressing concerns of widespread remediation, placement policies should be reviewed. Are students adequately placed in appropriate classes and are the assessments valid and fair? Many dimensions of validity could be explored, including cut scores and how well they predict student performance issues, as well as reliability and an examination of assessments for bias. Also, it must be established that the subject matter of the exam is appropriate for its intended use, that it has content validity. Many studies have been conducted that explore the predictive validity of placement tests used by California Community Colleges (Armstrong, 1994; Isonio, 1992). However, placement test scores alone are not necessarily better predictors of success than high school transcripts (Marwick, 2004). Furthermore, no matter how predictive a score is of student future success, it is not a fair assessment if it is predicated on content that students have not had the opportunity to learn. Entry-level college placement tests that are

based on content outside of the standard college preparatory curriculum are biased against students who do not have the additional resources to prepare for them.

High school students prepare for college by taking college preparatory courses, which is defined in California as the a-g coursework requirements for university admission (Education Trust-West, 2004; University of California, 2008). In the absence of specific matriculation standards, the content of college placement tests becomes the "de facto" standard for college readiness. However, there is no clear evidence that placement test content assesses students on the standards associated with prerequisite high school level courses. In other words, there is a lack of evidence as to whether the secondary and postsecondary educational systems agree about the content skills that are necessary to prepare students for college-level work.

California Community Colleges are open access institutions with the mission to serve anyone who can benefit (California Community Colleges, 2006). In practice, this means that anyone with a high school diploma, and even some without, can enroll in these institutions. Students take placement exams that determine if they will be placed in college-level or basic-skills level courses. These course placements can have a significant impact on an individual student's course-taking trajectory and ultimate degree attainment. For those who are placed in the lowest level remedial courses, the chances of completing a degree are quite low. For instance, students placed in arithmetic level courses have only a 10% chance of eventually attempting transfer level math (California Community Colleges, 2006). This issue disproportionately affects students of minority background, as 65% of African American and 54% of Latino students are placed in remedial math courses compared to only 26% of White students.

School accountability systems utilize standards-based, high stakes tests to assess the proficiency level of students (No Child Left Behind Act of 2001, 2002). These assessments function as messages to teachers and students about what is important to teach and learn (Herman, Webb, & Zuniga, 2007). They do not provide feedback to the students on their progress towards college readiness (Lundell, Higbee, Hipp, & Copeland, 2004). However, students who are performing well in college preparatory classes have reason to believe that they are successfully preparing themselves for college-level work.

California Community Colleges do not have explicitly defined entrance standards or standards for college-level work (California Department of Education, 1960). The University of California system, however, has outlined minimum standards for college preparation by defining the course requirements for admission and requiring high schools to petition for approval of all courses designed to meet these requirements (University of California, 2008). Furthermore, part of the California Community College (CCC) mission includes preparing students to transfer to the state four-year university system (California Community Colleges, 2006); consequently, their definition of college preparation should be in accordance with the UC/CSU systems. In other words, students who have mastered the content in the college preparatory curriculum should be able to place into college-level coursework. Therefore, if the placement test content is valid for its intended use in California Community Colleges, it should test students on content that is part of the stated college preparatory curriculum. In mathematics, this curriculum requires students to take math through Algebra II. For this reason, remedial placements should be determined by the standards of the a-g courses and any content outside of this course sequence that is necessary for future math success should be included in postsecondary, credit-bearing college math courses.

Purpose of the Study

The purpose of this study is to measure the alignment between community college entrance expectations and the tests taken by the majority of California students. This investigation focuses on the alignment of CCC placement test content with the California Standards Tests (CSTs) in General Mathematics, Algebra I, and Geometry. This study is designed to build upon the work conducted by Brown and Niemi, which investigated the alignment between the CCC placement exam content and the augmented forms of the CST in eleventh-grade English, Algebra II, and Summative High School Mathematics (see Brown & Niemi, 2009). As the authors indicate, the Algebra II and Summative High School Mathematics tests are taken by only 18% of California high school students; whereas, the math tests addressed in the current study are taken by 81.2%. Therefore, the results from these two studies, when considered alongside one another, provide an indication of how well the community college standards are aligned with the CST's taken by 99.2% of California students.

Methodology

In the absence of formal entrance standards in open-access California Community Colleges, the placement exam content defines college-level expectations. To help provide a clear picture on how consistent these expectations are with the high school curriculum, the alignment between these "de facto" entrance standards and K-12 content standards in mathematics was explored.

There are several methodologies available to investigate the alignment between these exams. One approach, developed by Norman Webb, has become widely accepted due to its complexity and adaptability (Bhola, Impara, &

Buckendahl, 2003; Impara, 2001). This study follows a modified Webb approach of content alignment (see Brown & Conley, 2007; Brown & Niemi, 2009; N. L. Webb, 1997, 1999, 2002; N. L. Webb, 2007) to investigate the alignment of the "de facto" CCC entrance standards with the California K-12 content standards in mathematics.

Alignment Rating Process

Participants. Consistent with past alignment studies, 9 subject matter experts, four from California high schools and five from California Community Colleges, were recruited to serve as raters. For the purposes of this study, a subject matter expert is defined to be someone who is qualified to teach and has experience in teaching high school level or introductory college-level math courses. Raters were recruited from local high schools, community colleges, and universities and were purposefully chosen due to their qualifications and experience with high school and postsecondary mathematics. Several individuals had experience at both the high school and postsecondary levels. Each rater was familiar with the California Content Standards in mathematics and/or the content in remedial or entry-level college math classes.

Activities. The alignment exercises took place within the context of a one-day alignment workshop that began with a training session. First, the raters were introduced to the purposes of the study and important definitions, including the concepts of categorical concurrence (CC) and depth of knowledge (DOK). Second, raters were introduced to the 5-point scale being used to quantify DOK. Raters practiced assigning DOK levels to sample training items. The purpose of this training was to help reviewers develop a shared understanding of these levels. It also helped to calibrate the concepts of content match and DOK coding, improving consistency between raters.

Once training was completed, the raters independently analyzed the CST test elements in General Mathematics, Algebra 1, and Geometry and compared them to the CCC placement test objectives in two steps. The first step was to determine the DOK assessed by individual objectives on a 1-5 scale using Marzano's taxonomy (Marzano, 2001; Marzano & Kendall, 2007). The DOK ratings for the community college objectives had been previously determined with a high degree of rater reliability (Brown & Niemi, 2009) and was not repeated here. Second, each rater compared the content of the high school assessment elements with the CCC placement exam content to determine if and where matches occurred.

Every rater compared each placement test objective against each high school standard to determine if there was a content match. This resulted in three matrices of CCC objectives by CST items for each rater, one for each high school test. Analyses were performed for every rater and then averaged to determine the results for each standard. The reliability of these ratings was then assessed utilizing the generalizability coefficient (see Brennan, 2001; Mushquash & O'Connor, 2006; Shavelson & Webb, 1991, 2006; Shavelson, Webb, & Rowley, 1989).

Alignment Criteria

Brown and Niemi identified the CCC placement test content through the analysis of the most commonly utilized placement tests in California Community Colleges. These tests include the Accuplacer Arithmetic, Elementary Algebra, and college-level math tests; ACT Compass' Numerical Skills/Pre-Algebra, Algebra, College Algebra, and Geometry tests; and MDTP's Algebra Readiness and Elementary Algebra tests (2009). The content objectives discovered were arranged into 12 major groupings (see Brown & Niemi, 2009). These are listed in Table 1. These community college standards were compared with the CSTs in General Mathematics, Algebra I, and Geometry across four dimensions: CC, DOK, range of knowledge (ROK), and balance of representation (BR).

Categorical Concurrence. CC is a measure of how well two assessments are matched in content. It helps to quantify the extent to which the mandatory high school assessments measure the same content as assessments used for community college placement. A test item and an objective show CC if they address the same topic. Raters assign each test item to one or more community college objectives, or to no match. CC has been achieved when at least six assessment items map into the objectives for that standard. Each standard either meets or fails to meet this criterion, with no partial achievement.

Depth-of-Knowledge Consistency. DOK consistency measures cognitive complexity on a 1 - 5 scale using Marzano's definitions of levels of cognition. These include retrieval, comprehension,

Table 1. List of Community College Objectives

Community College Objectives
Whole Numbers and Fractions
Decimals and Percents
Applications and Interpreting Tables/Graphs
Integers and Rationals
Algebraic Expressions and Operations
Operations with Exponents
Equations, Inequalities, and Word Problems
Functions
Trigonometry
Geometry
Graphing
Other Algebra Topics

analysis, knowledge utilization, and metacognitive processes. DOK measures the degree to which placement exams and high school tests assess matched content to a similar degree of complexity. This indicates the degree to which California high school tests measure content at higher or lower levels of complexity compared to community college placement exams. An item matches an objective in DOK if it has a complexity rating equal to or greater than the associated objective. The DOK criterion requires at least half of the items matched to a given standard to be tested at a level of complexity at or above that of the standard.

Range of Knowledge. ROK refers to the number of objectives tested by items mapped into a given standard. This measure indicates whether the span of knowledge measured by high school standards tests and community college placement exams are comparable. The minimum criterion is that at least half of the objectives within the standard have at least one question mapped to them, reflected in a desired ROK value greater than .5.

Balance of Representation. The DOK and ROK criteria allow an exam to have a large number of questions clustered around a few objectives. In order to determine if the questions are evenly spread among the various objectives within a standard, the BR index is computed. BR refers to the distribution of assessment items among the various objectives. It quantifies the overall balance of items. A specific assessment is high in BR if the assessment items are distributed evenly across the given objectives. The desired level of balance is .70 or higher.

Results

Indices of Alignment

Reliability of Ratings. This study relies on the judgment of multiple raters in analyzing test alignment. Therefore, before examining the results of these judgments, it is important to determine the degree to which the raters are in agreement. For this purpose, the generalizability coefficient (g-coefficient) was employed to measure the degree of rater consistency. The generalizability coefficient (see Brennan, 2001; Mushquash & O'Connor, 2006; Shavelson & Webb, 1991, 2006; Shavelson, Webb, & Rowley, 1989) is a measure of reliability that, unlike its counterpart in classical test theory, distinguishes between systematic and unsystematic sources of variability.

The g-coefficient values were calculated independently for each of the three tests (see Table 2). Rater agreement for both the General Mathematics and Geometry tests exceeded the preferred threshold of .80. The relative and absolute g-coefficients for the General Mathematics test were both calculated at approximately .90, whereas the ratings for the Geometry test were .84 and .83 respectively. The Algebra I test showed slightly less consistency, while still meeting the minimally acceptable level of .70, with relative and absolute g-coefficients calculated at .79 and .77 respectively.

Categorical Concurrence. CC was analyzed on a per standard basis, with six assessment items mapping into the objectives for that standard indicating that CC has been achieved (see Table 3). The Algebra I standards test achieved CC in two areas: (1) algebraic expressions and operations and (2) equations, inequalities, and word problems. The Geometry test met the CC criterion in the area of geometry only. The General Mathematics test met the CC crite-

Table 2. Reliability Ratings (DOK)

CST Subject Area	Relative G-Coefficient(ρ)	Absolute G-Coefficient(φ)
General Mathematics	.90	.90
Algebra 1	.84	.83
Geometry	.79	.77

Table 3. Categorical Concurrence Ratings

CCC Math Placement Test Content	General Math CST	Algebra I CST	Geometry CST
Whole Numbers and Fractions	16.89	4.67	0.00
Decimals and Percents	13.33	0.78	0.00
Applications and Interpreting Tables/Graphs	12.67	4.33	1.78
Integers and Rationals	3.11	1.78	0.00
Algebraic Expressions and Operations	5.67	16.67	0.33
Operations with Exponents	6.67	2.78	0.00
Equations, Inequalities, and Word Problems	6.44	8.00	0.44
Functions	2.33	2.78	0.11
Trigonometry	0.00	0.00	4.22
Geometry	11.22	0.33	18.56
Graphing	3.44	4.78	0.89
Applications and Other Algebra Topics	5.56	0.11	4.78

Note: Criterion value for alignment: ≥6

rion in most categories including a near match in algebraic expressions and operations, as well as applications and other algebra topics. CC was not achieved for (1) integers and rationals, (2) functions, (3) trigonometry, or (4) graphing.

Depth-of-Knowledge Consistency. The DOK criterion is met for a standard if at least half of the items matched are tested at a level of complexity at or above that of the standard. The calculated DOK values for all standards are reported in Table 4.

Standards with a small number of matches can easily meet the DOK criterion, but the results are not necessarily meaningful. For instance, if there is only one content match within a standard, then either 100% or 0% of the matched items assess the content at the desired level of complexity. Of course, in this case, there are not enough items testing the standard to determine that it is being adequately measured. Therefore, in this discussion the authors will only explore the DOK level of standards that has also met the CC criterion.

For all three tests, the majority of the standards that achieved CC far exceeded the DOK criterion. The only exception was with the standard of applications and interpreting tables/graphs, which only weakly satisfied the DOK criterion for the General Mathematics test. This indicates that where high school tests are assessing the same content as community college tests, they generally do so at a cognitive level at least as great as that of the community college placement tests.

Range of Knowledge. As with DOK, and for similar reasons, ROK will only be discussed in areas where the CC criterion has been met. Table 5 provides the calculated values for this index for all standards.

Within the General Mathematics tests, equations, inequalities, and word problems met this criterion only weakly, while algebraic expressions and operations as well as applications and other algebra topics failed to meet the criterion even minimally. For the Algebra I test, algebraic expressions and operations met the required ROK criterion. Additionally, equations, inequalities, and word problems weakly met the criterion. The Geometry test exceeded the minimum requirement in its sin-

Table 4. Depth of Knowledge Ratings

CCC Math Placement Test Content	General Math CST	Algebra I CST	Geometry CST
Whole Numbers and Fractions	52.51%	46.49%	N/A
Decimals and Percents	62.34%	33.33%	N/A
Applications and Interpreting Tables/Graphs	45.75%	65.54%	68.33%
Integers and Rationals	81.48%	78.13%	N/A
Algebraic Expressions and Operations	70.85%	89.64%	33.33%
Operations with Exponents	63.99%	41.67%	N/A
Equations, Inequalities, and Word Problems	61.07%	81.45%	66.67%
Functions	100.00%	91.27%	100.00%
Trigonometry	N/A	N/A	89.63%
Geometry	71.12%	100.00%	82.98%
Graphing	97.78%	76.93%	100.00%
Applications and Other Algebra Topics	86.86%	100.00%	91.08%

Note: Criterion value for alignment: ≥ 50%

Table 5. Range of Knowledge Ratings

CCC Math Placement Test Content	General Math CST	Algebra I CST	Geometry CST
Whole Numbers and Fractions	58.33%	23.75%	N/A
Decimals and Percents	65.28%	14.58%	N/A
Applications and Interpreting Tables/Graphs	50.79%	20.41%	9.52%
Integers and Rationals	48.15%	31.25%	N/A
Algebraic Expressions and Operations	27.34%	68.06%	6.25%
Operations with Exponents	54.17%	52.08%	N/A
Equations, Inequalities, and Word Problems	42.42%	49.49%	12.12%
Functions	25.40%	20.99%	11.11%
Trigonometry	N/A	N/A	38.89%
Geometry	56.94%	18.75%	70.14%
Graphing	18.06%	27.08%	25.00%
Applications and Other Algebra Topics	21.67%	6.67%	16.19%

Note: Criterion value for alignment: ≥ 50%

gular matched standard of Geometry. The fact that several of the standards failed to meet the minimum ROK requirements suggests that many of the standards that meet the benchmark for CC do so because many high school test elements map onto only a few community college objectives within that standard.

Balance of Representation. BR is analyzed differently than the other three alignment values and is benchmarked at a higher proportion of .70. For all three tests, every standard that met the criterion for CC far exceeded this minimum standard. This is partially explained by the fact that the community college objectives rarely matched more than one or two high school test elements. Table 6 provides the calculated value for the BR index across the CCC objectives for General Mathematics, Algebra I, and Geometry.

Discussion

The primary purpose of this study was to determine the degree CCC entrance expectations are consistent with the mathematics content to which high school students are exposed. Previous studies suggest that on a national level alignment between secondary and postsecondary educational systems is poor. Studies in California of tests taken by the best prepared eleventh-grade students suggest that alignment is good in English but poor in mathematics.

Table 6. Balance of Representation Ratings

CCC Math Placement Test Content	General Math CST	Algebra I CST	Geometry CST
Whole Numbers and Fractions	90.72%	94.73%	N/A
Decimals and Percents	90.62%	100.00%	N/A
Applications and Interpreting Tables/Graphs	84.74%	84.39%	72.50%
Integers and Rationals	97.69%	98.44%	N/A
Algebraic Expressions and Operations	86.31%	87.15%	66.67%
Operations with Exponents	86.71%	100.00%	N/A
Equations, Inequalities, and Word Problems	90.61%	86.49%	100.00%
Functions	89.05%	89.71%	100.00%
Trigonometry	N/A	N/A	88.13%
Geometry	94.05%	100.00%	87.38%
Graphing	81.53%	94.14%	100.00%
Applications and Other Algebra Topics	85.97%	100.00%	79.26%

Note: Criterion value for alignment: ≥ 70%

How well do the CSTs in General Mathematics, Algebra I and Geometry align with the content of the most commonly utilized math placement tests in the California Community Colleges? Overall, the CSTs explored did not demonstrate a considerable amount of content alignment with the CCC placement tests. Fully one-third of all objectives emphasized on community college placement tests are not tested on the General Mathematics, Algebra I, or Geometry CSTs. Furthermore, if the results of the Brown and Niemi study (2009) are considered along with those of the current study, only one additional category, functions, is measured by the additional tests. Therefore, one-quarter of math objectives emphasized by community college placement tests are standards that are not tested at the high school level.

Several standards that matched in terms of CC failed to meet the ROK criterion. This indicates that many standards that meet the benchmark for CC do so because the high school test elements are mapped onto a minimal number of community college objectives within that standard. This demonstrates that there are significant areas of content mismatch between the exams. In the areas where content match does occur, however, the high school tests do comparatively well in terms of depth and balance. This indicates that, when the same content in high school and community college tests are assessed, the high school tests are generally at a cognitive level at least as great as that of the community college placement tests.

Are there areas emphasized on the mathematics placement tests that are not measured by the CSTs? As previously indicated, this analysis identified four categories, or one-third of the CCC placement standards, that failed to achieve a sufficient content match. According to the Brown and Niemi study (2009), the augmented forms of the Summative High School and Algebra II standards tests also fail to meet the minimum criteria in three of these four identified categories, that is integers and rationals, trigonometry, and graphing. Overall, when the results of these two studies are considered together, it becomes apparent that 25% of the core objectives being assessed by the CCC placement exams are not emphasized in California high school assessments. Furthermore, given that several standards failed to meet the minimum benchmark for ROK, it can be determined that a considerable proportion of standards that have demonstrated content match place emphasis on objectives that do not appear on high school tests.

It is possible that the areas of integers and rationals or graphing are assessed

on earlier CSTs. However, considering that the General Mathematics test measures standards as early as sixth grade, this is not likely. It is more plausible that placement tests measure course elements that are no longer emphasized to the degree they have been in the past. Since California adopted high school mathematics content standards, the mathematics curriculum has changed considerably. Although there are specific standards for Trigonometry and Linear Algebra (California State Board of Education, 2007) that may address some inconsistencies, these courses are no longer part of the standard college preparatory math sequence (see University of California, 2008).

To what degree can performance on the CSTs measure progress towards meeting the "de facto" college readiness standards in mathematics, as defined by CCC placement test content? Although there are areas of gross inconsistencies between the high school and college-level assessments explored here, many standards did show adequate alignment. Furthermore, where alignment did occur, the high school assessments measured the objectives at a level of cognitive complexity at least as great as that of the college placement tests. This indicates that the high school standards tests have the potential to be utilized as benchmarks towards meeting college readiness standards, as they do a good job at measuring achievement of these standards in which a content match does occur. Therefore, should the articulation between the two systems be improved in terms of content, the CSTs have the potential to be utilized to diagnose areas in which students need additional preparation before matriculating to a postsecondary course of study.

Most of the alignment that did occur was found within the General Mathematics Test. In fact, neither the Algebra I nor the Geometry test showed CC with any standard that was not also addressed by the General Mathematics Test. The only exception is that the Algebra I test did a better job at measuring the standard of algebraic expressions and operations.

The General Mathematics test also demonstrated content match in several of the categories that are essentially excluded from the augmented CSTs that are used to make placement decisions at the UC/CSU level: whole numbers and fractions, decimals and percents, applications and interpreting tables/graphs, and operations with exponents. Therefore, it would be beneficial to explore the degree to which this test could be utilized, either in its existing or a modified format, to make placement decisions at the community college level.

Implications for Policy and Practice

Findings suggest that California's K-12 and college-level expectations need to be more explicitly articulated. This is consistent with findings across the nation that indicate that there is a disconnect between what occurs at the secondary and postsecondary levels of education. This lack of connection means that a student who masters the standards of a college preparatory curriculum during high school is still likely to be denied access to college-level courses at the community colleges. It also means that the high school standards, in their current form, do not prepare students for the reality of community college expectations. Given that community colleges are designed to serve any student who can benefit from a higher education, this current situation is not only inefficient and unfair, it is inconsistent with the philosophy of the institutions.

This could be addressed through a combination of two main policy changes. One option is that the high school level standards and assessments could be revised to reflect the expectations that students will face upon matriculation to the college campus. Alternatively, the community colleges could predicate their placement test on the high school level standards of the prerequisite classes for college-level coursework.

The best solution may be a combination of the two. The community colleges could explicitly define their expectations for beginning college-level work, keeping in mind the high school standards for the prerequisite coursework. A common set of placement exams should then be developed that considers these expectations. Should the postsecondary education system determine that any objectives not currently addressed in the K-12 standards are vital, the K-12 education system could re-evaluate their standards. This will ensure that all required content knowledge is sufficiently emphasized during the standard course-taking sequence that most college bound high school students take.

Implications for the K-12 System. California needs to ensure high school level standards sufficiently emphasize the topics that are deemed necessary for college preparation. In the next revision of the California Content Standards, it is important for the K-12 educational system to take steps to ensure that these standards reflect college readiness standards. Once the higher education system ensures that their expectations are made explicit, the K-12 standards can include these expectations.

To help students, teachers, and counselors diagnose problem areas early in students' preparation during high school, the testing system should include college readiness indicators. Along with their scores on the regular standards tests, students should receive feedback on their progress towards meeting college readiness goals. Teachers should be given a report in the fall on the areas of strength and weakness of their class so that they can supplement classroom instruction to strengthen these areas. Counselors can utilize the individual reports to place students in the proper classes.

College readiness indicators would allow students to improve their math preparation during their senior year of high school. This would allow them to review the core

concepts that are necessary to successfully place into and perform well in college-level math classes, and would give the students time to review content that is emphasized on placement exams but underemphasized in the high school curriculum.

Addressing this problem completely will take a great deal of time and collaboration across various educational sectors. However, high school instructors and administrators can immediately take steps to improve their students' postsecondary success. First, these leaders should work with the local community college district where the majority of their graduates attend. Through articulation agreements and clear and continuous communication, student outcomes can be improved at community colleges. For example, high school administrators can negotiate with community college administrations to allow students to place into college-level courses through the successful completion of pre-approved courses. Second, high school teachers should be made aware of the content of the placement exams of the local community colleges. This will allow teachers to supplement the regular curriculum with content that appears on the placement exams, but is not emphasized by the state standards.

Implications for California Community Colleges. First, California Community Colleges should explicitly define expectations for college-level coursework. Incoming college freshmen would also benefit from a systemwide placement policy so that high school students and teachers are clear about what individuals are to demonstrate in order to be placed into college-level classes. A new, system-wide placement test based upon the high school standards, with a well-publicized blueprint, would also help to clarify the expectations of students preparing for college. Once the testing systems are better aligned, the California Department of Education should begin to include college readiness indicators as part of its Standardized Testing and Reporting procedures. This would allow schools, teachers, parents, and students to become aware of any deficiencies students may have while there is still time to address them.

Second, the California Community Colleges may want to consider the feasibility of utilizing data from the augmented form of the CSTs for student placement, given that these exams are being used for this purpose by the California State University system. Finally, they may want to consider working with the department of education to develop an augmented form of the General Mathematics CST that includes the CCC placement standards currently not being assessed. This is important because the majority of community college bound students do not take the Algebra II or Summative High School math tests. In this way, all students would have an opportunity to take a math test that could be used to make college placement decisions.

Community colleges have a history of local control over all decisions, including curricular content. This has led to the current system of different placement tests and course content across the state. The concept of standards for community college courses is met with resistance from many instructors, as they both enjoy and feel entitled to their autonomy. However, the California higher education system is built around a transfer model, and community college courses designed for transfer to the four-year universities should have the same prerequisites and content as their counterparts at the university level. In practice, this means that students will be more successful if the courses are standardized. The University of California and California State University both have standardized their entrance expectations with the a-g requirements. The K-12 system has standardized its course specific and exit expectations with curricular standards. Community colleges are the only public institutions within the state that have not standardized expectations.

Standardizing community college expectations will require a significant investment initially in both time and money; however, it will be better for students and more fiscally responsible. Standardization will allow the colleges to develop a common placement exam and facilitate communication with high schools and their students. Ultimately, standardization has the potential to significantly reduce the time and money spent on basic skills level courses.

Limitations of the Study

This study was conducted using a Webb alignment methodology (1997). Although this is the most widely accepted and comprehensive method of assessing content alignment, it is not without limitations. One of the primary concerns is with the binary nature of content matching. Each item and standard is either considered a match or not; there is no room for partial or near matches. Raters found this confusing. During the training session, they were encouraged to be liberal in determining whether a match occurred, considering a partial match to be a match. Therefore, this study likely overestimates the amount of content alignment that actually occurs.

During the training period, raters expressed concern regarding the DOK levels. They felt that the cognitive complexity of an item varies with students' developmental ability and mathematical expertise. Raters were encouraged to consider the complexity of an item for the 'typical' college freshman. However, each rater's concept of a typical student is likely to vary greatly depending on his/her exposure to high school seniors and college undergraduates. For example, the rater who teaches basic math at the community college likely views the cognitive level of the typical freshman differently from the rater who teaches AP Calculus to high school students.

Furthermore, although measuring the alignment between secondary and postsecondary assessments is an important step in understanding the factors that contribute to the widespread placement of students into remedial level noncredit bearing courses, alignment alone will not fix the problem. Other factors that may contribute to the issue are language barriers, student motivation, and lack of preparation for college. Additionally, alignment is not the only important issue to consider when evaluating the appropriateness of college placement tests. Colleges also need to examine the predictive validity of the cut scores utilized against performance in future coursework. This analysis highlighted system-wide areas of misalignment across many placement tests, and does not provide validity evidence for individual assessments within the system.

Suggestions for Future Research

Although there are areas of misalignment, many CCC placement objectives were adequately measured by the California high school standards tests. It would be useful to utilize these assessments as one measure of readiness for college-level work. Using high school tests to make college placement decisions could mitigate many alignment concerns while saving colleges a considerable amount of money. Therefore, the potential for utilizing CST scores to make placement decisions should be explored.

However, these tests were designed as summative evaluations and not as placement tests. Therefore, before they can be used for this purpose, an analysis is needed to verify both the predictive validity, for performance in future courses, and to determine appropriate cut scores. This could be accomplished by following a sample of high school graduates and determining how well their high school standards scores predict future math success.

Furthermore, in order to graduate from California high schools, students are required to pass an examination in mathematics and English, namely the California High School Exit Exam (CAHSEE). Considering that all students take this exam, it would be informative to determine the degree to which performance on the CAHSEE could be used to measure progress towards college readiness or to make placement decisions. To that end, an alignment study should be performed on the CAHSEE and the core objectives for the CCC placement tests.

Finally, the timing and subject matter of courses students take in high school has an impact on future performance. Prior research has shown that the likelihood of college success is enhanced by taking more advanced high school courses such as Algebra II (ACT Inc., 2007). California could benefit from a study that looks at the course-taking patterns of high schools students and its effect on both placement scores and future performance.

In conclusion, this study found that there are several areas of misalignment between California secondary and postsecondary expectations. Specifically, community college placement tests assess students in three main areas that are not part of the key standards for which students are held accountable in high school, namely integers and rationals, trigonometry, and graphing. In order for placement tests to fairly measure students' capabilities to perform in future math courses, the high school and community college assessment systems should be better aligned.

Most students, regardless of ethnic or economic background, want to go to college. However, the current misaligned system disproportionately affects poor and minority students. African American and Latino students are more likely to begin their education at the community college level, more likely to be placed into noncredit bearing courses, and less likely to remediate successfully. Therefore, misalignment contributes to racial inequities rather than providing an equal opportunity for advancement. Improving the alignment across secondary and postsecondary assessments can help to ensure that students are given a sufficient opportunity to learn and demonstrate the skills and knowledge that are necessary for college success.

Although improving alignment will not solve all social inequities, it is a vital step toward providing all students equal opportunities to obtain the education they want and need. Improving outcomes at the community college level, where students enter the postsecondary educational pipeline, has the potential to improve students' motivation and performance in community college classrooms, leading to increased opportunities for transfer and ultimate degree attainment. This will provide all students, especially poor and minority students, with the opportunity to improve their social standing through increased educational attainment.

References

ACT Inc. (2007). *ACT National Curriculum Survey®*, 2005-2006. Iowa City, IA: ACT, Inc.

Armstrong, W. B. (1994). *Math placement validation study: A summary of the criterion-related validity evidence and multiple measures data for the San Diego Community College District.* CA: San Diego Community College District, Research and Planning.

Armstrong, W. B. (1999). *Explaining community college outcomes by analyzing student data and instructor effects.* Unpublished doctoral dissertation, University of California Los Angeles, CA.

Armstrong, W. B. (2000). The association among student success in courses, placement test scores, student background data, and instructor grading practices. *Community College Journal of Research and Practice, 24*(8), 681-695.

Bhola, D. S., Impara, J. C., & Buckendahl, C. W. (2003). Aligning tests with states' content standards: Methods and issues. *Educational Measurement: Issues and Practice, 22*(3), 21-29.

Brennan, R. L. (2001). *Generalizability theory.* New York: Springer.

Brown, R. S., & Conley, D. T. (2007). Comparing state high school assessments to standards for success in entry-level university courses. *Educational Assessment, 12*(2), 137.

Brown, R. S., & Niemi, D. N. (2009). Content alignment of high school and community college assessments in California . *The Journal of Applied Research in the Community College, 16*(2), 109-118.

California Community Colleges. (2006). *System strategic plan.* Retrieved March 25 2007, from http://strategicplan.cccco.edu

California Department of Education. (1960). *A master plan for higher education in California, 1960-1975.* Sacramento, CA.

California Department of Education. (2008). *California Standardized Testing and Reporting (STAR) Program.* Retrieved May 5, 2008, from http://star.cde.ca.gov/star2007/Viewreport.asp

California State Board of Education. (2007). *Content standards - Standards & frameworks (CA Dept of Education).* Retrieved Nov 27, 2007, from http://www.cde.ca.gov/be/st/ss/

California State University. (2006). *Fall 2006 final regularly admitted first-time freshmen remediation systemwide.* Retrieved Mar 19, 2007, from http://www.asd.calstate.edu/remediation/06/Rem_Sys_fall2006.htm

Education Trust-West. (2004). *The a–g curriculum: College-prep? Work-prep? Life-prep. Understanding and implementing a rigorous core curriculum for all.* Oakland, CA

Herman, J. L., Webb, N. M., & Zuniga, S. A. (2007). Measurement issues in the alignment of standards and assessments: A case study. *Applied Measurement in Education, 20*(1), 101-126.

Impara, J. C. (2001). *Alignment: One element of an assessment's instructional utility.* Paper presented at the National Council on Measurement in Education, Seattle, WA.

Isonio, S. (1992). *Implementation and initial validation of the MDTP Tests at Golden West College.* Huntington Beach, CA: Golden West College, Office of Institutional Research.

Lundell, D. B., Higbee, J. L., Hipp, S., & Copeland, R. E. (2004). *Building bridges for access and success from high school to college: Proceedings of the Metropolitan Higher Education Consortium's Developmental Education Initiative.* Minneapolis, MN: Minnesota University Center for Research on Developmental Education and Urban Literacy.

Marwick, J. D. (2004). Charting a path to success: The association between institutional placement policies and the academic success of Latino students. *Community College Journal of Research and Practice, 28*(3), 263-280.

Marzano, R. J. (2001). *Designing a new taxonomy of educational objectives.* Thousand Oaks, CA: Corwin Press.

Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives.* Thousand Oaks, CA: Corwin Press.

Mushquash, C., & O'Connor, B. P. (2006). SPSS and SAS programs for generalizability theory analyses. *Behavior Research Methods, 38,* 542-547.

No Child Left Behind Act of 2001, Public Law 107-110 (2002).

Shavelson, R. J., & Webb, N. M. (1991). *Generalizability theory a primer.* Newbury Park, CA: Sage Publications.

Shavelson, R. J., & Webb, N. M. (2006). Generalizability Theory. In J. L. Green, G. Camilli, P. B. Elmore & American Educational Research Association (Eds.), *Handbook of complementary methods in education research.* Washington, D.C: Lawrence Erlbaum Associates.

Shavelson, R. J., Webb, N. M., & Rowley, G. L. (1989). Generalizabilty theory. *American Psychologist, 44*(6), 922-932.

University of California. (2008). *2008 Guide to "a-g" Requirements and Instructions for Updating Your School's "a-g" Course List.* Retrieved April 14, 2010, from http://www.ucop.edu/sas/admit/a-greqs2.pdf

Webb, N. L. (1997). *Criteria for alignment of expectations and assessments in mathematics and science education.* Research monograph No. 6. Washington, DC: Council of Chief State School Officers.

Webb, N. L. (1999). *Alignment of science and mathematics standards and assessments in four states.* Research monograph No. 18. Madison, WI: Wisconsin Center for Education Research.

Webb, N. L. (2002, April 1-5). *An analysis of the alignment between mathematics standards and assessments for three states*. Paper presented at the American Educational Research Association Annual Meeting, New Orleans, Louisiana.

Webb, N. L. (2007). Issues related to judging the alignment of curriculum standards and assessments. *Applied Measurement in Education, 20*(1), 7-25.

Willett, T. (2007). *Research Summary 2006-2007.* Encinitas, CA: California Partnership for Achieving Student Success.

Alison R. Shelton, *Ed.D., Department of Mathematics, Walnut High School, can be reached at 909-594-1333, x34438 or ashelton@alumni.usc.edu.*

Richard S. Brown, *Ph.D., is an associate professor with the Rossier School of Education, University of Southern California. He can be reached at 213-740-9567 or richard.brown@usc.edu.*