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Exploring Mathematics College Readiness in the United States

Nancy J. McCormick and Marva S. Lucas

Middle Tennessee State University

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Abstract

Large numbers of students graduate high school unprepared for post-secondary education and ill-equipped for the labor force of the 21st century. Research on college readiness reveals the prominent role that mathematics preparedness plays in the fulfillment of hopes and dreams for a college degree. As requirements for post-secondary education and qualifications for the workforce merge, college readiness in mathematics is a significant factor in job opportunities and career choices. This report provides an in-depth exploration in mathematics college readiness in the United States and offers a compilation of recommendations from many significant constituents who have made notable advances in mathematics preparedness in the education of today's high school students.

Keywords: college readiness; mathematics college readiness; workforce readiness; underprepared students; remediation

About the Author(s)

Authors: Nancy J. McCormick and Marva S. Lucas

Affiliation: Middle Tennessee State University

Address: Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37132

Email: nmccormi@mtsu.edu

Biographical information:

Dr. Nancy J. McCormick is currently an Associate Professor in the Department of Mathematical Sciences at Middle Tennessee State University. She has served as an area representative and as the chapter treasurer for the Tennessee Association for Developmental Education. Her work with online courses earned an Outstanding Achievement in Instructional Technology Award in 2003, as well as a Tennessee Board of Regents Distance Education Innovations Award in 2004.

Dr. Marva S. Lucas is currently an Associate Professor and Chair of University Studies at Middle Tennessee State University. She teaches mathematics and is responsible for testing and placement of incoming students. In 2004, she received certification as a Developmental Education Specialist from the Kellogg Institute of Appalachian State University. In the past, she has served as President and Political Liaison for the Tennessee Association for Developmental Education (TNADE), a chapter of the National Association for Developmental Education (NADE).

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Exploring Mathematics College Readiness in the United States

Research shows a surprisingly large number of students in the United States (U. S.) graduate from high school unprepared for post-secondary education. Various sources resoundingly echo each other in the conclusion that the U. S. faces a college readiness crisis (ACT, 2004; Bradley & Blanco, 2010; Conley, 2007; Kaye, Lord, & Bottoms, 2006). According to a 2004 report from American College Testing (ACT), higher education is in the midst of an ongoing college readiness deficit that has not shown any significant improvement in the decade leading up to the report. Greene and Winters (2005) reported only 34% of the graduating class of 2002 left high school equipped with the skills necessary for college-level work. A report issued from the U.S. Department of Education indicated that 28% of first-year students enrolling in four-year institutions in fall 2000 required remedial coursework (Adelman, 2006). The proportion rose to 42% for students entering public two-year colleges (Kobrin, 2007; Russell, 2008). A similar study in 2001 conveyed a more disturbing number stating approximately 50% of first-year college students were enrolled in remedial courses (Morgan & Michaelides, 2005).

Moreover, as requirements for readiness in post-secondary education and readiness for the workforce continue to converge, many high school graduates also find themselves ill-equipped for the 21st century job market (Achieve, 2005; Ali & Jenkins, 2002). Mathematical skills and abilities are often tested and used to judge the qualifications of job applicants in many career choices (Duranczyk & Higbee, 2006). A joint publication of the National Governors Association Center for Best Practices, the National Conference of State Legislatures, the Council of Chief State School Officers, and the National Association of State Boards of Education (2008) stated more than half of all new jobs through 2014 will require some college experience. Studies also emphasize the significant role that mathematics college readiness plays in an applicant's choice of and admission to institutions of higher education (Olson, 2006) and even in the eventual attainment of a college degree (Adelman, 2006; Hall & Ponton, 2005). This literature review explores the following questions:

1. What is mathematics college readiness?
2. What is the status of college readiness in mathematics?
3. Why is mathematics college readiness important?
4. Why is there a deficit in mathematics college readiness?
5. What efforts are underway to address mathematics college readiness?

Finally, this investigation offers a compilation of recommendations from many significant constituents. Using this information, the authors outline the elements of a strong mathematics program for today's high schools.

What is mathematics college readiness?

College readiness is a vital issue to several important groups. High school teachers have heightened interest because as key players in a student's final preparation prior to college, they are more likely to be held accountable when students graduate without skills necessary for post-secondary education. Parents are apprehensive because the hopes and dreams for their children's futures hinge most likely on a college degree (Greene & Winters, 2005). Students who receive a high school diploma want to have the assurance that they are prepared to meet the challenges of a post-secondary curriculum leading to a college degree and a promising career. Employers desire qualified personnel who will enable companies to be productive and competitive in a global economy. Lastly, government officials at both state and national levels realize the value of an educated citizenry. This diversity of stakeholders at various points of involvement attests to the importance of college readiness (Achieve, 2005; Ali & Jenkins, 2002).

In spite of the attention that has been devoted to this topic, a great deal of ambiguity remains about the definition of college readiness. As a result, research identifies several perspectives by which college readiness is measured and defined. These perspectives include, but are not limited to, high school courses completed, high school grade point average (GPA), mathematics content and procedural standards, scores on national tests and college placement exams, and success in first-year college courses. A summary of the viewpoints is reflected by Conley's (2007) statement that "college readiness can be defined operationally as the level of preparation a student needs in order to enroll and succeed – without remediation – in a credit-bearing general education course at a post-secondary institution that offers a baccalaureate degree or transfer to a baccalaureate program" (p. 5).

Applying Conley's definition, mathematics college readiness is a student's ability to be successful in college-level mathematics courses without the need for remedial or developmental coursework (Conley, 2007). Efforts to establish standards or benchmarks that are indicative of a student's readiness in mathematics have been undertaken by both secondary and post-secondary educational systems in various states and by several national organizations. At the secondary level, successful completion of a required number of high school mathematics courses signifies college readiness while college readiness at the post-secondary level is more often judged by scores on institutional placement exams or on nationally recognized college entrance exams.

Using national data, ACT in a 2007 report defined mathematics college readiness by a correlation of ACT benchmark scores with success rates of students in credit-bearing mathematics courses at post-secondary institutions. The ACT benchmark score for mathematics college readiness was determined to be 22, which is associated with a 50% chance for a student to earn a grade of B or better and a 75% chance of a C or better in college entry-level mathematics courses (ACT, 2007; Kaye, Lord, & Bottoms, 2006).

In defining college readiness, Kobrin (2007) examined scores on the Reasoning Test component of the Scholastic Aptitude Test (SAT). First-time students enrolling at 41 postsecondary institutions in 1995 were studied in an effort to establish benchmarks that predict at least a 65% probability of attaining either a first-year college GPA of 2.7 or higher or a first-year college GPA of 2.0 or higher. It should be noted that this investigation looked at the overall college GPA, while ACT considered GPAs for specific entry-level college courses. The research determined benchmarks for a first-year college GPA of 2.7 or higher to be 590 on the SAT Verbal and 610 on the SAT Mathematics. Indicators for a first-year college GPA of 2.0 or higher were 360 on the SAT Verbal and 370 on the SAT Mathematics.

Various state initiatives identified both procedural and content standards in defining mathematics college readiness. The Transition Mathematics Project (TMP) in Washington State undertook a collaborative endeavor involving K-12 education, colleges, and universities to determine requirements for college readiness in mathematics. Procedural standards included the abilities to communicate, to reason and problem-solve, to make connections between mathematical concepts, and to relate mathematics to other disciplines and real-life situations. Content standards included number sense, geometry, statistics and probability, algebra, and functions (TMP*,* 2006). Ohio, one of the early partners in the American Diploma Project (ADP), emphasized both content and process for college readiness in mathematics and asserted, "algebra continues to be the most fundamental prerequisite for success in college mathematics" (Ohio Board of Regents [OBR], 2007c, p. 12). Similar standards defining mathematics college readiness were developed by faculty from seven campuses in the University of Maine System (n.d.). This group also stressed procedural and conceptual knowledge as important achievements for the understanding of mathematics.

In considering the role of technology in college readiness, its proficient use is an important standard that can be used to promote students' understanding of mathematical concepts, but with the stipulation that proficiency in technology does not equate to competency in mathematics (OBR, 2007a; TMP, 2006). Ohio's position statement on technology advised that a mathematics curriculum provide students with the knowledge of how to use technology and, more importantly, with the ability to recognize when the use of technology is warranted for efficient problem solving (OBR, 2007c).

What is the status of college readiness in mathematics?

The work to define mathematics college readiness reveals and quantifies a lack of preparedness on the part of many students enrolling in institutions of higher education. Only 43% of students tested nationally reached the established ACT benchmark. Though test scores for Caucasian and Asian students were slightly to somewhat higher than the national average, 52% and 68%, respectively, minority students did not fare as well with 13% of African-American students and 27% of Hispanic students tested reaching the benchmark (ACT, 2010). Studies also revealed that female students are less likely to be prepared for college-level mathematics than their male counterparts (Kobrin, 2007; Long, Iatarola, & Conger, 2009).

Assessment of college readiness benchmarks as defined by SAT research and presented by the College Board showed that for 1995 and 2005 only 22% and 25%, respectively, of college-bound students met the criterion for a 2.7 or higher first-year college GPA (Kobrin, 2007). The National Assessment of Educational Progress (NAEP) showed one-fourth of high school seniors in 2005 were proficient in mathematics (Boser & Burd, 2009; Huebner & Corbett, 2008). Although 66% of high school graduates enroll in colleges and universities, many of this number are unprepared for college-level work (Achieve, 2008a).

Ohio reported that for first-time freshmen entering post-secondary institutions in fall 2003, 70% had completed the minimum college preparatory curriculum that includes four English courses and three courses each of mathematics, science, and social studies. Twenty-four percent had taken the complete core of college preparatory courses consisting of four courses in English, mathematics, and social studies, and three courses (biology, physics, and chemistry) in science (OBR, 2007b). Yet, 32% of these first-time freshmen required remedial or developmental coursework in mathematics (OBR, 2007a). For students who had taken the complete core of courses, every measured outcome was better with remediation rates of 15% and average ACT scores of 24 (OBR, 2007b). Overall, almost one-third of the nation's high school graduates who enroll in college are not prepared for college-level mathematics (Long, Iatarola, & Conger, 2009).

Why is mathematics college readiness important?

The number of students seeking enrollment in higher education institutions has been increasing steadily. According to the National Center for Education Statistics, undergraduate enrollment was 7.5 million in 1970, 15.2 million in 2006, and projected to be 17 million in 2017. (National Center for Education Statistics [NCES], 2008). Approximately 33% of all first-year college students enroll in remedial programs, which are available at 99% of public two-year institutions and at more than 75% of public four-year institutions (Boser & Burd, 2009) The cost of remediation for these students ranged from 2.31 to 2.89 billion dollars in public post-secondary institutions during the 2004-2005 academic year (Strong American Schools [SAS], 2008). Citing difficulties in obtaining reliable information as to the exact costs associated with remediation, Russell (2008) stated a cost of $1.4 billion annually for community college students as estimated by the Alliance for Excellent Education. It should be noted that this calculation represented only the cost for students who were recent high school graduates and did not include non-traditional students and students attending four-year colleges.

Within the larger post-secondary population, there are a growing number of underprepared students who also find themselves unready for a workforce that has changed considerably (American Council on Education, 2004). According to Ali and Jenkins (2002), several studies have indicated increased commonalities between skills necessary for the workplace and post-secondary success. Employers have expressed a need for applicants to have not only a high school diploma, but to have comparable skills and knowledge required of students entering post-secondary education (Achieve, 2005). Based on national surveys conducted by the American Management Association, many potential employees fail literacy and mathematics skills tests. The 17% increase in failure rates from 1996 to 1998 was attributed to the testing of more advanced job skills as opposed to an actual decline in the skills of applicants (Ali & Jenkins, 2002). A more recent survey by the National Association of Manufacturers indicated 84% of companies surveyed suggested that K-12 schools were not doing an adequate job of preparing students for the workforce (Eisen, Jasinowski, & Kleinert, 2005).

Employers identified the following areas of great concern: basic skills related to timeliness, attendance and work ethic; mathematics and science; and reading comprehension (Eisen, Jasinowski, & Kleinert, 2005). The cost of remediating these basic skills is shouldered by many employers and providing this service can be very expensive. In Michigan, the most conservative estimate of the cost for remediation of basic skills by businesses was $222 million yearly (Greene, 2000). Approximately 60% of jobs in the labor force require some education at the post-secondary level and that percentage is expected to continue to increase. In addition to basic skills, employers also want to hire individuals who have the ability to be effective oral and written communicators, to be independent researchers, and to be complex problem solvers (Achieve, 2005). It is predicted that almost two-thirds of future jobs will require college-level mathematics skills (Huebner & Corbett, 2008).

The role of higher-level mathematics is increasingly significant in paving the way to post-secondary and workplace success. In 2008, the Vice President of Achieve appeared before the House Committee on Education and referred to mathematics as a "gateway" to college and career goals (Achieve, 2008a). ACT (2006) reports that high school students need a comparable level of readiness in mathematics for success in college and in workforce training programs. Advanced mathematics courses, upper-level courses beyond Algebra II, are among the high school courses ACT labels as *Courses for Success* and greatly affect students' readiness for college (ACT, 2004). The *Texas College Readiness Standards* adopted by the Texas Higher Education Coordinating Board in 2008 and published by the Educational Policy Improvement Center (EPIC) goes even further in stating the increasing importance of mathematics as the world becomes more and more quantitative in nature. The standards indicate "mathematics knowledge is essential to becoming a productive citizen" (Achieve, 2008a, p. 15).

The understanding of mathematics bridges all subject areas, as well as the globalization of today's society, and provides measures to effectively interpret, critically analyze, and evaluate data in both numeric and visual presentations. In a global economy where American 15-year olds ranked 25th among 30 developed countries in mathematical literacy in 2006, there is a growing concern whether the U.S. can remain competitive without a greater emphasis on mathematics in its schools (Chikoore, 2008). The economy, security, and government of the nation depend more than ever on a college-educated population in the workforce (SAS, 2008).

Mathematics readiness affects college admission and acceptance to many degree programs. Although many public two-year institutions of higher education have an open-door policy for admission, students often find they are denied access or have limited opportunities for enrollment in some four-year institutions or universities based on a lack of readiness for college-level mathematics (Huebner & Corbett, 2008). Even when admitted to higher education institutions, a deficit in a student's preparation in mathematics often limits choices of college majors and careers. In addition, there is a strong correlation between preparedness for college mathematics and the actual completion of a college degree. Students who need remediation in mathematics are considered at-risk for academic success and for retention and perseverance in their post-secondary education (Ali

& Jenkins, 2002). ACT reports that students who are prepared for college mathematics are more likely to enroll in college. Once there, students who are college-ready in mathematics are far more likely to earn grades of B or better in college algebra and to earn college GPAs of 3.0 or better. Also, a greater number of them return to the same institution for their second year of college (ACT, 2007). Clifford Adelman (2006) reports a far higher percentage, 71%, eventually complete a bachelor's degree if they have completed their college-mathematics credits by the end of their sophomore year compared to a 38% graduation rate for students who have not completed their mathematics credits during the same time frame.

Why is there a deficit in mathematics college readiness?

Clearly, not enough graduates are exiting high school with the preparation that will be needed to be successful either in college or in the workplace (Achieve, 2008a; Eisen, Jasinowski, & Kleinert, 2005). One reason offered for the lack of preparedness for college mathematics includes the number of students not tracked to the college-preparatory curriculum. Only in recent times has the need for all students to be college-ready been recognized by educators. Prior to the 1980s, few believed that high school should prepare all students for college. Until then, barely 50% of high school graduates enrolled in higher education (SAS, 2008). As a result, the K-12 educational system was not designed to prepare all students for college (Russell, 2008).

More recently, the number of high school graduates who enroll in higher education has risen considerably. Approximately 66% of graduates now enroll in institutions of higher education in the fall following high school graduation (Boser & Burd, 2009). A major impetus to the growing number of high school graduates seeking college degrees lies in changes in the skills and training necessary to be competitive. Yet, most high schools are not preparing students for the rigors of coursework at the university level (SAS, 2008). Only 29% of low-income students are tracked to college preparatory classes, compared to 49% and 65% for medium- and high-income students, respectively.

Similar disparities exist for African American and Latino students whose enrollment rates in a college-prep track are 28% and 23%, respectively, compared to 34% for white, non-Latino students (Chait & Venezia, 2009).

A 2006 report prepared by the National Math Panel of ACT reveals an actual loss of momentum in students' progress toward college readiness during their high school years. The loss is attributed to a lack of direction on the part of the states in establishing and defining specific course standards and expectations for mathematics achievement in high schools. While more than two-thirds of high school teachers surveyed believe they are meeting state standards for preparing students for college-level mathematics, approximately the same ratio of post-secondary educators believe students are coming to college unprepared (ACT, 2007), indicating a serious misalignment between the expectations of K-12 and post-secondary education. The high school exit exams in several states are assessing mathematics content at an eighth or ninth-grade level (Achieve, 2004; Boser & Burd, 2009). In many cases, teachers at the secondary level are focused on preparing students to pass state exams that are not aligned with post-secondary expectations for mathematics (Conley, 2007). Also, teachers at the secondary level often assume they need to cover a broad range of topics in advanced mathematics courses while teachers at the post-secondary level are more concerned that high school students receive a rigorous and in-depth coverage of the fundamental mathematics topics (Chait & Venezia, 2009).

One of the more significant factors in mathematics college readiness is whether high school students take a higher mathematics course following completion of Algebra II. Seventy-three percent of students who had completed a course higher than Algebra II placed into college-level mathematics at North Arkansas College compared to a 29% placement for students who did not take a course beyond Algebra II (Berry, 2003). In a Higher Education Policy Brief by the American

Association of State Colleges and Universities, Russell (2008) reported only 21% of students who completed three years of high school mathematics were college-ready.

Several studies of students in post-secondary public institutions noted increased test scores on standardized exams for students taking more advanced mathematics courses in high school (ACT, 2004; Berry, 2003; OBR, 2007b). A study conducted on students in Florida high schools who continued to public higher education institutions in the state found that 35% of the deficit in readiness gaps for students of Hispanic ethnicity could be attributed to the differences in courses taken when compared to Caucasian counterparts. It was also determined for higher readiness rates among Asian students, compared to Caucasians, that 75% of the readiness gap was attributable to the number of mathematics courses taken. However, African American students and those students from a poorer socio-economic background received smaller gains from completion of higher-level mathematics courses than their racial and socio-economic counterparts, suggesting differences in the quality of educational opportunities (Long, Iatarola, & Conger, 2009). Research has shown that schools in low socio-economic communities do not offer the higher-level mathematics courses needed for a college preparatory curriculum. Adelman (as cited in Huebner & Corbett, 2008) reported that while 72% of high schools in the wealthiest communities offer Calculus, only 44% of high schools in high poverty communities do so.

Even when the right courses are offered, often a lack of rigor or inconsistency in the level of rigor still leaves students unprepared for college mathematics (ACT, 2005). Additionally, some students may opt to take easier courses, especially in their senior year, and others may be discouraged from taking the more challenging courses as a result of low expectations by teachers (Bamburg, 1994; Russell, 2008). Ali and Jenkins (2002, p. 18) went so far as to state “the cycle of low achievement begins and ends with low expectations of our students.”

What efforts are underway to address mathematics college readiness?

Nationally, President Bill Clinton introduced legislation in 1994 requiring states to develop more rigorous academic standards and to provide ways to assess student performance. President George Bush followed up on this action by endorsing the No Child Left Behind Act in 2002. Other federal initiatives focused on assisting low-income students in gaining access to post-secondary education. Three such programs include TRIO Talent Search, TRIO Upward Bound, and GEAR UP. For disadvantaged middle and high school students who have been recognized as having college potential, TRIO Talent Search offers both in- and out-of-school programs to encourage these students to pursue higher education. TRIO Upward Bound works with high school freshmen and sophomores to provide academic support for core subjects, and GEAR UP begins in middle school grades establishing college partnerships to make counseling and other college outreach services available to disadvantaged students (Boser & Burd, 2009).

Achieve, an independent, bipartisan, non-profit education reform organization based in Washington, DC, launched the ADP Network in 2005. The goal of Achieve through ADP is to help states raise academic standards and graduation requirements, thus enhancing college and career readiness. Since its inception, the ADP Network has grown to include 35 states (Achieve, 2010). This growth is an indication that states are acknowledging the problem and are actively involved in seeking solutions. Often mathematics courses with the same name are not created equal. For example, a student's high school transcript may list Algebra II as a course successfully completed. However, Algebra II could have been classified as "general" or "honors" at the high school attended, indicating that the course requirements were different. Furthermore, "honors" Algebra II can be quite different in content covered from one school to the next or from one state to the next (Kaye, Lord, & Bottoms, 2006). Recommendations emphasize the importance of aligning content on high school exit exams to reflect newly developed college readiness standards. Criteria should be consistent and built on skills and knowledge that high school and post-secondary faculty have agreed as necessary for success in beginning college-level courses (Kaye, Lord, & Bottoms, 2006; Spence, 2007).

In an effort to promote instructional rigor, consistency, and accountability among high schools, the Southern Regional Education Board (SREB) advocates end-of-course exams particularly in mathematics and English (Kaye, Lord, & Bottoms, 2006). In May 2005, representatives from fourteen states participating in the American Diploma Project, with support from Achieve, took initial steps toward the development of an Algebra II end-of-course exam. Secondary and post-secondary faculty, working together, constructed the exam to directly assess content knowledge following completion of Algebra II. Test items were designed to correspond to identified standards that faculty agreed correlated to college-readiness in entry-level mathematics courses. Constructed in this manner, the exam was judged to be “significantly more rigorous than most statewide high school exams” (Achieve 2008b, p. 11). Many sources have noted that high school exit exams often test mathematical content at an eighth or ninth grade level and do little to measure college readiness in mathematics (ACT, 2007; Boser & Burd, 2009; Chait & Venezia, 2009). In spring 2008, approximately 90,000 students across 12 states took the exam. In the initial administration, student performance on the exam was low, as expected, with average scores ranging from 21-35% (Achieve, 2008b). The low performance was attributed to the increased level of difficulty of the exam, to it being the first year of using the test instrument, and to a lack of motivation as no consequence or reward was associated with students’ test scores. In 2009, an Algebra I end-of-course exam was also developed and administered. With the exams firmly in place, the consortium acknowledged the next step would require states to ensure a level of consistency and rigor within the mathematics curriculum. For optimal results, states must also provide students and teachers with necessary resources (Achieve, 2009).

Mathematics college readiness merits special attention due to the prominent role that mathematics preparedness plays in admission to post-secondary institutions and in ultimately earning a college degree. According to two landmark studies conducted by the U.S. Department of Education, "the highest level of math taken in high school is the most powerful predictor of whether a student will ultimately earn a bachelors degree, and that students completing Algebra II in high school more than doubled their chances of earning a four-year college degree" (Massachusetts Department of Elementary & Secondary Education, 2007, ¶ 7). The SREB advocated that all students take an essential core of mathematics courses that go beyond Algebra II to include a mathematics course in the senior year. However, for the core to be effective, SREB also proposed the development of uniform standards and end-of-course assessments to promote instructional rigor in these courses. In six of the SREB states that utilized end-of-course tests in Algebra I, initial pass rates have increased (Kaye, Lord, & Bottoms, 2006).

Prior to end-of-course evaluations, instruction can be tailored to meet the needs of students through formative assessments administered over several short periods throughout the academic year. Both informal and formal assessments can be used to modify teaching and learning strategies in an effort to address student deficiencies. Informal reviews include teacher observations and classroom discussions, while formal reviews include homework and tests (Boston, 2002). When citing elements of a strong mathematics program, Huebner & Corbett (2008) stated "this kind of assessment can provide critical and timely information about what students understand and where they need help. Armed with this knowledge, teachers are better prepared to adjust their instruction, keep students on track, and help them meet learning goals" (p. 3). Using this approach, Fenway High School in Boston, Massachusetts adjusted mathematics instruction based on students' specific needs and recorded a 91% pass rate for tenth graders taking the state's mathematics exam (Huebner & Corbett, 2008).

In Washington, a statewide effort began in 2004 to develop standards for mathematics college readiness. Representatives from both secondary and post-secondary faculty groups formulated a set of standards called College Readiness in Mathematics (CRMS). The project revised a mathematics placement test given at both two-year and four-year post-secondary institutions to align with the newly developed standards. The revised placement exam provided "a standard definition of college readiness in mathematics" (Office of Educational Assessment*,* 2007, ¶ 2). A version of this placement test will be administered to 11th graders in the state as an earlier assessment of college readiness in mathematics to identify areas of weakness and to provide needed interventions (Office of Educational Assessment*,* 2007; TMP*,* 2006).

Interlake High School in Bellevue, Washington made dramatic improvements to its mathematics curriculum that resulted in noteworthy increases in achievements for all students. The school had been noted as the poorest performing school in the district. Since 2003, Interlake has been reported by *Newsweek* as one of the highest ranking schools in the nation (as cited in Huebner & Corbett, 2008). Unlike the state, Interlake High School strongly encourages all students regardless of their past academic history to take four mathematics courses including pre-Calculus. All basic mathematics courses were eliminated, and all mathematics courses were offered at the honors level or higher. To go along with this recommendation, numerous support options were made available to enhance the students' chances for success. The school staff operated on the premise that "every student is a math student" (Huebner & Corbett, 2008, p. 9). As a result of this approach, students' mathematics scores on the Washington Assessment of Student Learning improved from less than 49% to almost 75% proficiency over a three year period. This improvement in the state assessment was also reflected at the national level on the SAT college entrance exam. In the reporting period for 2007, Interlake students had an average mathematics SAT score of 550, which was 19 points above the state average and 32 points above the national average (Huebner & Corbett, 2008). According to

SAT benchmarks, a score of 550 predicts a first-year college GPA between 2.0 and 2.7 (Kobrin, 2007).

Examples of student support efforts at Interlake include a summer program offered to students before their entrance to high school. Middle school teachers identify students who may need additional assistance in mathematics and communicate with the high school to direct students to this program. The high school also recognizes that some problems with student success are not academic, but rather problems with self-regulatory behavior such as being organized, coping with stress, and managing time. Interlake provides an after-school program in which students receive assistance in these areas (Huebner & Corbett, 2008).

Granby High School in Norfolk, Virginia emphasizes collaboration among its teachers in the mathematics department to encourage the exchange of ideas for more effective teaching methods and strategies. This sharing of teaching techniques cultivates an atmosphere of continual teacher development and professional learning. Teachers, working collaboratively, collect and analyze student data to provide on-target and timely changes in instruction. At Granby, "professional learning is a constant, guided by teachers' real-world needs and, thus, targeted to their daily efforts to help all students succeed in mathematics" (Huebner & Corbett, 2008, p. 17). Based on findings from the Third International Mathematics and Science Study (TIMSS) and the National Science Foundation (NSF), Granby High School is taking the right approach for improving mathematics education (Zucker, 1997, 2010). Granby High School students have shown increased pass rates of 84% and 90% for Algebra I and Algebra II, respectively, and now take more advanced mathematics courses including Calculus. Faculty professional development at Granby High School contributed significantly to Granby's student achievement gains (Huebner & Corbett, 2008).

Although states are looking for ways to strengthen students academically prior to receiving a high school diploma, state officials are concurrently providing support for underprepared students who, nevertheless, have been granted admission to higher education. State funding is often used to help post-secondary institutions respond to the college readiness crisis and to effectively serve the needs of underprepared students. Across the nation, many programs and initiatives have been implemented. Most of these efforts include offering remedial courses that are designed to bring students to a level where they can be successful in entry level college courses. Over the years, the discipline addressing this concern has been termed "developmental education" (Boylan & Bonham, 2007). For many institutions, developmental education programs have been enhanced through the Achieving the Dream project, another national effort that focuses on improving the success rates of community college students (Boser & Burd, 2009). Various projects aimed at aligning secondary and post-secondary standards include, but are not limited to, the following: AP courses, dual enrollment, International Baccalaureate degree program, tutoring services, and professional development for teachers (Boser & Burd, 2009).

Conclusion

The literature reveals the significant role that mathematics readiness plays in admission to higher education. Mathematics readiness merits special attention because a deficit in a student's preparation in mathematics limits choices of college majors and careers. There is also a strong correlation between preparedness for college mathematics and the prospect of earning a college degree (Ali & Jenkins, 2002). This review provides a broad examination of college readiness in mathematics. Many studies have established that the lack of college readiness is a long-standing and prevalent problem, affecting greater and greater numbers of U. S. high school graduates. Overall, nearly 33% of students admitted to post-secondary institutions are not prepared for college-level mathematics (Long, Iatarola, & Conger, 2009). The SREB reports the number of students requiring remediation in mathematics exceeds numbers for remediation in either reading or English (Kaye, Lord, & Bottoms, 2006).

The mathematics readiness problem significantly impacts college success, workforce eligibility, and U. S. competitiveness in a global economy. This study presents various factors influencing college readiness and reveals a serious disconnect between a high school diploma and a student's preparedness for post-secondary education. Historically, secondary and post-secondary institutions have functioned as separate entities. The goal of formulating realistic and effective college readiness standards obligates these two groups to collaborate in identifying skills and content knowledge that students will require to be successful in entry-level college courses. The elements for a strong mathematics program as indicated from the examination of literature should be implemented within an emerging culture focused on intellectual development and high expectations for all students. Only then will real value be restored to a high school diploma enabling graduates to reach their highest potential in post-secondary education and in a labor force geared to a global economy.

Recommendations

A review of college readiness in general suggests that all high schools should foster a climate of academic challenge necessitating continuous intellectual development on the part of students and teachers alike. Specifically, the literature indicates the following elements of a strong mathematics program:

1. A common college preparatory core of rigorous courses for all students;
2. An offering of advanced courses beyond Algebra II;
3. A continual emphasis on teacher professional development to improve content knowledge and pedagogical skills;
4. A culture of high expectations and intellectual development for all students;
5. Student support services;
6. Formative assessments utilizing student data to modify instruction as needed; and

7. Standards developed by secondary and post-secondary educators with exit exams reflecting agreed-upon standards for college readiness.

Taking higher-level mathematics courses in high school relates positively to student success in initial post-secondary coursework (Russell, 2008). A high school curriculum consisting of more rigorous coursework is needed for all students. Tracking all students to a college preparatory curriculum has been shown to be particularly effective for minority students and for students formerly classified as low-achievers. In fact, a rigorous course selection has been shown to be more important in student success than either income or education level of parents (ACT, 2005, 2007; Ali & Jenkins, 2002; Boser & Burd, 2009; Huebner & Corbett, 2008; Olson, 2006). A curriculum of demanding courses needs to go beyond the traditional core to span four years of mathematics including courses beyond Algebra II. Students taking more advanced courses are the ones who are most likely to be ready for college. Advanced mathematics courses are a part of the *Courses for Success* that ACT recommends for all students going into college or the workplace (ACT, 2004).

Increasing student requirements to include more advanced mathematics courses necessitates teacher development in content knowledge and pedagogical skills to address new standards (Achieve, 2009; Conley, 2007). Strategies for teaching should include ways to serve a diverse student population and multiple learning styles. Support for students in challenging college preparatory courses might be provided in the forms of double class periods for some subjects and through after-school and summer programs that target those students needing extra help. Additionally, customized learning plans based on formative evaluations and individual needs could be generated for at-risk students (Achieve, 2005).

States are recommended to reevaluate and change teacher licensure requirements to correspond to the more rigorous curriculum that is being promoted. Concurrently, post-secondary education needs to make adjustments in teacher preparation programs to produce qualified teachers for effective instruction in more advanced course offerings (Achieve, 2005; Chait & Venezia, 2009; Spence, 2007).

The elements of a strong mathematics program reflect a school culture of high expectations and an environment where all students are given the opportunity to reach their potential. Such an environment promotes the success of individual students and serves to narrow achievement gaps among ethnicities and socio-economic groups within the student population (Achieve, 2005). A demanding school curriculum immersed in a culture that not only emphasizes content knowledge, but also recognizes the importance of developing key cognitive strategies such as analysis, interpretation, precision, accuracy, problem solving, and reasoning prepares students for success both in post-secondary education and in the workplace (Conley, 2007).

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ARIZONA STATE UNIVERSITY