Annotated Bibliography – Mathematics, Course Requirements and the Relationship to College Preparation and Success

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Barth, P. (2013). **The Curious Case of Algebra II**. *American School Board Journal.*

This short article discusses the importance of Algebra II to college and career success and provides some history about the research reports that came to this conclusion in 2004 and 2005. Barth acknowledges that the importance of Algebra II has more recently been called into question, citing a more tenuous connection between intermediate algebra and career readiness.

- Two reports that contributed to the notion that Algebra II is an indicator of college readiness come from the American Diploma Project in 2004, which was arrived at through surveys of business leaders and higher education faculty as well as analyses of admissions and placement exams. In 2005, ACT conducted a crosswalk between its college admissions tests and its WorkKeys assessments for various occupations.

- More recently, these results have been called into question. The issue seems to come down to whether students were going directly into the workforce or attending college at various levels, from community to the traditional four-year option. Algebra II does not necessarily matter as much for those students who are going directly into the workforce (Barth, 2013). NCEE's issue is not specifically about Algebra II but is based on community college math offerings; they would recommend that students be allowed to take various math pathways as they enter high school, focusing on varied types of reasoning like modeling, statistics, probability and applied geometry. Barth takes some exception to this, stating that this might be ideal if we expected students to immediately go into their career paths or college majors, but that the purpose of secondary education goes beyond specific notions of employment and career and instead is supposed to build reason, critical thinking and broader skills to prepare students for a variety of occupations or academic experiences (2013). After all, most 14-year-olds could not be reasonably expected to chart out their career path the moment they enter high school.

- "And of all high school courses, high-level math seems to have the most powerful relationship to future success in college and the job market, as the Center for Public Education (CPE) shows in our 2009 report."

- "Over the last decade, Algebra II has become the proxy math for both college and career readiness. By 2012, Algebra II was a graduation requirement in 19 states."

Buddin, R., Croft, M., & ACT, I. (2014). **Do Stricter High School Graduation Requirements Improve College Readiness?** ACT Working Paper Series. WP-2014-1.

This working paper explores the relationship between high school graduation requirements and student outcomes in the state of Illinois. It followed a change to graduation requirements in Illinois in 2005, increasing the math and science classes that students must take. The authors did a district-level comparison in one state because the districts had common standards and funding mechanisms.

- Budding & Croft quote the National Assessment of Education Progress (NAEP), "Only 35% of eighth-graders are proficient or advanced in math in 2013, and only 32% demonstrated proficiency in science in 2011."

- Their review of the literature on this topic shows, "Mandated course requirements may have only a small effect on student achievement (Budding & Croft, 2014)." The exceptions to this finding were if students were given progressively advanced coursework or if they were otherwise motivated to succeed. In the end, course content only matters if students are fully engaged in learning and getting good grades.

- Budding & Croft's research found that baseline math scores were similar in treated districts, which were affected by the new statewide requirements, and untreated districts, which already required the math and science coursework and that math scores have risen generally since 2005, but these results were not statistically significant. Math scores also differed among student demographic groups, with Black students and Latino students scoring lower, while non-Latino students and Asian American students scored higher. Additionally, income was related to math scores, with an increase of 0.04 per $10,000 in family income.

- College enrollment rose faster in districts affected by the higher requirement than other districts to a tune of a 5% increase in treated districts versus a 2% increase in untreated districts.

- Budding & Croft conclude that policymakers are misguided to think that there would be a significant increase in academic achievement simply by changing course requirements. These changes are more likely to reflect the fact that underserved or less engaged students likely receive weaker educational foundations than their higher-achieving counterparts.

- Budding & Croft state that students: "must possess the necessary prerequisite skills to then take advantage of the advanced material. Efforts should be focused on early preparation to ensure that students have the skills by the time they reach high school.

For students already in high school, targeted remediation efforts are necessary, and the remediation efforts may need to be differentiated by ability level, distinguishing students with very weak ability to those only slightly behind." There is no magic bullet to improving academic outcomes and college readiness. Better instruction, student commitment, parent support, and a "host of other factors," are necessary for success. (2013)

Burdman, P. (2015). **Degrees of Freedom: Diversifying Math Requirements for College Readiness and Graduation**, Report 1 of a three-part series). Policy Analysis for California Education & LearningWorks.

This report, the first in a three-part series on math standards and college readiness with a focus on California, advocates for fundamentally changing how educators think of math course requirements to better meet the needs of modern students for the kinds of degrees and careers they are and will be pursuing. Specifically, Burdman asks readers to consider two major developments.

- Technological tectonics: New technologies require students and workers to think of math and reasoning differently in modern times. Operations that have gained importance include statistics, data analysis, modeling, and computer science. These changes are already being seen in post-secondary education with professors altering courses or adding focuses on statistics more than traditional, calculation-based offerings. With enrollment decreasing in traditional college algebra, it leads to the question of how effective it is to require all students to take it. Alternatively, post-secondary programs could redesign algebra to offer a greater focus on the processes most relevant to what students may need to know now, such as statistics.

- Demand for deeper learning: A constant need to revisit the basics has educational stakeholders up in arms about improving K-12 mathematics, with an emphasis on deeper learning. Educators, particularly in math and science, wish to move away from teaching isolated procedures and facts and toward encouraging students to solve problems in various contexts. This, of course, speaks to a broader conversation about what colleges and universities expect their students to know and how primary and secondary educators teach their students, which must also meet the demands of public schooling and testing. "Nationally, about $2 billion is spent on remedial math education." (Burdman, 2015)

- These debates have led to questioning the utility of learning Algebra II in high school. While people generally agree on the importance of Algebra I, the intermediate follow-up is still a hotly debated issue. The emphasis has now turned to making sure students learn concepts they can broadly apply to problems in and outside of academia rather than learning discrete skills and formulas for the purpose of passing tests. According to

Burdman, the issue comes down to whether a school wishes to prepare students for traditional colleges or community colleges. The assumption is that greater numbers of students in community colleges will pursue an education in science and technology.

- The issue of credentialing and Algebra II is an emergent issue in education. Namely, courses labeled Algebra II across the nation can teach vastly different things, and some better prepare students than others. A lack of standards can hurt students if these standards vary widely in schools around the nation.

- "In 2014, the American Mathematics Association of Two-Year Colleges (AM-ATYC) passed a resolution saying that intermediate algebra should not be a 'universal prerequisite for all college-level mathematics courses.' The experiments have reported surprisingly strong results, tripling and quadrupling students' passage of college-level math courses." (Burdman, 2015) Of course, weakening traditional requirements, if done on the basis that they think students will just not pass, leads to questions of whether alternative programs have rigor, whether ending Algebra II as a requirement will close off college pathways for students, and whether an education without algebra will lead students into a dead end.

- The report includes a small section on national math and science associations urging change to meet the challenges of new technology and STEM education.

- Revising math requirements to enact positive change and deep learning will require improving instruction at all levels. Recommendations offered by Burdman in this report include the following:
    - Keep the focus on maximizing student success.
    - Base requirements for coursework on what students need for subsequent coursework, career, and citizenship rather than basing them on abstract notions about desired knowledge.
    - Increase communication so that the implications of policies on students can be known to prevent misalignment.
    - Scrutinize academic requirements notable for high failure rates.
    - Make room for experimentation and innovation, but always gather evidence about its effectiveness.

Burdman, P. (2015). **Degrees of Freedom: Varying Routes to Math Readiness and The Challenge of Intersegmental Alignment** (Report 2 of a three-part series). Policy Analysis for California Education & LearningWorks.

This second report in Burdman's three-part series on the intersection between math readiness and college success covers the issue of remedial courses at the college level and how new strides, especially at the community college level, have been taken to emphasize other types of math and reasoning, but that this issue conflicts with long-held beliefs within math departments about the importance of algebra for all students. Burdman calls for educators and policymakers to reexamine their thoughts on math progression and how to better shape the college experience to suit the needs of different students. This report has more of a focus on California and how changing course requirements at the community college level creates alignment issues with universities.

- "Nationally, 68% of two-year college students place into remedial math…Though enrollment in remedial education is consistent across all racial groups, under-represented… students [of color] were more likely to be placed at lower levels."

- "Nationally, only 32% of students assigned to developmental math, some of whom actually skip developmental math, ever complete a college-level math course that is typically required for graduation."

- Research on remedial education in college has shown that it has insignificant or negative effects on student success. It also provides a barrier that lengthens a student's college career and potentially discourages his or her degree completion.

- This report also touches on the issue of Algebra II in high school and how there is a persistent lack of consensus on what this course entails (standards and definitions), which is problematic since it is considered such a metric in predicting college success and preparing students for their coursework.

- Burdman posits that if, over time, alternative math course offerings show that students do well in subsequent studies and their careers, then there will be an empirical basis that supports using various methods to prepare students.

- Burdman mentions the Texas New Mathways Project, being developed by the Charles A. Dana Center at the University of Texas at Austin, which is working with Texas community colleges to diversify remedial sequences. She points to this project, in particular, as a trailblazer in creating and testing new pathways for remedial math.

- In the end, Burdman recommends that we have a new conversation about what it means to know math. She emphasizes the following:
    - The pursuit of concrete, data-driven projects that seek to understand existing math offerings, analyze student progress in math across segments to understand roadblocks, and include math faculty and faculty from client disciplines in the name of collaboration and transparency.

- Higher education should not adopt policies to interfere with the ability to gather evidence on the effectiveness of alternatives in mathematics.

Burdman, P. (2015). **Degrees of Freedom: Probing Math Placement Policies at California Collegesand Universities** (Report 3 of a three-part series). Policy Analysis for California Education & LearningWorks.

This third and final report in Burdman's three-part series exploring "the role of math as a gatekeeper in higher education," centers on remedial courses, in general, and how they can prevent students from succeeding in college (2015). This leads back to the question of math requirements in high school, proper preparation, reliance on exams, and college policies that railroad students into remedial courses.

- Burdman acknowledges that higher education tends to fault high school instruction or curriculum for a high rate of students in remedial classes at the start of their post-secondary education. She states that recent research also faults unfair placement practices on behalf of post-secondary education; one example is that community college students are more likely to require remedial math courses than university students with similar records.

- "High school grades also appear to be better predictors of success in college math courses than the placement tests that are typically used."

- Burdman specifically addresses California when addressing placement policies. She states that test content, in general, does not always align well with high school or college curriculum, and that that use of test results frequently conflict with the norms of these tests that say test scores should never be the sole factor in placing a student.

- In an attempt to address inconsistent or inefficient placement policies, colleges and some universities are considering the following reforms:
  - Changing tests based on the assumption that they are flawed but can be improved.
  - De-emphasizing tests in favor of using multiple measures for placing students. This includes differentiated placement, self-placement, and accelerated placement.
  - Supporting student test-taking by using college readiness tests in high school and offering refreshers and boot camps for students in college.

- Burdman calls for reforms in how colleges look at remedial placement. Strategies must be more pragmatic, transparent, and supportive of student success. Additionally, there needs to be more research done on issues, such as text anxiety and stereotyping to inform policies at the college level.

- Burdman makes it clear that changing policies at the college level will affect primary and secondary education. Differentiated placement, in particular, might require that high schools force students to choose paths early on, which would be an unwise practice for young students who are still discovering what interests them. Rather than creating a battle between the systems, Burdman emphasizes transparency and collaboration.

Curry, D. (2017). **Where to Focus so Students Become College and Career Ready. Journal of Research & Practice for Adult Literacy.** *Secondary & Basic Education,* 6(1), Page 62-66.

This article focuses on the issue of students not being given a solid foundation in the earliest stages of math and reasoning, and Curry pinpoints this lack of foundation as a major contributor to students not being college and career ready. Curry also traces this issue back to how we educate teachers, the underlying assumptions of how students learn, and when students are expected to be able to master higher-level math concepts. The writer provides some guidance about how to help students build foundational math and even offers a few suggestions on what teachers can do to train themselves to more consciously build reasoning and basic math skills outside of rote math lessons.

- Students should have a strong conceptual foundation so that they can apply math knowledge and reason to any new situation that arises. Unfortunately, many educators feel that they do not have the time to teach proper foundations, so they focus on procedures and tricks to prepare students for the current coursework and testing demands.

- Without a fundamental, foundational understanding of concepts and processes, students will not retain the procedures or know how to use them properly in the future.

- Curry cites the National Center on Education and the Economy (NCEE), which conducted a two-and-a-half-year study on the skills and knowledge students needed to be college and work ready. Researchers found that high school math was not as important as foundational middle school level mathematics when it came to being successful in college courses.

- There's an exacerbated assumption prevalent in the United States that elementary level mathematics are basic, superficial, and that people commonly understand them; if educators, employers, and even lawmakers think that all students entering secondary and post-secondary education have a firm grasp of basic mathematical concepts, then of course they would expect them to be able to grasp intermediate and upper level mathematics.

- Curry also suggests that teachers themselves must be better prepared to teach mathematics because if the educator does not fully understand the basics, how can they be expected to clearly teach it to their students?

- "Teachers who not only teach procedures but also conceptual understanding give students a foundation from which to add new knowledge."

- Curry includes a sampling of ideas to help students develop skills in reasoning and analysis at earlier levels, which are based loosely on the CCR Math Standards. These include building on benchmarks slowly, teaching estimation strategies and expecting students to use them outside of structured math lessons, working on proportional reasoning early with graphs and patterns, helping students visualize what is happening with basic math and reasoning concepts, and constantly asking students to reason through their answers.

Gaertner, M., Kim, J., DesJardins, S., & McClarty, K. (2014). **Preparing Students for College and Careers: The Causal Role of Algebra II.** *Research in Higher Education,* 55(2), 143-165. doi:10.1007/s11162-013-9322-7

This paper by Gaertner and his colleagues attempts to tackle the question of whether or not college and career readiness are the same thing when it comes to high school coursework. More specifically, the study, "Compares the effect of advanced mathematics coursework in high school on college versus career outcomes (Gaertner, et al., 2014)." Their focus is specifically on Algebra II because of its status as a predictor of success in college.

- Gaertner and his colleagues state that degree requirements assume that college and career readiness are the same. They argue that this concept has far more nuance and, though the skills required for both are similar, the need to apply skills is what differentiates students who pursue post-secondary education, those attempting to learn technical careers and college students who are now pursuing the real-world application of their degrees.

- The results suggest that taking Algebra II is beneficial to students' college outcomes. In other words, it is a decent way to predict potential college success, but not career success. Overall, the study suggests that college and career readiness are not synonymous. The researchers add the caveat that their findings did not show that Algebra II actively hurt the career side, so policymakers should think twice about eliminating it in favor of vocational training while in high school. Taking Algebra II can also help students who change their minds about a career trajectory in high school or beyond.

- The researchers' findings also suggest that there is something about Algebra II that has changed in this century. They surmise that No Child Left Behind's emphasis on Algebra II for high school graduation has led to a watered-down version of the intermediate algebra course.

HaycocK, K. (2010). **Building Common College-Ready Standards.** *Change*, 42(4), Page 14-19.

This article is a little behind the times when it comes to changing standards, but Haycock provides some of the history underpinning the original shift on the part of governors and state school officers to increase curriculum requirements for high school students. It provides some potentially useful background information.

- When this report was written in 2010, about two-thirds of high school students were taking at least Algebra II, with about a quarter completing higher level courses, such as pre-calculus, trigonometry, statistics, or calculus.

- Many of these curriculum changes were driven by students and their parents. In this case, parent and community involvement enacted positive change when parents and students made it clear they wanted students better prepared for college and an eventual, stable career. "The growth in college orientation among low-income students and students of color has been nothing short of stunning. Perhaps more than any others, these students know that a college education is the best, if not the only, chance they have to enter the American mainstream" (Haycock, 2010).

- Haycock readily acknowledges that part of this standards reform movement is predicated on frustration about students not being prepared for college and taking remedial courses in record numbers. She thus emphasizes the fact that definitions of the fundamental skills needed for college success vary greatly between campuses and locales making it difficult for schools to adequately prepare wide varieties of students who may attend schools all over the country. She emphasizes the need for national standards so that educators across the United States can be on the same page when it comes to agreeing on the fundamental skills that students should learn to be adequately prepared for college and career.

- Haycock cites a conversation she heard in London where two educators, the equivalent to a principal and assistant principal, debated about a student's achievement. They used a very localized jargon that pointed to their commonly understood educational standards. She adds, "The standards in most of our states are so vague that it would be impossible to know how to approach such a conversation" This again speaks to the potential that educational woes on a national scale can be exacerbated by a lack of a

common language about standards in mathematics.

Loveless, T. (2013). **Algebra II and the Declining Significance of Course Taking**. Brookings.

This report from Loveless sheds light on what the author refers to as the weakening of credentialing of courses leading up to Algebra II in high school (2013). Specifically, Loveless describes the seemingly paradoxical state of affairs in California where more students than ever are taking advanced math courses but are not properly learning the advanced concepts presented in upper-level, college-prep math courses because their credentialing in earlier math classes has been poor. Rather than an issue with teacher quality or course textbooks, Loveless highlights a pipeline problem or prerequisite courses such as Algebra I and geometry being improperly labeled as such and no longer laying the foundation for higher level math courses, such as Algebra II.

- "A study out of California found that marginal math students who spent one more year before tackling Algebra I were 69% more likely to pass the algebra end-of-course exam in ninth grade than ninth grade peers who were taking the course for the second time after failing the algebra test in eighth grade. The researchers referred to a leaky pipeline put under increased pressure by California's aggressive placement of low achieving eighth graders in Algebra I, but a large number of students quit taking math just as soon as they could in high school.

- "The 2005 National Assessment of Educational Progress (NAEP) High School Transcript Study (HSTS) found that high school graduates in 2005 earned more mathematics credits, took higher level mathematics courses, and obtained higher grades in mathematics courses than in 1990. The report also noted that these improvements in students' academic records were not reflected in 12th grade NAEP mathematics and science scores. Why are improvements in student course-taking not reflected in academic performance, such as higher NAEP scores?"

Mazzeo, C., & Consortium on Chicago School, R. (2010). **College Prep for All? What We've Learned from Chicago's Efforts.** Policy Brief.

This brief describes a research study conducted by the Consortium on Chicago School Research (CCSR) at the University of Chicago and the University of Michigan on Chicago's 1997 curriculum reform to better inform legislation and national policy deliberations. The form mandated that all students entering high school in 1997 must complete college preparatory coursework that was four years of English, four years of math, three years of laboratory science, and three years of social science.

The brief, written by Mazzeo, only focuses on two courses, Algebra I and English I. Overall, the findings do not support the theory that requiring more students to take higher level or college prep classes improves graduation rates or test scores. Mazzeo provides a major caveat to this finding by stating that there are many possible reasons outcomes worsened including a lack of foundational support for educators and little effort to change the way they were teaching students who were weaker in English and mathematics to begin with. Prior to the 1997 study, differentiated curriculum was not serving Chicago students well, so there is clearly plenty of work left to be done.

- ● The author acknowledges that the question of changing course requirements potentially leading to improved outcomes for students is something that still needs to be better studied. He states that, too often, this kind of research is plagued with a type of selection bias, that students who choose to take higher level or college prep classes are self-motivated and so can be expected to do well in these harder classes. Additionally, schools that are prepared to teach these classes are likely already college-oriented in other ways.

- The findings of this study include the following.
    - 90% of Chicago Public Schools' students were enrolled in college prep classes after the policy change.
    - Gaps in course enrollment by race and ethnicity largely disappeared with this new policy.
    - This policy led to a reduction in tracking.
    - Though students were more likely to have earned English I and Algebra I credits by the end of the ninth grade, test scores in math and English were unaffected by the increase in college-prep coursework in the ninth grade.
    - Absenteeism increased significantly among students with stronger skills in both subjects.
    - Students with weaker skills in these subjects saw an increase in course failure by 7.7 percentage points in math and GPAs declined by 0.15 points.
    - Requiring a full four years of college prep courses made it more difficult for students to get the proper credits to graduate, and graduation rates saw an overall decline after the new policy.
    - Students with higher GPAs and a B average or better were slightly less likely to go to college.

- Mazzeo states that despite some of the more negative aspects of this study, the equity element and achievement in course taking was a very positive outcome.

- Curriculum reform cannot work without building better school capacity. Mazzeo hypothesizes that part of the reason these efforts were not more successful was because there were no major, foundational changes that went with these reform efforts. He states that there is a contrast between elementary school reforms that focus on the way courses should be taught, and high school reforms focusing on which courses to offer and to whom.

- Legislators and policymakers must provide more support to educators who will teach a wider range of students a more complex subject matter and so must have the proper support to teach varied learners.

Key Points

While math courses specifically tailored to each student's future career would be the most effective use of time, most students are not prepared to decide what their future career will be in high school. Therefore, a broader range of courses, including higher level math courses, is necessary to prepare all students for the multitude of paths they may eventually pursue in secondary education and in their careers.

The success of raising math requirement levels in higher grades is dependent on the quality of the students' educational foundation and their levels of motivation to achieve high grades.

The AM-TYC's success following the removal of Algebra II from the required coursework in two-year colleges questions the course's necessity but doubt about whether this new pathway has the same level of rigor echoes the concern of varying credentials of Algebra II itself.

With so much evidence pointing to the negative effects of remedial math courses in secondary education, extensive research is being pursued to find alternative ways to teach higher math courses in high school that will result in deeper understanding for all types of learners as opposed to the traditional path, which some students fail to grasp.

The misalignment of high school and college math requirements, including dependence on test scores for placement, non-standardized levels of learning in courses like Algebra II, and little research on students' test taking weaknesses, like anxiety, result in many students placed in remedial math courses in secondary education.

The underestimation of early mathematical learning and its retention results in unprepared high school and college students. The more basic math courses taught in middle school have been found to be more essential to students' understanding of math than courses learned in high school.

College and career readiness are differentiated by the need to not only learn but apply skills. While Algebra II proved necessary and a good indicator to the success of college students, it had no real effect on their career readiness.

In the past decade, a large motivator to align college and high school math standards originated in the students and their parents who struggled to be prepared for local as well as out of state colleges where coursework and knowledge rarely lines up.

Even when students do motivate themselves to take upper level math courses, many struggle to learn the advanced concepts because they do not have a stable foundation of basic math knowledge from previous years of school.

The 1997 Chicago research did not support the claim that high requirements of math courses would increase the test scores and graduation rates, however, more students did earn course credit, supporting the theory that how high school math courses are taught is more important than to whom and when.

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