



Which Method Matters? A Comparative Analysis of Traditional and Integrated Mathematics Pathways in Secondary Education

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Abstract

This literature review evaluates two pathways of mathematics instruction, the Traditional siloed pathway of Algebra I, Geometry, and Algebra II and the Integrated pathway of Math I, II, III, with a focus on three critical domains: conceptual retention and critical thinking development, college and career readiness, and teacher effectiveness and preparation requirements. This review synthesizes existing research, highlighting the trade-offs in choosing either pathway. Findings suggest that the Integrated pathway carries advantages in standardized test performance, student confidence, and conceptual understanding, particularly for already-high-performing students, while the Traditional pathway is strong in developing students' algebraic skills and may reduce cognitive load through its focused and sequential instruction. Therefore, neither pathway is definitively superior over the other: effectiveness of either depends on student goals and interests, as well as overall teacher implementation quality. The Integrated pathway, in particular, demands broader instructional knowledge on the part of teachers and so may require more intensive professional development, which presents a challenge in implementation that could limit its advantages for the general population. Both pathways carry structural limitations: the Traditional model's rigidity stands as a barrier for non-STEM students, while the Integrated model requires teaching expertise that may exceed available training resources. This review therefore concludes that pathway selection must account for student demographics, career aspirations, teacher capacity, and available professional development; neither pathway should be adopted as a universal requirement.

Keywords: *integrated mathematics; traditional mathematics pathways; conceptual retention; college readiness; teacher professional development; pedagogical content knowledge; Common Core State Standards*

1. Introduction

Since the adoption of the Common Core State Standards (CCSS) in the United States in 2010, there have been two main structural pathways for students to follow in mathematics: the Traditional model, sometimes referred to as a "siloed mathematics model," (Algebra I, Geometry, Algebra II) and the Integrated model (Math I, Math II, Math III), which includes courses that blend together algebraic, geometric, statistical, and probabilistic concepts into three discrete segments throughout a student's high school years, with the goal of adoption being to improve college and career readiness for students (Regional Educational Laboratory Northwest, 2023; Gao, 2019). By describing an integrated option alongside the traditional course sequence, CCSS opened the door to a different philosophical approach to teaching high school



mathematics. The Traditional pathway emphasizes depth, with each year focused on a single subject, e.g. Algebra I, which allows students to, ideally, achieve mastery in that specific area prior to moving on to a greater challenge. Contrastingly, the Integrated Pathway aims to mirror international curricula, particularly those with high levels of mathematical success at the time of adoption, such as Singapore and Japan (Harlow, 2015). By presenting mathematics as interconnected between subjects instead of as containing discrete subjects, the mathematical concepts would, according to the goals of the Integrated program, reinforce and illuminate one another in the eyes of students (Hanover Research, 2015).

However, more than a decade after CCSS made the Integrated model a widely available option, many states and school districts have maintained or returned to the Traditional model, reflecting a lack of consensus regarding either model's effectiveness for both college readiness and beyond (Loveless, 2013). For instance, in California during the 2017–18 school year, 54% of districts followed the Traditional pathway, while 46% chose the Integrated pathway (Gao, 2019). Of special note, California districts with more high-need students (English learners, low-income students, or foster youth) were more likely to adopt the Integrated model, while districts with more certified math teachers were slightly more likely to choose the Traditional pathway; student performance, however, did not differ significantly by pathway (Gao, 2019). Therefore, school districts must continue to navigate pathway selection without certainty. In October 2025, for example, a Glendale Unified School District board meeting on pathway selection was contentious and ultimately led to a delay in decision-making for the sake of further needed research and community feedback (Glendale Unified School District, 2025). This is a vital issue precisely because the chosen pathway affects student learning, teacher training, curriculum material, and how prepared the student will ultimately be for post-high school education. One important consideration for such a decision is the fact that research shows fewer than half of students complete gateway mathematics courses in their first year of college, and this greatly decreases the likelihood that those students are going to earn postsecondary credentials (Jeffrey & Jimenez, 2019). Understanding which high school mathematics pathway is best for preparing students is a key question for all high school educators, policymakers, and families. Moreover, the question of effectiveness is one that rests not just on immediate test performance but on long-term conceptual retention: how well students are able to recall, apply, and transfer the mathematical knowledge they've gained from years of learning long after initial instruction has ended.

1.1 Research Objective

This literature review aims to bring together existing research in order to compare Traditional and Integrated mathematics pathways across three areas of consideration: (1) long-term conceptual retention and critical thinking development, or which pathway aids in students' problem-solving and analytical skills and mathematical knowledge attainment; (2) college readiness, or how well the pathways set students up for college mathematics; and (3) teacher preparation, or the level of professional development that is needed to successfully implement each pathway.



2. Literature Review

2.1 Student Engagement and Conceptual Retention

Conceptual understanding and mastery of prerequisite topics is a key factor for long-term success in college mathematics, including with college calculus. For instance, a longitudinal study, which consisted of over 6,200 students, found that a student's mastery of preliminary mathematical subjects, such as algebra, geometry, and precalculus, had more than double the impact on college calculus performance compared with taking calculus in high school (Sadler & Sonnert, 2018). This need for step-by-step mastery would, on the surface, seem to be most fulfilled by the Traditional mathematics pathway, since that pathway follows a rigid, required sequence of learning, one in which students are expected to only move forward upon mastery of a prior subject, from Algebra I to Geometry to Algebra II (Riggleman, 2017). This has been the default sequence for over 90% of high schools before the widespread implementation of CCSS (Regional Educational Laboratory Northwest, 2023). In contrast, the Integrated Model offers a sequence of three courses that each contain a combination of components, that of arithmetic, algebra, geometry, probability, and statistics. This integrated approach aims to practice and hone students' abilities to make connections between topics, emphasizing problem-solving over compartmentalized skills (Riggleman, 2017). The rigidity of the Traditional sequence leads to some foundational challenges, such as its need to culminate with a heavy focus on Algebra II, which then establishes a default requirement of College Algebra, and that becomes a significant obstacle for student success in their postsecondary education, as this sequence often leads non-STEM students toward a gateway course that may be irrelevant to their long-term academic and career goals (Moussa et al., 2020; Gandal, 2025). Therefore, the Traditional pathway displays a structural flaw: it prioritizes a single, one-size-fits-all sequence designed for calculus, which is ultimately unnecessary and inefficient for many students (Regional Educational Laboratory Northwest, 2023; Gandal, 2025). This is especially illustrated by the high failure and retake rates that students undergo in college calculus as well as by the common placement of high school calculus completers into remedial math, pointing to students moving up the ladder of the Traditional pathway stages without proper mastery in tow (Regional Educational Laboratory Northwest, 2023). By design and in contrast, the Integrated pathway, by incorporating statistics and data literacy early, facilitates heading in relevant directions (e.g. Quantitative Reasoning and Statistics) for non-STEM students, which is a more flexible and all-encompassing curriculum that considers a range of needs while still incorporating a wide range of concept integration (Tarr et al., 2013; Regional Educational Laboratory Northwest, 2023).

Proponents of the Traditional model argue that there is value in the siloed approach of subject by subject learning, as segmenting each subject allows for easier management of cognitive load for young students. According to cognitive load theory, developed by John Sweller, learning is constrained by the limited capacity of working memory. From this perspective, students benefit from practicing new concepts until they become automatic, meaning they can be performed without conscious effort. Automaticity frees up mental resources for the student so that they can focus on more complex forms of problem solving (Sweller, 1988). This supports the structural model of the Traditional pathway, as it dedicates an entire academic year to a single subject, e.g. Algebra I, and thus allows for necessary repeated practice for students to become fluent in that subject.

The differences between the two pathways affect how well students perceive their own achievements in mathematics, which in turn affects their conceptual retention. One study suggests that integrated learning can produce improvements in how students perceive the success of their efforts, positively affecting their self-concept and confidence in mathematics (Kulpa, 2021). This is vital, as a meta-analysis of 747 effect sizes from studies published between 1992 and 2018 found a significant negative correlation between math anxiety and math achievement (Barroso et al., 2021). Therefore, students' confidence in their mathematical ability is closely related to their success, although this correlational evidence does not show which comes first. Whichever method increases that confidence, then, may have a strong influence beyond the rote capacity it offers. This confidence also has a strong influence on whether or not to pursue a STEM major in college, as a 2018 study found that students with consistently less math anxiety chose to pursue STEM at university (Ahmed, 2018). Therefore, if the Integrated model does improve students' academic self-concept by linking concepts together, it may offer a stronger foundation for student success for when they engage in difficult mathematics classwork in college (Kulpa, 2021; Sharpe & Marsh, 2021).

The logic of the Integrated pathway is straightforward: real world use of mathematics involves bringing together concepts from across a range of subjects. The belief is that this approach will deepen understanding by offering practice of this process of mental integration, since part of the coursework is for students to recognize the interconnected nature of mathematics concepts and to see their application within a given context (Hanover Research, 2015). By exposing students again and again to similar math topics across subsequent courses, ideally, this allows students to build their understanding of how those topics connect across domains and in a proficient manner. Some Integrated courses take this thinking a step further by also shifting the instructional focus away from rote memorization and procedural practice and toward personal reasoning through careful conceptual understanding and application (McNaught, 2009). For instance, the Core-Plus Integrated approach centers instruction around continuous collaboration, where small groups investigate and deal with problems together, and afterward, the teacher leads the whole class in summarizing their activities and choices. For those students within the Core-Plus program, a 2002 study across 11 high schools and 1,050 students reported that these students scored higher on SAT math scores, the Iowa Tests of Educational Development for Grade 9 mathematics, and on subtests for Core-Plus Mathematics (Hanover Research, 2015). Furthermore, based on 186 classroom observations in a 2013 study, students who followed the Integrated pathway—not solely the Core-Plus one—were seen to sit in groups and work collaboratively more often than those in Traditional, subject-specific classes (Tarr et al., 2013).

Ultimately, research points toward a trade-off between the focus that the Traditional model offers with its subject-by-subject segmentation and the interwoven learning of the Integrated pathway. While the Integrated method may develop higher levels of student confidence and is designed to support long-term retention through blending mathematical concepts together intuitively and practically, a question remains as to whether or not any of the above structural advantages actually show up in testing and real-world application. The following section will examine whether the spiraled learning of the Integrated pathway translates into superior college readiness and standardized test performance, or if the Traditional pathway's more siloed approach provides a stronger foundation for what is needed in higher education.

2.2 College and Career Readiness

Both pathways are expected to prepare students for college. Leading higher education institutions, such as the University of California (UC) system, affirm that both pathways provide the necessary "essential mathematical foundation" for college-level work (Board of Admissions and Relations with Schools (BOARS), 2024). That said, current research generally points toward the Integrated model as being associated with higher achievement on standardized tests, while the Traditional model is linked to better performance in specific algebraic skills, so the determination of which method is better depends greatly on the goals of the student (Tarr et al., 2013; Mallanda, 2011).

Regarding test scores, success leans toward the Integrated pathway. In a study consisting of 3,258 students, those who studied from an Integrated mathematics program scored "significantly higher than those in the subject-specific curriculum on the standardized achievement test" (Tarr et al., 2013, p. 683). Specifically, those students taking part in Integrated Course 2 outperformed those in the subject-specific course by more than 10 points as measured by the ITED-16 standardized test, which is a nationally-normed test that gauges the problem solving and reasoning of test-takers (Tarr et al., 2013). This matches up with findings from the first year of the Comparing Options in Secondary Mathematics: Investigating Curriculum (COSMIC) project, which assessed student learning in their first year of high school taking mathematics courses. Here, the first year study involved 2,161 students across 10 schools in 5 states. Around half of the students in this study participated in an Integrated mathematics curriculum, while the other half followed a Traditional pathway, starting with Algebra 1. Three outcome measurements were then taken at the end of the year for these students, accounting for differences in implementation of lessons and students' prior achievement: a test of common objectives, an assessment of problem solving and reasoning, and a standardized achievement test. Students who studied from the Integrated curriculum significantly outperformed Traditional students on all three measures, and opportunity to learn and teaching experience were significant moderating factors (Grouws et al., 2013). In the second-year study, students with higher prior achievement benefited more from the Integrated program, which suggests that higher-performing students may be most capable of synthesizing what they learn in Integrated classes into one coherent whole (Tarr et al., 2013).

There is some research that points to advantages for those high school students who take the Traditional pathway or that show how overall achievement differences might be negligible. Regarding students' development of algebraic skills, one study summarized by Mallanda (2011) that compared 500 Advanced Placement Calculus students indicated that single-subject curriculum students scored significantly better in algebra. Additionally, these students were superior at solving a range of problems, including those that require connections between mathematical skills and those that don't (Mallanda, 2011). In addition, a study examining ACT math scores in Tennessee found that, in three of the four high schools that were included in the study, the students who took part in the Traditional pathway scored higher on the ACT mathematics subtest than their Integrated curriculum peers (Potter, 2019).

Finding definitive evidence that favors strictly one pathway over another in all factors of mathematical success is unlikely. The U.S. Department of Education's National Mathematics Advisory Panel issued a report that attempted to determine specific pathway success, and they concluded that there is "no basis in research for preferring one or the other" (U.S. Department of Education, 2008, p. 22). Furthermore, studies of certain Integrated programs have shown many



instances of no significant difference in SAT or ACT scores between students taking the Integrated pathway and those taking the Traditional pathway (Mallanda, 2011). Mallanda's own study of Georgia's shift to an integrated curriculum found a significant relationship with PSAT/NMSQT mathematics scores in the first year of implementation but not in the second (Mallanda, 2011). The fact that research doesn't define a clear "winner" in terms of standardized testing could be the result of a mismatch between the goals of each curriculum and the design of student assessment. For instance, traditional standardized tests, such as the ACT and the SAT, could be historically weighted toward fluency in algebra, and this is precisely the area in which Traditional-pathway students excel. Therefore, it could be possible for Integrated pathway students to possess a broader conceptual understanding of how to apply the mathematics they've learned to fresh problems, but they could underperform if the assessment focuses especially on siloed algebraic problems, which is exactly what the Traditional pathway trains for. The work of Tarr and others in 2013 points to the challenge of properly assessing curriculum effectiveness, as standardized tests tend to isolate procedural skills, which doesn't always assess other mathematical competencies, such as when students in NSF-funded curricula "scored significantly higher on problem solving and open-ended items than on procedural (computational) questions on standardized achievement tests" (Tarr et al., 2013, p. 688). Furthermore, as the same paper discusses, the test findings may be reflective of the specific practices of the teachers giving each lesson rather than the curriculum itself, specifically the "pedagogical orientation" of the teachers and how well that aligns with the curriculum (Tarr et al., 2013, p. 687). Therefore, even when a district adopts an Integrated curriculum, some veteran teachers who grew up with Traditional methods or prioritize Traditional-like procedures could influence the findings. There could be an implementation gap to sort through. This possibility is discussed further in the next section.

In terms of career readiness, there is a question regarding whether or not algebra should be centered in the way that it is, and if not, then that suggests a weakness of the Traditional pathway for preparing students for the careers they desire. For many fields of work, Algebra II level or Precalculus mathematics is not needed, and by requiring that Algebra be done in stairstep format within the Traditional system, that step can become a barrier to both educational and career opportunities for many students (Regional Educational Laboratory Northwest, 2023). By adhering "to traditional math sequences that place algebra as the gatekeeper and center[ing] calculus... at the expense of not teaching [students] the types of math more relevant to their postsecondary plans" the Traditional pathway could be blocking students unnecessarily from progress and achievement in less math-focused careers that they may want to choose (Jeffrey & Jimenez, 2019). Furthermore, prioritizing a rigid pathway of Algebra I to Geometry to Algebra II could be a waste of resources and time if students end up repeating their courses without success, a concern highlighted by a 2012 study of California students, which found that "roughly one third of students in the study sample repeated algebra 1 at some point between grade 7 and 12... Only a small percentage of students who repeated algebra 1 attained proficiency on the algebra 1 CST the second time they took the course" (Finkelstein et al., 2012, p. viii). There may be a split, then, in priority: for students who are already interested in STEM, aiming for advanced courses, such as precalculus and calculus, may be the best preparation; while, on the other hand, aiming for an advanced course like AP Statistics would be best for those most interested in quantitative social sciences (Board of Admissions and Relations with Schools (BOARS), 2024). Therefore, with this in mind, the most effective career preparation may not be

a one size fits all approach of one pathway over another but rather a choice in either based on the student's priorities.

One vital consideration as well is the inflexibility of either pathway and its effects on educational inequities when we consider a diverse student body and their different aspirations. Since each pathway contains its own form of tracking student success, and that form of success can isolate certain groups of students over others, this can become an issue. For instance, the siloed Algebra I–Geometry–Algebra II pathway, since it requires success in the prior stage before advancement and expects completion of Algebra II, can lead to unintended consequences by reproducing "existing societal inequities along race, gender, and class lines" (Regional Educational Laboratory Northwest, 2023, p. 8). Even though more and more students have enrolled in Algebra II, mathematics proficiency has "remained stagnant as measured by National Assessment of Education Progress (NAEP) mathematics scores" (Regional Educational Laboratory Northwest, 2023, p. 6). This ultimately discourages many students from pursuing their postsecondary schooling if they find mathematics as a barrier rather than an enriching subject of learning. Students who enrolled in an Integrated math program were found in a 2002 comparative study to be "more likely to score 'proficient' or higher... than were their peers in traditional math classes (58.2 percent compared to 46.5 percent)" (Hanover Research, 2015, p. 9). Proficiency in mathematics is necessary for college readiness. One alternative solution, then, and a means of flexibility for students, is dual enrollment courses, which allow interested students to pursue college-level math courses, typically at a community college, while still in high school. There is research that shows that students who complete a dual enrollment math course have an increased likelihood of entering and sticking with STEM majors in college, especially for Black and Hispanic students, addressing some concerns regarding inequity in math proficiency between certain groups (Minaya, 2021). Though this research does not focus on Integrated versus Traditional pathways specifically, it does suggest the need for student choice and the value of effective mathematics programs.

2.3 Teacher Effectiveness & Training

Ultimately, the differences in curriculum effectiveness may rely on curriculum implementation, regardless of the specific pathway the student is on. In a 2013 paper, researchers found dramatic differences in how curricula were implemented by teachers in the classroom. Teachers used their assigned textbooks in very different ways, and the share of the textbook they actually taught varied widely by curriculum: "on average about three fourths of textbook lessons were taught[, and] teachers of the subject-specific curriculum taught approximately 86% of textbook lessons, whereas teachers of the integrated curriculum taught only 58%, on average" (Tarr et al., 2013, p. 702). Therefore, it is clear we must review teacher effectiveness on student mathematical outcomes as well as the influence of teacher training on improving teacher quality in order to determine the benefits of both and their relation to pathway strength.

Research points to teacher quality as an essential factor in student high achievement (Engida et al., 2024). However, that quality splits along a few factors, such as the specialized knowledge of the teacher and the instructional practices they follow. Various studies demonstrate that when a teacher has specialized mathematical knowledge, their students show significantly greater achievement gains (Hill et al., 2004; U.S. Department of Education, 2008). The Hill longitudinal study defines improvement of students to be roughly " $\frac{1}{2}$ to $\frac{2}{3}$ of a month of

additional growth per standard deviation difference on CKT-M [the teacher's content knowledge for teaching mathematics]," making that knowledge "the strongest teacher-level predictor" (Hill et al., 2004, p. 33). This positive effect seems to be specifically tethered to mathematics, as teacher content knowledge was a weaker predictor of student gains in English Language Arts. Furthermore, the effectiveness of teacher knowledge may be non-linear, as in the same study students of teachers in the lowest two deciles (0–20%) of content knowledge gained approximately 10 fewer points than students taught by more knowledgeable teachers (Hill et al., 2004). Therefore, considering the value of a teacher's mathematics knowledge, strengthening that knowledge is essential for improving students' mathematics achievement.

Beyond the base level of content knowledge that the teacher has, the instructional practice of the teacher (how the content is delivered) is also essential for student success. Beyond the specific curriculum pathway, the most significant factor in terms of a teacher's success with students is arguably the opportunity for students to learn from the textbook. The Opportunity to Learn (defined as the percentage of textbook lessons taught) is considered by the 2013 Tarr study to be possibly the "single most important predictor of student achievement" (Tarr et al., 2013, p. 718). How these textbook lessons are taught, though, is also essential. Earlier research on the Pedagogical Content Knowledge (PCK) of teachers, which is the special combination of teacher subject-matter expertise in tandem with a teacher's ability to represent concepts in accessible ways, points to PCK as being a key factor in lesson effectiveness (Ball et al., 2008). This may serve as a general advantage for teaching in the Traditional pathway when accounting for a wide range of teaching ability. In a Traditional pathway, PCK is specialized in such a way that an Algebra II teacher, for instance, can focus deeply on the specific misconceptions a student has, such as regarding logarithms or complex numbers. Contrastingly, the Integrated pathway demands a broader PCK, since teachers must maintain the pedagogical skills to guide students through connecting ideas across mathematical subjects. This requirement could exceed the training of some teachers, which may explain why there is still some uncertainty in outcomes when comparing Integrated to Traditional curriculums (Ball et al., 2008; McNaught, 2009).

With the above in mind, professional development (PD) is a key consideration for improving teachers' effectiveness; however, studies have offered mixed results. Multiple studies have demonstrated that for a PD program to be effective it should aim to align with "the teacher's school curriculum or learning goals for students[,...] the day-to-day operations of schools and teachers[,...] and [be] compatible with the instructional practices and knowledge needed for the teachers' specific assignments" (Blank & de las Alas, 2009, p. 24). Furthermore, the most effective professional development programs stick to specific principles in terms of content, duration, and participation. Regarding content, PD programs should focus specifically on "deepening teachers' content knowledge and pedagogical skills" while also providing "opportunities for practice, research, and reflections" (Franklin, 2015, p. 28). A later meta-analysis by Franklin and Chang found that this should be done in combination, as aligning a teachers' "math knowledge and pedagogical content knowledge had a greater effect on student achievement than content knowledge alone" (Franklin & Chang, 2025, p. 4). This meta-analysis further found that PD focused on Geometry that also explicitly included a combination of content and pedagogy as opposed to pedagogy on its own showed a significant improvement in student achievement gains.

The duration and sustained support on offer to teachers, as well as honing an active learning environment, correlate strongly with an effective PD program. Via a long-term, sustained

duration, teachers have the time to implement new strategies and to reflect on the effectiveness or lack thereof of each attempt, keeping their learning active and their involvement persistent (Murray et al., 2024). Active learning, in particular, on the part of teachers, e.g. having teachers analyze student work, plan lessons themselves, and watch video examples, and having those teachers work in groups or within a professional learning community, shows positive outcomes for student learning (Murray et al., 2024). Collaborative activity among training teachers reinforces learning and supports long-term instructional change (Blank & de las Alas, 2009). However, Franklin and Chang's 2025 meta-analysis, which focused on duration, did find conflicting results, as it noted that shorter PD programs of just one time or less than a year showed a more positive effect on student learning when compared to programs that last an entire year (Franklin & Chang, 2025). Furthermore, even large-scale and rigorously-designed PD programs show inconsistent effects on student outcomes. For instance, a comprehensive evaluation of the Swedish national-scale program "Boost for Mathematics," which incorporated many of the research-backed features of a high-quality PD, found that the program generated a "small but statistically significant impact on teachers' instructional practices" but had "no effect" in terms of "student achievement" (Lindvall et al., 2021, p. 2). Therefore, considering the challenges to certainty about which instructional changes to implement, some researchers advocate for an incremental approach that builds upon what the teachers already know in terms of their foundational expertise (Murray et al., 2024). This would focus on small adjustments to daily practice rather than massive and sudden overhauls.

In terms of teacher training and the Integrated versus Traditional pathways, the Integrated pathway may offer a distinctive challenge in terms of teacher expectations, as the Integrated pathway tends to be student-centered, problem-based, and include collaborative instructional methods (Mallanda, 2011). Research shows that teachers who use the Integrated curriculum often demonstrate a higher fidelity to the content covered but struggle substantially when it comes to the required presentation of the material (McNaught, 2009). In McNaught's study, this resulted in teachers of the Integrated curriculum demonstrating especially low Presentation Fidelity ratings in comparison to their Content Fidelity of the same material, with many teachers skipping key components of their lessons. This suggests that the Integrated curriculum may offer particular challenges to some teachers that need to be accounted for in their training, otherwise they may sacrifice various collaborative and reflective elements of the curriculum that are intended to help grow deeper conceptual understanding, which, as covered above, is integral for effective mathematics learning.

3. Limitations

This review has several limitations. First, it is a narrative rather than a systematic review, so the selection of studies may not be comprehensive. Second, much of the comparative evidence comes from a small number of studies, particularly the COSMIC project (Grouws et al., 2013; Tarr et al., 2013), and from dissertations, policy reports, and secondary summaries such as Hanover Research (2015), rather than from randomized experiments. Third, several key studies predate or coincide with the adoption of CCSS, and much of the policy evidence is specific to the United States and especially California. Finally, although long-term conceptual retention was a central question of this review, few studies directly measured retention years after instruction; most of the available evidence concerns test performance, self-concept, and course

progression. Longitudinal studies that follow students from each pathway into college and careers would help answer this question more directly.

4. Conclusion

This literature review reveals that the choice between the Traditional or Integrated mathematics pathway does not carry a simple answer. After over a decade since initial Common Core State Standards implementation, the trade-offs shown in various research studies indicate that there is no clear winner for all students and contexts. The Integrated pathway demonstrates some advantages in standardized test performance, especially when those tests emphasize broad conceptual understanding, and supports students' self-concept and confidence in mathematics. These benefits seem most notable for higher-performing students who are able to synthesize their learning within the interconnected presentation that the Integrated pathway offers. Contrastingly, the Traditional pathway is strong in building up a student's algebraic fluency, and it may offer cognitive advantages through its step-by-step structure, since students can achieve mastery in one subject at a time prior to advancement.

Both pathways carry structural limitations, and there is a lack of consensus in research findings. The Traditional pathway follows a rigid, algebra-focused sequence. This serves students who are pursuing STEM, but it may create an unnecessary burden for the majority of students whose career aspirations do not require advanced algebra. Alternatively, the Integrated pathway has a high demand for broader mathematical knowledge, which requires more sophisticated instruction. Teacher quality, especially a teacher's pedagogical content knowledge, is essential to student success. The Integrated pathway, even though it has theoretical advantages in terms of connecting mathematical concepts together into one coherent whole, carries a greater demand on teachers. For successful employment of the Integrated curriculum, teachers must have expertise in how to implement lessons, and not all professional development programs adequately support this. Without a significant investment in teacher preparation and continued teacher support, the Integrated curriculum may fail to achieve the advantages that exist within it in theory.

With the above in mind, districts and policymakers cannot simply choose either pathway as a one-size-fits-all approach. The evidence suggests that pathway effectiveness depends a great deal on particular student characteristics and teacher capability. Therefore, instead of pushing for one approach, policy should allow for pathway choice: students and families can select the pathway that best aligns with their postsecondary goals. Not all students benefit from the rigid, siloed structure of the Traditional pathway, and not all students are best served by the cognitive demands and spiraling structure of the Integrated pathway. Families should be able to make informed decisions, which also requires school districts to inform the public about how each pathway prepares students for their different aims. Furthermore, since curriculum success is so dependent on teacher implementation quality, the pathway adoption decision must correspond with investments in teacher professional development. Research shows that how teachers deliver lessons may be more vital than the curriculum itself. To maintain the necessary quality of instruction, then, resources must be allocated for teaching programs that focus on active learning, collaborative planning, and opportunities to directly analyze student work. This is especially necessary for the Integrated pathway, since its instructional requirements are more complex.

Ultimately, this review shows that improving mathematics outcomes for students is not just a choice between one pathway or the other. In order for either pathway to be effective, it must align with student aspirations and correspond with substantive professional development for teachers. Both Traditional and Integrated pathways can succeed, and they both can fail, depending on how well each school board decides to adapt to the needs of their district. Further research should focus on understanding which approach works best for which students under which conditions, and it should also include evaluations of different methods of teaching implementation to deliver high-quality mathematics instruction regardless of pathway structure.

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