Using Preschool to Close the Socioeconomic Math Achievement Gap

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A Senior Thesis submitted in partial fulfillment
of the requirements for graduation
in the Honors Program
Liberty University
Spring 2020

Acceptance of Senior Honors Thesis

This Senior Honors Thesis is accepted in partial
fulfillment of the requirements for graduation from the
Honors Program of Liberty University.

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Abstract

Socioeconomic status (SES) heavily influences students' academic performance, creating an achievement gap in core subjects like reading and mathematics. This thesis will describe the socioeconomic achievement gap as it relates to mathematics specifically, discuss the problem's causes, and propose how preschool programs should be implemented more prevalently as a solution to close the gap. Children with low socioeconomic statuses enter school with lower math proficiency due to their limited math exposure in their early years and the quality of their home learning environments. This thesis will propose an expansion of preschool programs as a solution to this problem to help mediate the proficiency in foundational math concepts of low-SES students prior to school entry.

Using Preschool to Close the SES Math Achievement Gap

Inequalities have been embedded into the history and culture of the United States since its beginning. One of the major categories in which inequality falls is socioeconomic status (SES). SES can be broken down into multiple components, including household income, parent education, parent occupation, and even number of books in the home (Blums, Belsky, Grimm, & Chen, 2016; Chmielewski, 2019; von Stumm, 2017). A family's SES affects nearly every facet of life; however, perhaps the most influential area affected is that of education. SES between families has caused wide academic achievement gaps, which predict the achievement and success of children in their future families, workplaces, and communities. Many interventions have been attempted in the last several decades to help low-SES children catch up in school to their higher-SES peers, but the gap persists. Because of the profound impact of SES on a child's academic achievement from as early as birth, this thesis suggests using preschool as a viable solution to compensate for the lacking early home learning environments of low-SES families and to ultimately close the SES math achievement gap.

The SES Achievement Gap

SES achievement gaps are present in countries all over the world (Chmielewski, 2019). School has often been considered to be the "great equalizer" among children from different backgrounds, but achievement gaps still continue to exist (von Hippel, Workman, & Downey, 2018). In a study of over 100 countries, trends have shown that in the last fifty years academic achievement gaps have been increasing in a large number of nations around the world. For example, the math achievement gap specifically has increased by 40% in the United States between 1970 and 1990 (Chmielewksi, 2019). Research shows that there could be "a number of potential explanations for growing achievement gaps, including rising income inequality,

increasing school choice, and growing inequality in parental investments in children" (Chmielewski, 2019, p. 519). Recognizing this growing gap and the factors behind it is an important step in finding a viable solution to offer educational equality for all children.

How SES Leads to the Achievement Gap

SES affects the academic abilities and achievement of children through cognitive development, opportunities and support available in school, and stimulation and parental academic involvement in the home. Important cognitive abilities in early development can be divided into the categories of executive function, language abilities, and problem-solving skills (Blums et al., 2016). Executive function is a mental skill set that includes working memory, inhibition, attentional control, and cognitive flexibility. This has been shown to be strongly correlated with math problem solving abilities such as representing a problem, planning an approach, executing a problem, and evaluating the outcome (Blums et al., 2016). An aspect of executive function that has also been recognized as an issue among low-SES students is mind wandering. Mind wandering comes from the working memory piece of executive function, and it occurs when someone tries to engage in an exercise but involuntarily falls into thought that is random or unrelated to the work at hand (Gearin, Fien, & Nelson, 2018). This explains that while low-SES students may be trying to succeed and grow academically, their working memory capacity may make it especially difficult due to their early environment and how that has affected their brain and executive function development.

Language abilities at an early age are measured through vocabulary, print knowledge, phonological awareness, letter identification, listening comprehension, and expressive communication (Blums et al., 2016). These abilities are a significant factor to the growth of problem-solving abilities as well because children are better able to use self-talk strategies to

work through problems and have stronger “self-reliant classroom behaviors” (Blums et al., 2016, p. 20). Early math education is also often delivered verbally, so strong language abilities are important even outside of traditional letter and print instruction.

Problem-solving skills include planning, calculating, and relational reasoning (Blums et al., 2016). Planning refers to determining a progression of necessary actions for achieving a specific goal; calculating involves performing number operations like addition, subtraction, multiplication, and division; and relational reasoning is the ability to make connections between pieces of information to create “abstract mental representations of relations among objects, attributes, and events” (Blums et al., 2016, p. 20). Relational reasoning is necessary for math achievement and important for scientific thinking as well, especially in early childhood, because it allows children to begin viewing different variables within a question in terms of their relationships to one another so they can appropriately address them in their approach to the problem. The frequency with which problem-solving strategies are implemented in elementary school to challenge and develop these skills is linked to math achievement, so problem-solving skills like these are one of the most important factors contributing to the lower math achievement that low-SES children tend to have (Blums et al., 2016).

Cognitive development is primarily a result of a child’s early environment, which is strongly predicted by family income and maternal education, two figures also significant in determining SES (Blums et al., 2016). Early environment involves both the home environment and the primary childcare environment, taking into consideration the quality of the enrichment and engagement found in those environments. Enrichment includes physical aspects of the environment such as general safety or the presence of books, puzzles, and educational games, while engagement refers to interactions between the child and the primary caregiver(s), which

can be centered around learning or emotional sensitivity (Blums et al, 2016). These factors begin to affect children cognitively even before birth through the stimulation and development of their executive function, language abilities, and problem-solving skills. Children from varying SES levels do not have early environments of equivalent qualities, and low-SES children have been found to have less access to learning materials like books in their early environments than middle and high-SES children (Galindo & Sonnenschein, 2015).

Lower parental education levels, which are closely tied with SES, have also been shown to predict lower cognitive abilities in elementary school because adversity and poor environmental factors early in life like household chaos, stress, neglect, maltreatment, parenting, cognitive stimulation, language stress, and even prenatal environment can work individually or cohesively to negatively alter brain development (Gearin et al., 2018). Low-SES children are often under a variety of different stressors in the home that can affect thought patterns and abilities, ranging from financial difficulty to incarcerated family members and more. Parents of low-SES families generally are not aware of mediators for these factors, so they do not provide the adequate academic support for their children to reach the same standards as children from higher-SES families. For example, the presence of enriching materials in the home and instructional help from adults on how to use them contributes to executive function development through a child's attentional control, and caregiver engagement with a child in academically stimulating thought or conversation contributes to their inhibition and attentional control as well (Blums et al., 2016). However, lower levels of parental education and a lower income generally leads to less cognitive stimulation through less verbal interactions, less engagement in stimulating activities like museum visits, for example, and less read aloud time with parents.

These are all linked to academic success in general, but also specifically to future math achievement (Galindo & Sonnenschein, 2015).

Verbal interactions between children and their caregivers are especially important when it comes to math. Every family engages in math interactions and conversations before children reach kindergarten age, but each family differs by the frequencies and types of math encounters they have (Susperreguy & Davis-Kean, 2016). These encounters can include talk about numbers, number words, or number elicitations (e.g. using words and phrases like *how many*, *count*, or *number*), and they can be conceptual, procedural, or monetary in nature. The amount and quality of math talk present in a child's early home environment is linked to his or her math knowledge and ability at age four (Susperreguy & Davis-Kean, 2016). Mothers who initiate more math talk often have children with better knowledge and skills about number facts, number comparison, calculation, and concept comprehension. More educated mothers tend to have higher scoring children, implying that low-SES children fall into a disadvantage with generally less educated mothers (Susperreguy & Davis-Kean, 2016). Due to these factors within the home, low-SES children are set up to struggle academically before they even reach the elementary school age. The home is a vastly important learning environment, and without investment into academic achievement and cognitive stimulation within the home, children can very easily fall behind.

SES has significant effects within the school environment as well. Low-SES students have different elementary experiences than more advantaged students due to factors like expenditure per student in the classroom, special education opportunities and resources, frequency of classroom disruptions, parental involvement, teacher qualifications, and more (Gearin et al., 2018). Minor, Desimone, Spencer, & Phillips (2015) write, "there is still a need to address the allocation of qualified teachers to the most disadvantaged schools" (p. 257).

Research suggests that minority and low-SES students in elementary school have less-experienced teachers than more privileged students (Minor et al., 2015). This is characterized by teachers' years of experience, standardized test scores, quality of college, level of degree, and number of math methods courses taken at the collegiate level. Some of these variables remain the same across the SES spectrum like the average number of methods courses, however the number of years of experience and the level of degree does tend to differ regarding SES, favoring more privileged students and schools (Minor et al., 2015). Teachers with more advanced degrees tend to teach higher-SES students, while many first- or second-year teachers end up teaching the most disadvantaged students who need the most help. These teachers, due to their lack of experience and less education, generally know less about instructional strategies, differentiation, and classroom management methods that are effective for struggling students. Research shows that high income students spend more time learning math in the classroom (Huang, 2015), but low income students are still expected to spend more time on math homework every night and even take more math tests throughout the year than higher-SES students, implying that less experienced teachers in low income classrooms focus on procedural instruction more heavily than conceptual instruction (Minor et al., 2015). These factors create opportunity-to-learn gaps between socioeconomic groups that contribute to the math achievement gap and have been measured through research studies all throughout elementary school in first, third, and fifth grades.

Parental involvement in school is a factor of student achievement as well, and low-SES families tend to be less involved in schools than middle- or high-SES families (Galindo & Sonnenschein, 2015). Financial difficulties, occupational requirements, and low understanding of the benefits of school involvement can all be reasons for this lack of academic investment. As

parents become more involved in their child's school and raise their expectations for their child's academic performance, the child will succeed more in the classroom and prioritize their learning, persistence, and effort at a greater level (Galindo & Sonnenschein, 2015).

Many economically disadvantaged children come into elementary school already cognitively behind, and they still do not get the assistance and instruction they need to catch up to their higher-SES peers. They come from homes that are less academically involved and conducive to learning and are never offered the chance to catch up within school either. Low-SES children face a difficult paradox to overcome: "They struggle in school because they are from low-SES backgrounds, but the only way they can change their SES is by performing well in school" (Gearin et al., 2018, p. 140). The achievement gap is a complicated issue that is comprised of factors from all areas in a child's life.

Why Conscious Efforts to Combat the Achievement Gap are Necessary

It is easy to fall back on an American Dream mentality in response to the socioeconomic achievement gap, simply willing low-SES children to work harder and put more time and effort into their academics to close the gap. Huang (2015) conducted a study testing whether low-SES students can increase grit and persistence in problem-solving to increase their achievement. The research found that high-SES students view themselves to be persistent three times more than low-SES students do. However, even the highest performing low-SES students did not compare equally to the highest performing high-SES students. Though this does not mean that low-SES students can never achieve the same academic level as high-SES students, it does show that individuals cannot increase their own achievement enough to close the gap. Huang (2015) writes:

> Without systemic, societal changes in schools, families, and communities to address problems like income polarization, the SES-based achievement gap will likely remain…

> Encouraging economically impoverished students to work harder and keep trying will leave problems due to poverty (such as the SES-based achievement gap) untouched in the United States. (pp. 24-25)

Thus, intentional efforts outside of individual academic input must be implemented in order for there to be significant change in the SES math achievement gap.

Another question can come into play about the role intelligence has in determining student achievement. Von Stumm (2016) researched this and found that low-SES students in elementary school performed at a lower level than high-SES students even with the same level of intelligence. Additionally, high-SES students performed better at age seven than low-SES students even when they had a lower intelligence level. This shows that SES affects student achievement independent of intelligence, furthering the argument that individual students cannot help themselves enough to close the gap and efforts need to be put into place to counter the external factors influencing low-SES students' achievement.

Preschool as a Solution to Close the SES Achievement Gap

Why Preschool Should be Implemented as a Solution

Preschool is a viable solution in closing the math SES achievement gap because of the academic boost that it offers students as it sends them into kindergarten. A child's math proficiency as he or she enters kindergarten is incredibly significant in the progression of his or her overall math achievement. According to Galindo & Sonnenschein (2015), all children acquire informal math skills at home prior to entering elementary school, but low-SES children tend to begin school with lower math skills than their middle or high-SES peers. Disadvantages in math proficiency are visible as early as the kindergarten level, and these are directly linked to lower math proficiency at the end of kindergarten as well (Galindo & Sonnenschein, 2015).

These disadvantages are also associated with lower math achievement later in elementary school and high school. Galindo & Sonnenschein (2015) write, “eliminating the SES achievement gap in early childhood is a major social concern given its lasting consequences for children’s academic and subsequent economic well-being” (p. 33). This study indicates the importance of starting kindergarten with a specific level of math skills so that students will be appropriately challenged and allowed to capitalize on the instruction in the classroom (Galindo & Sonnenschein, 2015). This pattern has been recognized internationally as well: Bangladesh and ten other countries have reported preschool increasing students’ elementary achievement, and a study done with 65 other countries participating reported that high literacy in the teenage years has been increasingly found in countries that have widely applied preschool programs where most of the children are involved in the programs for longer periods of time and there is some kind of accountability component to measure the quality of the preschool education and care (Melhuish, 2018). Because inequality primarily affects children in early childhood, preschool has a profound, lasting impact on any student’s educational achievement, but it is especially important and necessary for low-SES students who are already behind in early childhood.

This argument is also supported by von Hippel et al. (2018), researchers who studied the rates of elementary growth in school months and over summer breaks, replicating a previous study done on this topic. This study was to determine whether intervention mainly needed to be placed in school or over summer vacation, but it determined that early childhood was actually significantly more important: “The practical reality is that nearly all of the inequality ‘action’ occurs prior to school entry… Our results suggest that inequality in basic reading and math skills originates mainly in early childhood, before kindergarten begins” (von Hippel et al., 2018, pp. 349-350). School can be used to equalize high and low-SES students slightly, but the inequality

that is formed before school age in children is far greater than in school and should be addressed more significantly. Research shows that most inequality in core skills like reading and math can be seen before children turn five, regardless of gender differences (von Hippel et al., 2018). For this inequality to be adequately addressed, students need before-school intervention, which can most easily and efficiently be accomplished through preschool.

Preschool is also an important solution to close the gap because struggling students' academic growth does not increase enough in elementary school to catch up to their advantaged peers. Scammacca, Fall, Capin, Roberts, & Swanson (2019) conducted a study that measured the growth rate for low-SES student achievement in elementary school. The researchers found that low income students who enter school with lower math skills grow at a much more rapid pace than higher income students who enter school with more advanced math skills. However, after two years of this accelerated growth, lower-achieving students participating in the study still had not reached the same level of achievement as their higher-SES peers. The rapid growth slowed as students progressed through elementary school: Scammacca et al. (2019) writes, "math concepts become increasingly complex as students progress through school, taking more time to master and potentially explaining the slowing pace of growth" (p. 14). This trend of elementary growth shows that while school helps students grow in achievement, it does not intervene as significantly as necessary to close the achievement gap. Low-SES children need to begin elementary school with higher math proficiency so they can build on their knowledge and reach the same achievement level as their higher performing peers.

Not only is preschool important for educational achievement, but it also has many long-term benefits for national and economic growth that have been measured internationally. Melhuish (2018) discusses the potential that low-income students waste when they do not have

the resources they need available to them, saying, “the consequence of these inequalities is an enormous waste of talent. The potential contribution to society of individuals who grow up in disadvantage is far greater than is often realised” (p. 68). Low-SES children could grow up to be the doctors, scientists, teachers, writers, lawyers, politicians, and more that can improve our communities and nation if they were given the right educational support to succeed.

Several decades ago, France implemented free optional preschool programs for all children aged three and older, increasing the number of preschool attendees to 90% of three-year-olds and 100% of four-year-olds. Data has been retrieved that shows increased achievement for French students since preschool implementation, higher wages being earned by the preschoolers as they grew into adults, and less SES inequality overall (Melhuish, 2018). Norway has seen similar results from implementing universal preschool, and Switzerland has noticed increasing educational mobility with their expansion of preschool as well. Investing in preschool can save money over time as governments will have to spend less later on welfare and public programs. Melhuish (2018) writes, “as a population’s skills are essential for economic development, universal pre-school can be seen as part of the infrastructure for economic development in a successful economy” (p. 69). Politicians can argue that preschool is expensive and not worth the money to establish on a large scale, but this data counters that view by showing that it is actually more economically wise to spend money on establishing widespread preschool programs. Von Hippel et al. (2018) also writes that because gaps have already formed by the beginning of kindergarten, “later school or summer interventions must be viewed as remediating gaps rather than preventing them. It might be more cost effective to reduce inequality between children, and between parents, before kindergarten begins” (p. 350).

Preschool implementation benefits not only the students and families who are involved, but also the entire community, nation, and globe around each program (Melhuish, 2018).

Preschool Instructional Math Methods to Prevent the Gap

Preschool is often characterized by its informal instruction and play-based learning, which is extremely important in early math development. Play is crucial for early cognitive growth as it relates to attention, memory, and math skills (Zippert, Eason, Marshall, & Ramani, 2019). Informal play experiences like counting, classifying, and comparing the magnitude of different toys or blocks and noticing patterns and shapes within them as well builds a solid foundation for later math instruction and is associated with future higher math achievement (Zippert et al., 2019). Math exploration can occur individually as children play separately, simultaneously as children play alongside one another, or cooperatively as children play together. According to Zippert et al. (2019), it is critical to involve both individual and cooperative explorative math play in the preschool environment so children have the opportunity to build strong nonverbal and verbal math skills.

Zippert et al.'s (2019) research focuses on peer interaction and shows that preschool math exploration through cooperative play is especially important in early math development. They find that cooperation between peers helps promote verbal math experiences because children engage in more counting and magnitude interactions, which are vital numeracy skills contributing to future math achievement. Additionally, interactive play between peers helps develop spatial skills, which are related to the growth of more advanced problem-solving and calculation skills. Zippert et al. (2019) write, "engaging with math-related toys with a peer allows children to both verbally and nonverbally explore areas such as patterns and shapes, classification, numbers, and space" (p. 12). This can come to life in children playing "store" and

counting money and products together, using numbered cards to match with corresponding pictures, or counting and classifying similar toy animals, for example. These experiences can build social awareness in young children and even teach them to enjoy learning math as well. Research like this helps provide early childhood education teachers with practical options to apply to activities in the classroom that can help their students grow cognitively.

American preschool programs have often shied away from intentional and direct math instruction in the early classroom. However, this needs to be balanced with informal, play-based instruction to give developing students a chance to build strong math foundations prior to entering kindergarten. Intentional math instruction is necessary in preschool because it enables students to solve problems and master skills that can be challenging for young children (Li, McFadden, & DeBey, 2019). Carefully planned lessons with set objectives "help preschool children learn the numerical, geometric and spatial skills that are critical to future achievement, particularly in the STEM disciplines" (Li et al., 2019, p. 765). In order to be effective, these lessons need to be considered age appropriate in the content they are covering, individually appropriate in the learning styles and group contexts that they implement, and socially and culturally appropriate in the background contexts that students are accustomed to.

Teachers should keep a variety of factors in mind as they develop preschool lessons. First, teachers should form detailed plans for their preschool classrooms. By carefully setting a learning objective and planning the activities they will use to reinforce the objective, teachers allow themselves to ask students better questions, make better use of impromptu teachable moments, and increase their efficiency by having materials prepared, thus reducing student wait times (Li et al., 2019). Within this planning, teachers need to ensure that the content chosen is age appropriate, including topics like counting, number recognition, and quantity relationships.

Second, teachers need to incorporate diverse learning styles into their instruction to cater to different students. These can include visual, auditory, and kinesthetic based activities, making learning exciting and fun for students. For example, musical components, games, and story contexts engage students in a lesson, and materials that students can touch and manipulate as the teacher is instructing help make students active learners in the classroom. Finally, it is vital at the preschool level that teachers direct the learning without centering the instruction around themselves (Li et al., 2019). This means that teachers should not give answers to the students but instead help them to self-correct when they make mistakes. According to Li et al. (2019), they should also implement small group time in addition to large group instruction so students can solve questions with their peers and utilize question loops to help students think through different problems. Frequent feedback and student-teacher exchanges like this provide significant instructional support to young children. These situations emphasize the individual children and offer young learners opportunities to think, reason, problem-solve, and share their opinions (Li et al., 2019).

One aspect of math instruction that can be practiced in direct preschool lessons and activities as well is non-symbolic approximate arithmetic. Many early math approaches prioritize teaching numbers and numeral identification to young students, however studies done by Park, Bermudez, Roberts, & Brannon (2016) and Szkudlarek & Brannon (2018) discuss the benefits of approximate arithmetic training of informal math skills for struggling young children. Symbolic math is defined as any learned math concepts or knowledge, like identifying symbols, number words, or solving arithmetic operations. Park et al. (2016) writes, “although humans are uniquely capable of symbolic mathematics, we share with other animals an intuitive ability to estimate, compare, and manipulate large numbers of items without counting that is present during human

infancy before symbolic math skills are acquired" (p. 289). This means that young students can learn how to perform approximate arithmetic without mathematic symbols, which can include adding, subtracting, comparing, and matching large arrays of icons or any other kind of mental manipulation of numerical quantities. Numerical manipulation is a common underlying factor of both non-symbolic approximate arithmetic and symbolic math operations and skills, so this technique is helpful at the preschool age because it can train young children to understand conceptual aspects of arithmetic and practice mental manipulation of quantities before they are old enough to learn number or symbol identification and counting (Park et al., 2016).

Approximate arithmetic also increases arithmetic fluency in students and supports the development of problem-solving skills, which are both foundational components of the math proficiency needed at kindergarten entry (Szkudlarek & Brannon, 2018). This method has been found to especially benefit low-SES preschoolers who are already cognitively behind in their math skills because they can catch up in learning the conceptual and foundational math knowledge that their higher-SES peers already come into kindergarten possessing. It is also significantly important to consider for preschools that have three-year-old students, so they can begin teaching them math skills before they are able to learn math operations and number words (Park et al., 2016). Overall, non-symbolic approximate arithmetic training has been found to benefit the future math achievement of preschool students, so the research of Park et al. (2016) and Szkudlarek & Brannon (2018) highly recommends incorporating this method into preschool math curriculums.

Technology is an incredibly helpful tool that preschool teachers can implement in their classrooms as well. One example of this is an iPad math curriculum called Math Shelf for the preschool level. Heavily influenced by Maria Montessori's educational theories, the tablet

application uses scaffolded short-term math goals and helps students learn by doing (Schacter & Jo, 2016). Students first take a placement test to determine where in the curriculum they will begin practicing, and then they move onto a variety of games and virtual manipulatives that will challenge them at their particular level. Schacter & Jo (2016) write, "Math Shelf teaches a wide variety of early number skills in a sequence that provides ample practice and opportunities for children to build flexibility and fluidity with numbers" (p. 225). These number skills include subitizing, one-to-one counting, sequencing numerals, comparing quantities, numeral identification, counting and applying the cardinal principle, matching quantity representations, and comprehending place value.

The progress that students make through this curriculum is astounding: Math Shelf preschoolers learn more than their peers who attend preschool without using the app, so much so that they finish the curriculum at a numeracy skill level that is 12 months ahead of their peers (Schacter & Jo, 2016). Teachers within the research study were able to implement the program into their classrooms, supervise their students, and solve any technological problems very easily. The research also shows that implementation of the app can even cost less over time than adopting a new curriculum or offering teacher training would. Schacter & Jo's (2016) research "[provides] evidence that tablet software can significantly improve public preschoolers' mathematics outcomes" (p. 228), and low-SES preschoolers who used this tablet software showed huge improvement as they moved through the curriculum. Technological options like this that can be implemented in preschool education are extremely promising in closing the achievement gap and preparing low-SES children to start kindergarten with higher math proficiency.

Examples of Preschool Improving the Achievement of Low-SES Students

There have been some studies done on existing preschool programs in the U.S. and how they have affected the students enrolled within them. One of these is the research of Bachman et al. (2018), which examines private, community-based preschool programs in low-income communities in the U.S. Bachman et al.'s (2018) research looks at the quality of the math instruction provided in these programs and how much time is spent on math instruction in each preschool classroom. Unfortunately, the study found that teachers in these preschools only spent an average of a few minutes a day on math content with their students. This time was generally dedicated to counting as well, which overlooks other significantly important early numeracy skills like geometry, measurement, and spatial skills. According to Bachman et al. (2018), this represents the typical preschool classroom, which shows that an extraordinary amount of work needs to be done to reform preschool math education and commitment. However, even this small amount of math exposure significantly improved the future math achievement of the students enrolled (Bachman et al., 2018). The research findings "strongly suggest that there are educationally meaningful benefits of math exposure for low-SES children's math development" and that the few counting activities done every day still "significantly narrowed early math gaps" (Bachman et al., 2018, p. 431). Though this research is discouraging regarding the current state of preschool math education, it is encouraging to see the powerful impact of even a little early math practice. This shows the potential that exists in the preschool classroom to close the SES math achievement gap.

Not only do preschool programs benefit the students who are enrolled within them, but they also benefit students who are not enrolled but just associate with those enrolled. Williams (2019) conducted a study in which he examined the spillover benefits that a South Carolina state

preschool program had in the low-income communities it was implemented in. The research first showed that preschool consistently improves the academic achievement of its participants. Furthermore, once these preschool students moved into kindergarten the following year, their academic progress also improved the achievement of their non-preschooled peers (Williams, 2019).

According to Williams' (2019) research, both the preschooled students and the non-preschooled students showed higher math and reading scores following the development of the preschool programs, which can be derived from a few different factors. First, this can be affected by fewer classroom disruptions. Preschool helps teach students non-cognitive skills like self-control and positive behavior on top of its cognitive benefits, so elementary classroom decorum improves with the growth of its incoming students. Peer influence should not be undermined here: children want to follow the lead of those around them, and a student's behavior has even been shown through Williams' (2019) research to affect the test scores of his or her peers, so this helps boost the academic achievement of the students who did not attend preschool. Additionally, preschooled students can share knowledge from their early education with their non-preschooled peers in collaborative activities and social settings. Children can learn about math methods and concepts from the examples of those around them and with teacher support, leading again to higher achievement from non-preschooled students (Williams, 2019). Wider expansion of preschool programs will help close the math SES achievement gap because of its direct influence on the children involved and the indirect influence on the children in those same communities who are not involved. This wide-reaching influence makes preschool more cost-effective as well, showing more efficiency and results for a lower expenditure.

Potential Solutions to Close the Math Achievement Gap Alternative to Preschool

Government Policy and Voting Choices

One option that could be used alternatively to or concurrently with preschool is influencing governmental education policies through voting choices. There are a few aspects of education on the national scale that can contribute to academic inequality and the SES math achievement gap. A study done by Bodovski, Byun, Chykina, & Chung (2017) based on achievement inequality and the educational policy choices of 37 countries found that higher standardization was correlated with educational inequality. Standardization refers to the level of control that the government has over curriculum, teacher preparation, and examinations. Many of the issues that exacerbate the SES achievement gap, like less qualified teachers and less resources allocated to low-income schools, are attenuated by a rise in standardization (Bodovski et al., 2017). For example, a standard curriculum has been internationally found through Bodovsi et al.'s (2017) research to lead to higher math achievement, and it also contributes to less repetition for students as they progress through school. Centralized exit exams, specifically in math, help students perform better as well, due to the increased accountability and reward linked to hard work and effort (Bodovski et al., 2017). These policies can be contrasted with popular differentiation techniques used in many schools, like different grouping or tracking methods meant to meet students' individual needs. Though standardized exit exams can moderate the effect of tracking methods, differentiation like this generally leads to higher inequality, rather than higher academic performance (Bodovski et al., 2017; Chmielewski, 2019).

Along the same lines, the balance of public and private schools has an effect on educational inequality as well. Bodovski et al.'s (2017) research shows that the larger number of private schools a country has decreases the overall achievement of all the schools in the country.

Students at private schools tend to perform better academically, but this for the most part is due to most of the students coming from high-SES families (Bodovski et al., 2017). Low-SES families typically cannot afford to send their children to private schools, which increases school segregation and general educational inequality in a country. High-SES parents sending their children to private schools also decreases the amount of parent involvement and extra funds coming into public schools (Bodovski et al., 2017). All of these factors contribute to the segregation seen between many public and private schools and ultimately to the achievement gap as a whole.

Finally, the government funding allocated to public schools also has a huge effect on academic inequality in a country. Higher spending on education is strongly linked with lower inequality because public schools are able to bring in more resources and support their students individually (Bodovski et al., 2017). Also, more funds allow schools to expand the programs they offer their students, which helps them supply intervention opportunities and after-school support that can help low-income students catch up once already in school.

Many of these issues are complicated and not always reliable, so while research shows their benefit on inequality, there are still many questions to be answered and trade-offs that might need to occur. Still, each of these factors mentioned are decisions that the government has control over, and an alternative solution to help close the SES math achievement gap can be to raise awareness of the gaps in education among people in general so they can leverage their political power and use their voting rights to support politicians working to close gaps in educational equality.

Parental Support and Awareness

Another alternative solution to preschool in closing the SES math achievement gap is to educate parents on the significance of the early home learning environment. The main reason why preschool is so important for low-SES children is because low-SES families generally do not provide the same quality learning environment at home as middle and high-SES families do (Blums et al., 2016). Some of the factors behind this are controllable, like the amount of math talk that parents initiate, while others are not, like buying books for financially struggling families, but the underlying truth is that low-SES children need to be better cognitively supported before they reach kindergarten so they can develop appropriately. The first step that needs to be taken in parental education is emphasizing the importance of a child's cognitive development in the first few years of his or her life (von Hippel et al., 2018). Many parents do not know how significant their role is in their child's achievement at that age, so they do not take intentional steps in cognitively stimulating their children's brains (Galindo & Sonnenschein, 2015). This can be done through simple methods like engaging in conversation about math topics with the child (Susperreguy & Davis-Kean, 2016), reading with them (Blums et al., 2016), going on educational trips to places like libraries and museums (Blums et al., 2016), or getting involved in the child's school once they are enrolled (Minor et al., 2015). These kinds of activities lead to early proficiency and are ways that parents can help their children catch up to higher-SES peers.

Parental education and awareness would be the best alternative solution to preschool if it were feasible to accomplish. However, there are many factors that make this solution problematic. Financial difficulties and little time due to multiple jobs often plague low-SES families and can keep parents from taking educationally beneficial steps for their children. Additionally, there is no easy way to reach all parents with this message or ensure that they

would read or practice the advice given. Parental education can make a difference, but this difference would likely never reach the magnitude needed to close the SES math achievement gap. Preschool stands over this solution because it allows parents to work without worrying about childcare, and it still addresses the need children have to be cognitively stimulated in early childhood.

Teacher Preparation and Support in Approaching Low-SES Students

The role of the teacher is another incredibly important factor involved in the SES math achievement gap. One of the main issues contributing to the gap as discussed in previous sections of the paper is that most teachers in low-income schools are ill-qualified, ill-prepared, and incapable of adequately addressing the diverse needs of struggling students affected by the SES achievement gap (Minor et al., 2015). Reform in teacher preparation and allocation in low-SES schools is necessary so teachers can help students maximize their learning in the classroom. This involves knowledge of appropriate instructional strategies and interventions, classroom management abilities in the face of extreme behaviors and disruptions, the willingness to establish meaningful relationships with individual students, and more.

Berkowitz et al. (2017) conducted research on school climate and found that climate is directly related to students' academic achievement. School climate can be perceived from the perspectives of the students, teachers, parents, and the surrounding community. Climate includes features like respectful relationships, teacher support, clarity of rules and fairness of consequences, school openness, student engagement within the school, school safety, and school health and cooperation (Berkowitz et al., 2017). Many of these factors lie in teachers' hands: they have influence in how connected, engaged, and supported their students are, what standard they set for student peer relationships, and how the rules are given and enforced. Berkowitz et al.

(2017) writes, “in a positive classroom climate, the teacher fosters a sense of ease and enjoyment by demonstrating positive regard and warmth in interactions with students” (p. 431). These student-teacher relationships and the quality of student engagement in the classroom can tie back to how persistence plays a role in academic achievement, as mentioned in the discussion of factors of the achievement gap. When students feel supported and encouraged, which is directly influenced by the actions of their teachers, they can exhibit more resilience and reach new levels of achievement (Huang, 2015). Improvement in teacher effectiveness for economically disadvantaged students can change their school experience and help them catch up during the school year. However, this does not change the concern that low-SES students enter school with lower academic proficiencies. While teachers can help students raise their achievement level, it is difficult for teachers to do that for each of their students at a large enough scale to close the SES math achievement gap.

Technological Interventions

A final alternative to preschool that is a viable option for addressing the SES math achievement gap is using technology to help children develop early cognitive and math skills in early childhood. Stacy et al. (2017) researched the use of tablets in providing math support and found encouraging results for low-SES students. One of the issues involved in the math achievement gap is that math skills are not practiced at the same frequency as reading skills. Technology is a helpful tool to push students to practice math because it is highly engaging, provides immediate feedback, limits math anxiety, and even allows students to have fun. Stacy et al.’s (2017) research has shown that students’ standardized math test scores can increase with as little as fifteen minutes of daily online math practice for five weeks. Students who participated in the study were willing to continue the online math practice, desired the tablet-based math over

practice on paper, and even showed fewer behavioral problems (Stacy et al., 2017). As students see themselves improving as well, their confidence and academic persistence can rise, leading to higher levels of achievement overall. There are a plethora of math websites and apps for young children that can help them learn early math skills. As discussed earlier, Math Shelf is one tablet application that has been proven to improve the math deficiencies of low-SES children (Schacter & Jo, 2016). Other options include IXL, ABCya!, Prodigy, DragonBox, and Khan Academy. Technological math practice centers like these options can be integrated in school curriculum as well as provided in early childhood before students reach school age. This can be a helpful intervention channel for low-SES students to gain extra math practice to make up for their lack of math skills.

Conclusion

The SES math achievement gap has been growing in the United States (Chmielewski, 2019) and needs to be addressed due to the weight that it carries for children's lives. SES begins to negatively affect children's cognitive skills and math achievement from as early as birth through their early home learning environments (Blums et al., 2016; Susperreguy & Davis-Kean, 2016), so elementary school interventions are often too late to help low-SES students catch up to appropriate achievement levels. For this reason, preschool presents itself as the most feasible option for developing the cognitive growth of children in early childhood (Galindo & Sonnenschein, 2015; Scammacca et al., 2019; von Hippel et al., 2018). Math exposure in preschool has been shown to significantly improve young children's future math achievement (Bachman et al., 2018), and expanding preschool programs even benefits the achievement of young students in the same communities who are not enrolled in preschool (Williams, 2019). Preschool favors low-SES students, their parents, and entire nations through economic

advancement (Melhuish, 2018). Preschool reigns over other intervention strategies to address achievement and proves itself as a positive and necessary step for national development and ultimately closing the SES math achievement gap.

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