Impediments to Math Comprehension in Primary and Secondary Education

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Abstract

Math comprehension in primary and secondary education students is varied and can be influenced by a variety of factors, all of which can be sorted into the categories of nature or nurture. The study's goal is to evaluate high school students' mathematical ability based on factors that may have influenced it early in their primary education. For example, based on some results of the study, out of all the seniors in Dual Enrollment Calculus (n=21), 19% chose "Very Often" to the question asking how heavily their parents were involved in their mathematics education, compared to 0% of seniors in any Pre-Calculus course (n=23). Other questions targeted factors pertaining to grade level, learning disorders, gender, and the easiness of mathematics education throughout their life. Overall, this study aims to prove that there are correlations between math ability and neurological factors, such as mental disorders and cognitive ability, and environmental factors, such as parental involvement and learning environment. In accordance with the survey conducted, this paper uses sources by trusted authors to compare any of my data that may correlate or contrast any data that may have contradictions.

Keywords: math comprehension, primary education, secondary education, learning environment

Impediments to Math Comprehension in Primary and Secondary Education

One of the most universal experiences a student can go through is struggling with math. It is like a rite of passage. Why does this happen so often with math? According to Sattem et al. (2022), "[m]ath skills build like a staircase," so if one skill early on is missed, a student cannot hope to master any others that come after it (p. 7). But what causes students to miss those skills early on? There are multiple factors that can contribute to this: each of which can be sorted into the categories of either "nature" or "nurture"; nature being neurological or genetic factors, such as learning disorders, brain structure, and genes; and nurture being one's surroundings in terms of either learning environment, home environment, or even what country one lives in. This paper will be examining potential impediments to math comprehension, organizing it using the themes of nature and nurture, and examining these research questions:

- How can math ability be environmentally influenced?
- How can math ability be genetically influenced?
- How can math ability be neurologically influenced?

In addition to the research, a survey was conducted asking high schoolers about their experiences with math in their childhood, experiences with math currently, and other questions targeting potential factors that could have impeded or increased their mathematical ability. Because it was a survey for high school students, permission was not given to ask questions regarding socioeconomic status due to ethical issues because it was considered too personal of a question to ask of minors. Some survey results may not coincide with what the sources say, which is also something to consider. Because the sample size only consisted of students at one high school in a small town, it may not be representative of the general population. In addition, the data backing up the sources could be more accurate and circumstantial, and that could

explain the discrepancies between survey results and sources. Despite these potential setbacks, the survey benefits the research by providing a way to do field research and collect data directly.

Literature Review

Nature

Throughout all the factors in the "nature" category, one thing connects them: they all have to do with the brain. This may be obvious, since students require the use of their brain to perform well in math, so if anything directly impedes brain function, it will indirectly impede mathematical ability as well. For example, if one has a learning disability, it may disrupt their learning in all subjects, not just math. Though, as mentioned above, the way math is structured makes it so if one skill is missed early on, it can be hard to catch up and learn the skills that come after it in time.

Learning Disorders

Learning disorders are one natural factor that may affect mathematical ability. Many people have heard of dyslexia, which affects reading and writing, but a disorder that most people are not remarkably familiar with is dyscalculia, which The Understood Team (n.d.) notes that "5 to 10 percent of people might have." People with dyscalculia may "often struggle with key concepts" in mathematics: students with the disorder may have a challenging time doing basic addition, subtraction, multiplication, and division, which are all backbones for more advanced math. It is not known what causes dyscalculia, but there are implications that brain development and heredity are involved (n.d.).

Cognitive Ability

Another neurological aspect that can affect math proficiency is cognitive ability. For young children, other cognitive skills can be a highly successful predictor of how well they do in

math when they are older, specifically language skills. According to Chow et al. (2021), "[l]anguage is a fundamental skill that contributes to mathematics performance," and there are high correlations between language skills and overall mathematical ability (p. 3571). Language skills can contribute to math education when a student needs to solve a word problem, or when it is needed for the student to comprehend new mathematical concepts.

Nurture

Along with factors that might neurologically occur, like mental disorders or variance in cognitive ability, a student's surroundings may also influence their mathematical ability. Their environments both at home and especially at school could be the difference between a student who lacks basic math knowledge and a student who excels at math and might even be above the average of their grade. At school, students could feel pressured to do better than their peers, and this may affect them either positively or negatively. At home, a parent's involvement, or lack thereof, could contribute to a student struggling in school. In addition, even the country in which a student resides may be a factor.

Learning Environment

Living in the United States. According to Brandon L. Wright (2020), the United States is faring poorly in mathematics based on the results of the Program for International Student Assessment (PISA). The PISA tests 15-year-olds on their math ability and is scored on a scale of 0-6, with 5 and 6 considered as "good" scores. In 2012, only 9% of test takers scored a 5 or a 6, followed by 6% in 2016, and 8% in 2018. In addition, there are 29 countries that either place above the United States or have similar scores. The United States is not going to be any better, and there are reasons why, the main one being that the school systems simply "haven't made this

a priority" (2020). Ultimately, living in the United States can take a toll on one's math achievement and be a reason for one's math inability.

Parental Involvement. Something that is not dependent on what country one lives in is the learning environment at home, more specifically, a parent's involvement in their child's education. As stated by the Annie E. Casey Foundation (2022), parental involvement can look like the following: "reading with children, helping with homework, attending and discussing school events, and volunteering in classrooms." One effect of parental involvement is the effect it has on a student's grades, particularly math achievement. Students whose families were involved in their math education at home were strongly associated with higher math scores on standardized tests (2022). However, being too involved in a student's education can often "[do] more harm than good," (2022), and can be associated with students with increased anxiety and decreased self-esteem.

Materials and Methods

Methodology and Design

A mixed method approach was used for this paper to achieve a broader perspective on every way a child's math ability can be hindered; in order to be answered, some research questions required the use of qualitative data and others required quantitative data. The research design was non-experimental and only called for a survey to collect data. Similar to the approach with locating and organizing sources, the questions asked in the study were sorted into the categories of "nature" and "nurture." The survey was created under the assumption that those in higher-level math classes were better at math than those of the same grade level in lower-level math classes; for example, a junior in Algebra II Honors is better at math than a junior in Algebra II Regular. In addition, there was also the assumption that those on the Advanced Math

Track are generally better at math than those on the On-Level Math Track. Those who are advanced have taken Algebra I their 8th grade year and are on track to be in Calculus their senior year. Those on the On-Level Math Track had not taken Algebra I until their freshman year and can only get up to Pre-Calculus their senior year. My primary focus was to investigate what could neurologically impede one's math ability. For my own data, I asked participants if they had ever been diagnosed with a learning disability. In accordance, I have gathered information from other sources about the learning disabilities dyscalculia and ADHD and their effects on math education. I compared my findings to the information in my sources to observe what matched and differed. After looking into neurological factors, my next focus was analyzing the effect of environmental factors on math competence. Specifically, questions in the study targeted factors regarding parental involvement, gender stereotyping, and learning disorders.

Aside from the survey, data was also collected through other sources and documents. Sources used in this paper address the topics in the survey in more depth, including the topics of the pandemic's impact on math education, competition among students, and United States' standing in the world in math education. A total of nine sources were analyzed, four of which are peer-reviewed journal articles, and the other five are by non-profit organizations written and reviewed by trusted authors. The peer-reviewed journal articles each contain their own surveys with their own data, which will be used to compare with the data I have collected. Both quantitative and qualitative data are used in the surveys. The articles by the non-profit organizations contain information that will help me reach a logical conclusion with my own data by providing more evidence that the factors addressed in my survey do cause discrepancies in math ability.

Participants

The study included freshmen, sophomores, juniors, and seniors from Dickson County High School (n = 400). The only aspect that may have affected those who responded is whether they were in the math classes of the teachers who were provided the link to the survey. The math classes included in the study were Algebra I (n = 68), Geometry Honors (n = 79), Algebra II (n = 79), Algebra II Honors (n = 33), Pre-Calculus (n = 31), Pre-Calculus Dual Enrollment (n = 43), Statistics (n = 20), Statistics Dual Enrollment (n = 34), and Calculus Dual Enrollment (n = 21). There was no specific selection process in choosing participants. The demographics of all the students are shown in **Table 1**.

Table 1

Student Demographics

[a]n=400		A1	GH	A2	A2H	PC	PCDE	St	StDE	CDE	Totals
Gender											
Male		32	36	33	12	14	17	8	18	10	180
Female		36	41	45	21	17	26	10	16	11	223
[b]Other		0	2	1	0	0	0	2	0	0	5
Grade Level											
Freshman		68	47	0	0	0	0	0	0	0	115
Sophomore		0	32	5	25	0	0	0	0	0	62
Junior		0	0	74	8	19	32	0	0	0	133
Senior		0	0	0	0	12	11	20	34	21	98

Note. The class names were abbreviated to allow for the table size. The key is as follows: A1 = Algebra I; GH = Geometry Honors; A2 = Algebra II; A2H = Algebra II Honors; PC = Pre-Calculus; PCDE = Pre-Calculus Dual Enrollment; St = Statistics; StDE = Statistics Dual Enrollment; CDE = Calculus Dual Enrollment.

[a]There were eight students who were in more than one math class, so the total sample size does not reflect the added up sample sizes of each class because each student was counted for both classes. [b]Those in the "Other" category are under the non-binary umbrella.

Instruments

The survey was designed to obtain data on secondary education students' perceptions on the difficulty of math. Each question was marked as required to prevent any holes in my data. In addition, no personal information that would give away the participant's identity, like names or email addresses, was collected to maintain anonymity. This survey consisted of nine questions, which were all multiple choice to provide ease when analyzing the results. The questionnaire asked the following: questions regarding the participant (3 items), questions regarding perceptions of the participant's own math ability (2 items), and questions regarding factors that may impede on the participant's math ability (4 items).

Procedure

After I created the survey electronically through the Google Forms application, I sent the link to all my current and previous math teachers, who then administered it to their classes. It was up to the students' discretion whether to fill it out or not, as no incentive was given unless the teacher offered extra credit for it. Other participants were sent the survey directly from me, either because they know me personally or they were in my research class. Those in my research class were the first to receive and fill out the survey. Following initially being sent out, the survey was open from September 2023 and closed in November 2023 to collect as much data as possible.

In terms of ethics, the survey was sent to the former director of schools, Dr. Danny Weeks, to be approved. It was originally rejected due to a question asking participants about their

socioeconomic status because it was considered too personal to ask of minors. After that question was removed, the survey was free to be sent out to anyone within the Dickson County Schools district.

Analysis

In order to make sense of all of the survey data, I organized results based on which math class each participant was in. As mentioned before, survey data was analyzed under the assumption that those in lower-level math classes had lower math ability than those of the same grade level in higher level math classes. In addition, it was assumed that those on the Advanced Math Track had higher math ability than those on the On-Level Math Track. Because a mixed method approach was used, both qualitative data and quantitative data was gathered in this survey. When analyzing results, quantitative and qualitative, the math class the participant is in was compared to their other responses, specifically looking for an overall lower math ability in those in lower-level classes.

Results

Quantitative Analysis

Results under quantitative analysis are deemed as quantitative for one or both of the following reasons: the question in the survey conducted was quantitative or the data from other sources was quantitative. Results collected from other sources are only quantitative if the data collected in that source is quantitative.

Gender Stereotyping

Other Sources. In a study conducted by Makarova et al., the career aspirations of high school students were analyzed and were compared to their views of STEM fields as masculine. The study included asking male and female high school students about three subjects that have

an underrepresentation of women, mathematics being one of them. **Table 2** shows that out of the three subjects of chemistry, math, and physics, "math has the strongest attribution of masculinity," meaning the students in the survey view math as a more predominantly male field than the science subjects (Makarova et al., 2019, p. 6). In addition, the view of STEM fields as being mainly masculine was more common among female students than among male students in any of the three subjects, but especially mathematics (see **Table 2**).

Table 2

Descriptive Statistics

	All	Female	Male
Masculinity of chemistry (min: −2.4, max: 4.28)	$n = 406$ $M = 0.13$ $SD = 0.71$	$n = 240$ $M = 0.27$ $SD = 0.66$	$n = 166$ $M = -0.09$ $SD = 0.72$
Masculinity of math (min: −1.76, max: 2.36)	$n = 512$ $M = 0.29$ $SD = 0.64$	$n = 242$ $M = 0.38$ $SD = 0.62$	$n = 267$ $M = 0.20$ $SD = 0.64$
Masculinity of physics (min: −2.08, max: 3.08)	$n = 446$ $M = 0.18$ $SD = 0.63$	$n = 257$ $M = 0.31$ $SD = 0.66$	$n = 189$ $M = 0.01$ $SD = 0.55$

M = mean, SD = standard deviation.

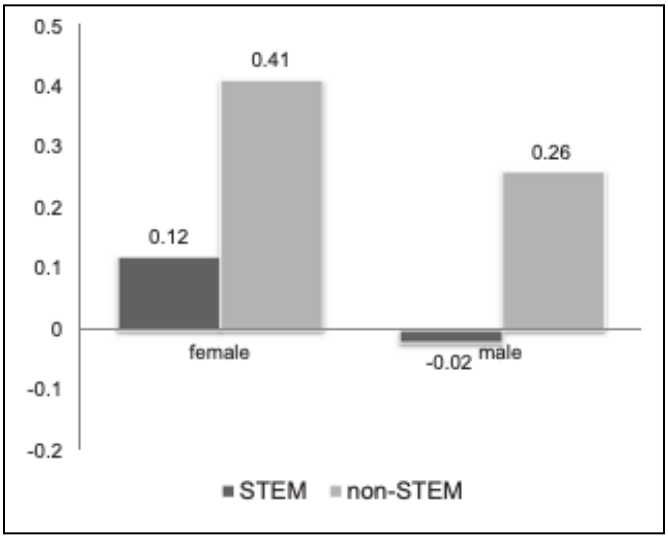
Note. Adapted from "The Gender Gap in STEM Fields: The Impact of the Gender Stereotype of Math and Science on Secondary Students' Career Aspirations," by E. Makarova, B. Aeschlimann, and W. Herzog, 2019, *Front. Educ.*, *4*(60), p. 6.

After analyzing high school students' masculinity attribution of different STEM subjects, Makarova et al. analyzed their career aspirations. Overall, it was shown that more males than females had taken a STEM route, and more females than males had chosen a non-STEM career path (2019, p. 7).

Based on the high school students' career aspirations, the study also consisted of analyzing the comparison of the attribution of masculinity between those pursuing a STEM field and those pursuing a non-STEM field. The results of the attribution of masculinity of the mathematics field are shown in **Figure 1**. It was shown that those pursuing a non-STEM field thought of mathematics as more masculine than those pursuing a STEM field, even more so for females pursuing a non-STEM career. The masculinity of mathematics was also more prominent than the masculinity of chemistry and physics (2019).

Figure 1

Masculinity Index of Math and Career Aspirations



Note. Adapted from "The Gender Gap in STEM Fields: The Impact of the Gender Stereotype of Math and Science on Secondary Students' Career Aspirations," by E. Makarova, B. Aeschlimann, and W. Herzog, 2019, *Front. Educ.*, *4*(60), p. 6.

Overall, this study showed that females are less likely than males to pursue a STEM-related career, especially in the mathematics field, because they view such careers as predominantly male. The study proved that there is a correlation between the attribution of masculinity of mathematics and the choice to pursue it as a career or a study choice in higher

education. This not only leads to an underrepresentation of females in such fields, but also discrepancies in math ability in the classroom. Gender stereotypes of STEM fields can cause a negative effect on girls' self-confidence in mathematics and can even lead to an overall lower math ability (2019, p. 2).

Survey Data. In my survey, I asked a question pertaining to the participants' perception of whether gender stereotyping has affected their math education, results of which are shown in **Table 3**. Overall it was shown that females made up 65.5% of those who responded "Yes," and 61.25% of those who responded with "I'm not sure."

Table 3

Perceptions of Gender Stereotyping and Math Education

n=400		Male	Female	Other
Has gender stereotyping impacted your math education?				
Yes		9	19	1
No		142	147	2
I'm not sure		29	49	2

When looking for a correlation between those who responded yes and poor math ability, it was found that 58% were on the On-Level Math Track. In addition, 62.1% of those who said yes currently find math to be difficult to some degree. It is worth noting that despite all these statistics that support my hypothesis and other sources, an overwhelming majority of participants responded that they do not feel that gender stereotyping has affected their math education, 147 of them being female. The results between my survey data and the data from the article could be so different because their sample was about 1300 and mine was only 400. Even so, the data does support that there is a correlation between poor math ability and gender stereotyping.

The United States' Standing in Math Education

The Program for International Student Assessment (PISA) tests fifteen-year-olds' ability in mathematics all around the world (Wright, 2020). The test has a 7-point scale ranging from 0-6, with 5 and 6 being regarded as good scores. As shown in **Table 4**, the results of the PISA in the United States have been topped by almost thirty countries since 2012. Wright notes that "the United States has consistently fared worse than virtually all of our competitors," and not by a small amount. Even worse, the percentage of those in the United States who scored a 5 or 6 has not been up to par in the last twenty years. One potential reason for such conditions in the United States is the way its education system deals with its gifted children. The country has never done a sufficient job of providing them with the attention they need. In fact, "[o]ne-third of American schools don't have any gifted programming at all," which means the gifted kids are treated the same way as the non-gifted (2020). Children like this need more advanced coursework to be able to achieve the same level of excellence as that of the countries listed in **Table 4**. Even the schools who do provide some type of gifted program "under-serve low-income, black, Hispanic, and Native American children" (2020). High achievers cannot thrive in the United States education system, and it is worse for those fitting into those categories.

Table 4

Percentage of high scorers on PISA math and rank among participating countries, 2012–2018, for countries matching or exceeding U.S. results

	2012		2015		2018	
	% at levels 5 and 6	Participating country rank	% at levels 5 and 6	Participating country rank	% at levels 5 and 6	Participating country rank
Singapore	40%	1	35%	1	44%	1
Hong Kong	33%	3	27%	3	29%	2
Taiwan	37%	2	28%	2	23%	3
South Korea	31%	4	21%	4	21%	4
Japan	24%	5	20%	5	18%	5
Netherlands	19%	8	15%	8	18%	5
Switzerland	22%	7	19%	6	17%	7
Belgium	19%	8	16%	7	16%	8
Canada	16%	12	15%	8	16%	8
Poland	17%	11	12%	14	16%	8
Estonia	15%	14	14%	10	15%	11
Slovenia	13%	18	13%	11	14%	12
Austria	14%	17	13%	11	13%	13
Czech Republic	13%	18	10%	23	13%	13
Germany	18%	10	13%	11	13%	13
Sweden	8%	34	10%	23	13%	13
United Kingdom	12%	22	10%	23	13%	13
Denmark	10%	27	12%	14	12%	18
New Zealand	15%	14	12%	14	12%	18
Norway	9%	30	11%	21	12%	18
Portugal	11%	24	12%	14	12%	18
Finland	16%	12	11%	21	11%	22
France	13%	18	12%	14	11%	22
Luxembourg	12%	22	10%	23	11%	22
Slovak Republic	11%	24	8%	33	11%	22
Australia	15%	14	12%	14	10%	26
Iceland	11%	24	10%	23	10%	26
Italy	10%	27	10%	23	10%	26
Israel	9%	30	9%	30	9%	29
Hungary	9%	30	8%	33	8%	30
Ireland	10%	27	10%	23	8%	30
Latvia	8%	34	6%	37	8%	30
Lithuania	8%	34	7%	36	8%	30
Malta	0%	60	12%	14	8%	30
Russia	7%	38	9%	30	8%	30
United States	9%	**30**	6%	**37**	**8%**	**30**

Adapted from https://fordhaminstitute.org/national/commentary/enduring-math-woes-jeopardize-americas-standing-world. Copyright 2020 by The Thomas B. Fordham Institute.

The Pandemic's Impact on Math Education

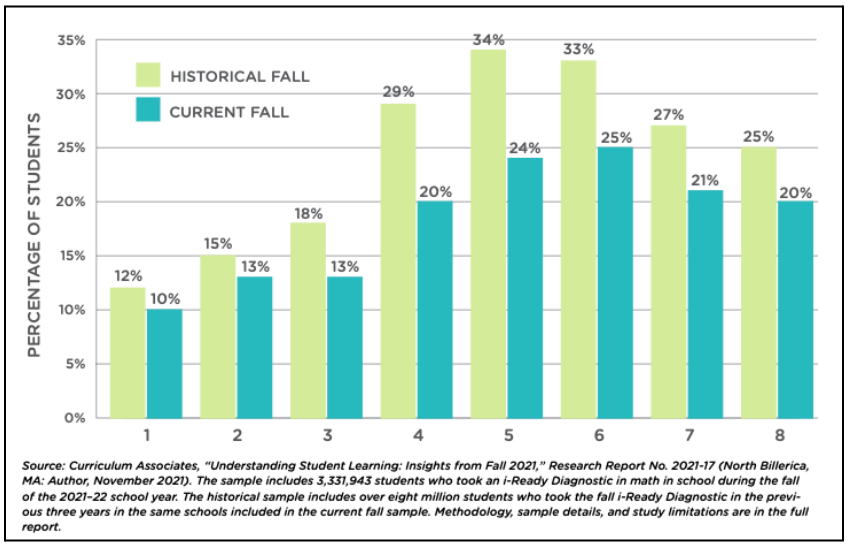
The 2020 pandemic caused by COVID-19 put a huge damper on education for students everywhere. Most students were unable to adapt to remote learning, and the effects of that are most prominent in math. Sattem et al. (2022) stated that math took the most damage because of its "sequential nature" (p. 7). With most subjects, missing early units is not going to affect the student's ability to learn the units later on in the course. For example, missing out on the water

cycle will not impede a student learning about the carbon cycle. However, it is completely different when it comes to math. There are foundational skills students need to master in their elementary and middle school math classes to be successful in their high school and college math classes. The transition from in-person to remote learning in 2020 put a halt on mathematics education for students in all grade levels, but a study by Sattem et al. showed that it was especially detrimental to those in grades 4-8.

Part of the study conducted by Sattem et al. was analyzing the math test results from the Curriculum Associates' i-Ready Diagnostic Assessment in grades 1-8 both pre-pandemic and post-pandemic (see **Figure 2**). The results showed that test scores of all grades 1-8 were lower after the pandemic than they were before it, being most pronounced in grades 4-8. In addition, the unfinished learning in math resulted in "fewer students in elementary and middle school [starting] the 2021–22 school year ready for grade-level work" (2022). The data collected in 2022 indicated that students at that time were still not up to par with the grade-level math ability shown pre-pandemic.

Figure 2

Grade 1–8 Students on Grade Level in Math, Fall 2021 and Historical Averages (percent)



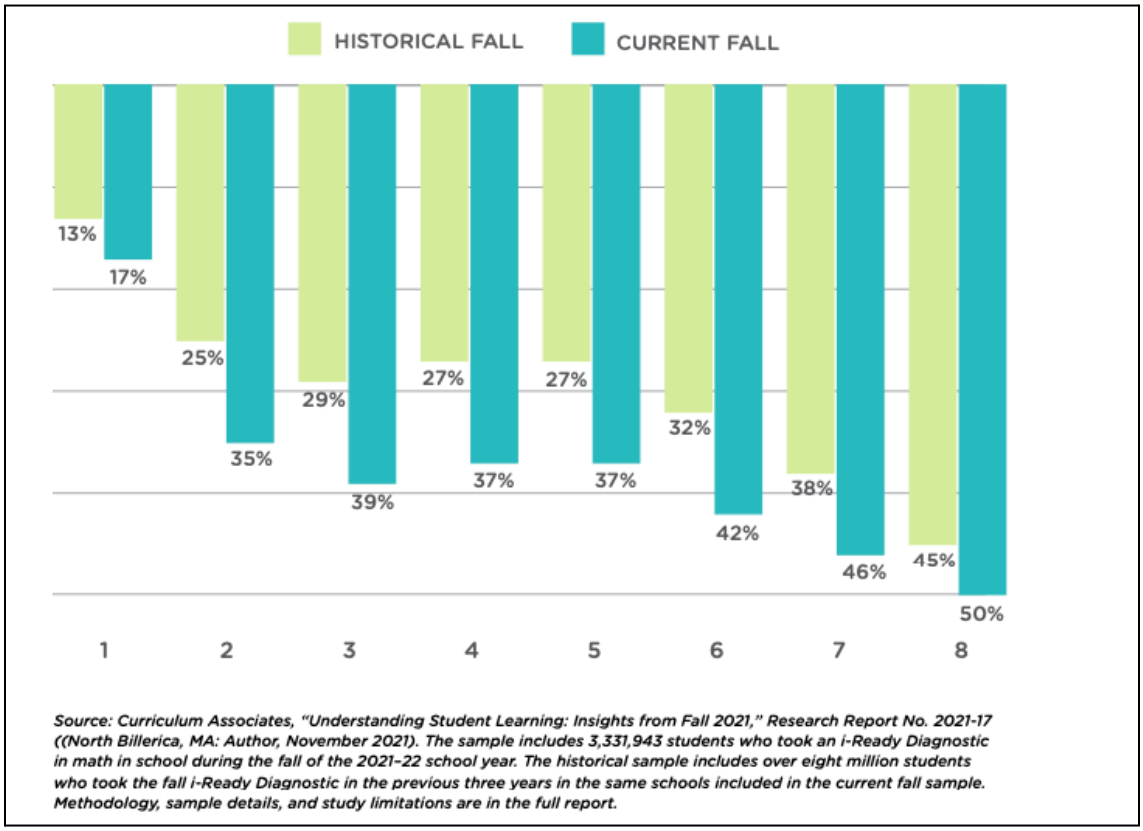
Source: Curriculum Associates, "Understanding Student Learning: Insights from Fall 2021," Research Report No. 2021-17 (North Billerica, MA: Author, November 2021). The sample includes 3,331,943 students who took an i-Ready Diagnostic in math in school during the fall of the 2021–22 school year. The historical sample includes over eight million students who took the fall i-Ready Diagnostic in the previous three years in the same schools included in the current fall sample. Methodology, sample details, and study limitations are in the full report.

Note. Adapted from "The Impact of COVID-19 on Math Achievement," by J. Sattem, M. Dawson, and E. Peyser, 2022, *Advancing Math and Science Instruction*, *22*(2), p. 8.

Figure 3 shows a comparison between pre-pandemic and post-pandemic students in how many of them were two or more grade levels below their grade-level mathematics curriculum. It is clear that students got more behind in math because of the pandemic. Sattem et al. (2022) highlights that this could be because "math instruction does not translate as well to a virtual learning environment," and as students get older, it becomes harder for parents to help them at home (p. 8).

Figure 3

Grade 1–8 Students Two or More Grades below Their Chronological Grade in Math, Fall 2021 and Historical Average (percent)



Source: Curriculum Associates, "Understanding Student Learning: Insights from Fall 2021," Research Report No. 2021-17 ((North Billerica, MA: Author, November 2021). The sample includes 3,331,943 students who took an i-Ready Diagnostic in math in school during the fall of the 2021–22 school year. The historical sample includes over eight million students who took the fall i-Ready Diagnostic in the previous three years in the same schools included in the current fall sample. Methodology, sample details, and study limitations are in the full report.

Note. Adapted from "The Impact of COVID-19 on Math Achievement," by J. Sattem, M. Dawson, and E. Peyser, 2022, *Advancing Math and Science Instruction*, *22*(2), p. 9.

Sattem et al. (2022) notes that even though mathematical ability in elementary and middle school is a reliable predictor of mathematical ability later on, fourth grade "is an essential grade to develop and master skills that prepare students for moving on to more advanced math" (p. 9). Data shows that those who started fourth grade in fall 2021 had trouble with almost all of the mathematical skills expected of them to know already. Such skills include algebraic thinking, working with operations, geometry, and measurement and data (p. 10). Though Sattem et al. only highlights fourth grade, they mention that the same problem is occurring with all grade levels as well. Fourth grade is just one of the most important grades in mathematics education.

Overall, this study has shown that the pandemic has had a significant impact on mathematics education, especially for children who were in grades 1-8 at the time. Those grade levels provide the foundations for math, and without those foundations, one cannot hope to be successful in any math course provided in secondary education and above. Because math is a subject that requires mastery of early skills to be able to master later skills, students without those early skills will have a very hard time in their future math classes unless something is done to help them catch up.

Language Skills

Because mathematics proficiency has a lot to do with the way one processes information and thinks, it also has to do with cognitive ability. As such, other cognitive skills may have influence over it. One such cognitive skill is language ability. Chow et al. (2021) conducted a study examining the links between language skills and math performance in first and second graders. To structure the study, they placed the students in one of these two groups: children with

mathematics difficulty and children without it, which was decided based on their test scores on an exam measuring addition fluency (2021, pp. 3572-3573).

After measuring the students' math ability, Chow et al. went on to measure language ability as well, using the Test for Auditory Comprehension of Language–Fourth Edition, which is a "verbally delivered language assessment that provides scores for vocabulary, morphology, and syntax" (2021, p. 3573). Out of the three parts of the language test, it was found that syntax had the most associations with mathematics proficiency. Syntax has to do with language order and rules. Chow et al. explains that this relates to mathematics because "[it] also involves the understanding of rules and order" (2021, p. 3574). Therefore, it can be seen that there is a correlation between syntactic ability and math competence because syntax allows for students to understand the material being verbally explained to them.

Qualitative Analysis

Data under qualitative analysis were gathered through qualitative sources that answer the research questions. Even though some parts of this section will include survey data that was initially quantitative, it required a qualitative viewpoint to analyze and make sufficient inferences. The sources that use qualitative data provide the information needed to analyze my own data from a qualitative perspective.

Neurobiological Factors

A study done by Skeide et al. suggests there could be a genetic component to variance in math ability. In the study, the brain scans of a group of children aged 3-6 were used to predict the math scores of the same children when they were in second grade at 7-9 years old (Skeide et al., 2020, p. 2). The researchers found that the gene ROBO1 is linked to variance in gray matter in the parietal cortex, which is the area of the brain responsible for quantity representation and

processing (2020, pp. 6-7). With this information, they hypothesized that there would be a correlation between gray matter volume and math test scores. Their findings corroborated that the gene ROBO1 "was significantly associated with individual scores in a comprehensive behavioral math test taken at 7–9 years of age" (2020, p. 3). In addition, the results showed that the presence of gray matter caused by the gene ROBO1 stayed consistent in the children from ages 3-6 all the way to ages 7-9. Overall, this study revealed that the parietal lobe of the brain can influence and account for differences in students' mathematical ability. One can use the amount of gray matter in that part of the brain to further predict up to 20% of the mathematical ability of the child later on in their life (2020, pp. 6-7).

Learning and Mental Disorders

When thinking about how one's math ability can be hindered, it is clear that disorders play a big role. This section addresses the disorders dyscalculia and ADHD and how they fit into math comprehension. Such disorders were chosen because dyscalculia is a math-specific disorder and ADHD is very common.

Dyscalculia. The Understood Team (n.d.) explains that dyscalculia is a learning disability that is prevalent in 5-10% of people. It can cause those with it to "struggle with key [mathematical] concepts." However, this disorder is lesser known than other learning disorders like dyslexia, which can further contribute to mathematics difficulty. If a teacher is unaware that they have students with dyscalculia, it can complicate trying to address any problems that the disorder may cause. It is currently unclear what exactly causes the disorder, but researchers hypothesize that brain development and heredity have a lot to do with it (n.d.).

Attention Deficit Hyperactivity Disorder. A mental disorder people are more familiar with is Attention Deficit Hyperactivity Disorder, otherwise known as ADHD. Witzel (2020)

states that students with ADHD struggle with three things relating to executive function (EF) that directly impact mathematical ability: “self-regulation, working memory, and reconstitution.” Self-regulation deals with impatience and impulsivity; working memory deals with the memorization and recall of facts and formulas, and reconstitution deals with switching from one form of thinking to another (2020).

Survey Results. A question in the conducted survey asked students about whether they were diagnosed with a learning disability, to which 82.2% answered no, 7% answered yes, and 10.8% answered that they were not sure. Of the participants who marked yes, 75.6% are on the On-Level Math Track, which shows further implications that learning disabilities can lead to impediments in math comprehension. The same implications can be made of the fact that 60.7% of the same group marked that they are taking a regular-level math class. The same percentage of participants with a learning disability marked that they currently find math difficult to some degree.

Competition Among Students

An article by The International School of Thrissur (2022) weighs the pros and cons of competitiveness among students and how it can affect their education. Though the article is about education as a whole, the same information can be applied to mathematics education specifically. Students typically compete with each other when comparing grades or playing in-class games like Kahoot. Positive effects of such competition can include an increase in motivation and innovation (2022). Students who want to surpass their peers typically feel more motivated to do their schoolwork. This can lead to overall better achievement. However, competition can be a stressful thing as well. Those who fail to do better than their peers can feel disappointed which can cause them to lose motivation (2022). Similar to parental involvement, competition can be a

good thing in hindsight, but too much can lead to learning anxiety, which in turn leads to poor grades.

Parental Involvement

The Annie E. Casey Foundation (2022) promotes parental involvement as a factor that "transcends nearly all others" in a child's education. Parents can contribute to their child's education by creating an encouraging learning environment at home, setting realistic academic expectations, and having close communication with the school. In terms of math education, the Annie E. Casey Foundation looked at data from a study analyzing how parental involvement can increase math achievement. Results showed that there was a correlation between children with involved parents and "higher percentages of students who scored at or above proficiency on standardized math achievement tests" (as cited in Sheldon & Epstein, 2005). However, even though parental involvement usually has positive connotations, too much can be overbearing on the student. As mentioned before, setting realistic academic expectations is one part of involvement, but if such expectations are unreasonable, it ends up hurting the child more than helping them (2022).

Survey Results. One survey question included asking students how often their parents were involved in their math education, the answer choices being "Not Often at All," "A Little Often," "Moderately Often," and "Very Often." Out of all the seniors in Dual Enrollment Calculus, 19% had parents who were very often involved in their math education, compared to 0% of seniors in any Pre-Calculus course. On a different note, results showed that a majority of students had parents who were not often involved in their mathematics education. 53.1% of those students are taking a regular-level math class, and 68.1% are on the On-Level Math Track.

Though the correlation could be stronger, it can be deduced from these statistics that parental involvement does have an influence on math achievement.

Discussion

The results of this study corroborate other studies proving a variety of factors can influence mathematics achievement. This study and others address the following factors: gender stereotyping, living in the United States, the impact of the COVID-19 pandemic, the impact of language skills, genetics, the influence of academic competition, and parental involvement. This section will offer potential solutions to problems based on the analysis of study results, as well as acknowledge limitations that may have impeded on the study.

Solutions

Work Out Problems Step-by-step

There are many potential solutions that one can use to tackle struggles pertaining to people with dyscalculia, ADHD, or anybody having math troubles. One is the Say-Ask-Check method (Witzel, 2020). While utilizing this, the student first says the problem aloud to gain a better understanding, then asks themselves what the problem is exactly asking, and checks that their answer matches what the question is asking. This is an effective way to take a slow and steady approach for solving math problems, especially for those struggling with self-regulation (2020).

Find Out Where Help is Needed

Another strategy students and teachers can use is finding exactly where help is needed. Solving complex math problems takes multiple steps and different formulas. If one is unable to complete any part of these steps, it can be hard to solve the problem. It can help to find exactly

which part of the problem that student would need help with and start from there. One way to counter it directly is by integrating mini-lessons into the full lesson, which Sattem et al. states is a way to "[build] [the student's] foundational skills while teaching him grade-appropriate material" (2022, p. 10).

Educating Teachers About Dyscalculia

The problem with addressing issues that dyscalculia could cause is that teachers don't know what to look for. Most likely, they don't know it even exists. If universities took the time to teach future math educators about the signs the disorder exhibits, children with it can be more easily identified. But only identifying such children does not help. Schools need to start knowing how to accommodate them as well. The Understood Team (2022) has compiled a list of symptoms of dyscalculia, which includes issues with the following:

- Understanding mathematical concepts, like "biggest vs. smallest" (2022).
- Associating numerical forms of numbers with the word forms, and that they both mean the same thing.
- Recalling basic math facts, like formulas and properties.
- Mental math.

Limitations

There were a variety of limitations concerning the conducted survey. When designing the questionnaire, it was my initial plan to include a question regarding the participant's socioeconomic status. However, it had to be removed due to ethical issues; it was deemed too personal to ask of a minor. Even though the survey was distributed to a good number of math teachers, not all teachers on campus received it. Due to time constraints, I could not go to each individual math teacher to send them the survey. This is the case for freshmen math teachers

especially, as the school campus is structured to where the first-year students are in the building down the hill from the main building. This barrier led to the disclusion of the classes Algebra I Honors and Geometry in the survey when analyzing data, as neither had the minimum responses (20) required to be used in the results. In addition, there was a question asking students if their education primarily consisted of in-person schooling or online schooling. The majority had put in-person, and there was not enough grounds for comparison to include the results in the research paper. Finally, the school consists of a regular and advanced level for all math classes except Calculus, which is only offered at the dual enrollment level. As such, there was no regular Calculus class to compare with the dual enrollment students.

Conclusion

This study aimed to prove there are correlations between poor math ability and a variety of factors including gender stereotyping, living in the United States, the impact of the COVID-19 pandemic, the impact of language skills, genetics, the influence of academic competition, learning and mental disorders, and parental involvement. Identifying and accommodating students that have trouble with any of the listed factors can prevent their mathematics ability from faltering. For example, teachers can integrate mini-lessons into their full lessons to catch up a class that is behind. Overall, the results of this study can be used to further improve mathematics education in primary and secondary students.

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