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EFFECTS OF THE PANDEMIC ON MATHEMATICS AND READING ACHIEVEMENT

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Abstract

During the pandemic, we talked with many educators about how they were doing in their efforts to reshape how they were teaching and how their students were learning. In our discussions with educators, most were telling us they were working harder than ever to attempt to help students and their families. Most teachers told us, during the pandemic, they were not able to teach the same quantity or quality they had been used to accomplishing with their students. When students returned to learning face-to-face in schools, many teachers told us they observed that many students had lost their drive to learn, and many students had lost or had not gained the social and emotional skills necessary to be successful in their classes. Teachers told us, because of the pandemic, students were behind academically, socially, and emotionally. In this article, we review standardized test scores in one school for grades two and four. We compared the test scores from 2019, prior to the chaos of the pandemic, and 2021, in the middle of the pandemic. Our hypothesis was that the pandemic would have a negative effect on student achievement in mathematics and reading. Our review of the data confirmed what teachers believed they were observing in their students, data showed significantly lower scores in both mathematics and reading for grade two and grade four. We also compared the scores for grade two in 2019 to grade four in 2021 (mostly the same students) and their differences were even more statistically significant.

Keywords: Achievement, mathematics and reading, pandemic, social and emotional learning

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1. Introduction

Most teachers remember where they were and what they were doing on March of 2020, because the world of education, teaching, and learning were devastated by the worldwide pandemic. In many ways teachers now think about their teaching lives in terms of prior to the onset of COVID-19 and after the onset of COVID-19. As in many other professions (e.g., medical people, first responders, grocery store workers), teachers became front line essential workers for their communities. Overnight, teachers were forced to almost completely change how they taught, and students had to almost completely change how they learned. Parents also had to reshape their lives to develop systems to help their children learn from home. Students of poverty, who had come to depend on schools for breakfast and lunch and for assistance in finding help for their families in gaining medical, shelter, and food security assistance, now were left almost helpless. At the beginning of the process of dealing with COVID-19, it appeared that people were willing to do whatever was necessary to get through this emergency. Then, as the pandemic continued to cause loss of jobs, loss of social lives, and loss of lives, it became clear that schools and their teachers would be asked to return to teaching face-to-face as soon as possible. Schools developed protocols, mostly based on the advice of medical professionals (e.g., wearing masks, socially distancing). Parents became concerned that their children were losing time for learning, and many people feared the losses would be difficult, if not impossible, to overcome. As important, and many people feared, more important, students were losing their social connections, and professionals like Burke Harris (2020) were worried about the social and emotional damage living in isolation was causing for young people.

Darcy (2022) wrote, “I have faced the most difficult year of my professional life; I survived, and I helped my students survive” (p. 8). But not everyone survived. Sainato (2021) reported that in the US teachers were retiring or quitting their teaching jobs in large numbers, causing some schools to close and causing difficult teaching circumstances in schools that were under staffed. Edelman (2022) wrote that one poll indicated more than half of teachers were contemplating leaving their profession. The toll of the pandemic has taken and continues to take its toll on teachers (and on everyone else). Sinek (2021) advised everyone to not cry by yourself. Especially in times like we have been facing, people should, according to Sinek, reach out to each other and take care of each other. Teachers must help take care of students, and we should all be reaching out to other people to help them and allow them to help us.

1.1. Anecdotal Data

Anecdotally, we have heard from many teachers that they did not teach as much curriculum, and the quality of the teaching and learning was of lower quality than in the past. According to Goodrich et al. (2022) a sample of 9,000 teachers indicated that:

> many students did not receive direct instruction in academic skills during the spring 2020 semester. Although by late fall 2020 teachers reported broad use of some form of in-person instructional model, teachers indicated that many of their students were not ready to transition to the next grade level and that achievement gaps were larger in fall 2020 than in typical years. (p. 1)

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That analysis agreed with what teachers were telling us, and what one of the authors of this study experienced. Claudia, one of the authors of this article, stated during one of our meetings for this article 'I worked hard and did my best but I just could not cover the material in the same way I had done prior to the pandemic.' Darcy (2022) agreed and stated that it was difficult to keep young students' attention and that she could not adequately monitor what students were doing and/or not understanding in the online platform. She explained that she was working harder than usual to try to create attention-getting experiences for her students but it simply was more complex than in face-to-face work.

Additionally, physical and emotional health issues developed for students during the pandemic that added to the issues of learning. A study in the UK (Ravens-Sieberer et al., 2021) indicated that students reported significantly more issues with their emotional health, depression symptoms, and feelings of isolation during the pandemic than pre pandemic. Other research reported declines in health-related quality of life issues and increases in emotional issues like depression, anxiety (Bignardi et al., 2021; Cost et al., 2021; Hawes et al., 2021; Maunula et al., 2021; Perțe, 2019) suicidal ideation, and suicide attempts (Keveney, 2021; Maunula et al., 2021) in school-aged children since the start of COVID-19. COVID-19 public health measures, including long periods of lockdowns, school closures, and remote learning, have upheaved children's daily lives and routines, resulting in feelings of boredom, lack of purpose, and loneliness. In these studies, children have reported they have reduced the amount and quality of social interactions, and they reported these situations, especially during lockdowns, have led to feelings of sadness and frustration. One student reported (Maunula et al., 2021), "I literally want to jump through the window and run to school" (Sec. 3.3).

1.2. Stress

Sousa (2017, 2022) reported from his review of studies from brain research that it is clear that emotions play a huge role in the teaching and learning process for students. If students are fearful, their brains are working to protect their owners, and that causes students to have a harder time to concentrate on learning. Creating an environment that is safe and encouraging is vital to learning (Boaler, 2019; Jensen & McConchie, 2020; Laurian-Fitzgerald & Fitzgerald, 2016; Robinson & Robinson, 2022; Sousa, 2017). Obviously, if students are frustrated, sad, depressed, or having suicidal ideations, teaching and learning become more difficult. Additionally, if teachers are feeling the same negative feelings as their students, it is more difficult for the teachers to concentrate on their preparation and instruction. Puntin (2022) reported that during the pandemic she and her colleagues, "met less often, and, when we did meet, it was not the same. Without the level of support we used to give each other, my colleagues and I struggled" (p. 26). There was a double whammy effect going on—students were more frustrated and sadder, and teachers had the same emotional issues as their students. Teachers also reported that the social and emotional (SEL) needs of many of their students led the teachers to concentrate on SEL issues like feeling cared for and about, working on relationship building, and ensuring students felt like their voices mattered (Booth, 2022; Darcy, 2022; Laurian-Fitzgerald et al., 2018; Leonard, 2022; Napolitano, 2022).

Burke Harris (2018, 2020) reported that students who have gone through childhood adversities (i.e. traumatic experiences) tend to struggle in school, and if those experiences are not dealt with effectively, children develop long-term emotional and physical issues throughout their lives. During the

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pandemic, Burke Harris stated that parents were experiencing the same kinds of traumatic issues as their children, and even though adults tend to have more coping mechanisms, the severity and length of COVID-19 issues have put more adults at risk. Sinek (2021) stated that adults must reach out for help in dealing with their emotional issues caused by the pandemic. He pointed out that many times adults do not understand what is happening to them until later, so it is important that adults notice when their emotions are causing negative feelings or even negative physical symptoms. As Puntin (2022) stated, adults should reach out to each other for support.

1.3. Basic Needs

All people have needs, and when needs are not being met, people struggle (Glasser, 1998; Laurian-Fitzgerald & Fitzgerald, 2019; Maslow, 1971, 2013). Maslow (2013) related that all people have five levels of needs: psychological needs, safety needs, love and belonging needs, esteem needs, and self-actualization needs. His ideas were that the first four needs were what he called deficiency needs, that is, if any of those needs are not met, people have negative emotional and physical responses. Maslow felt that self-actualization was a growth need. Reaching self-actualization makes people happier but the lack of reaching those needs does not cause people any negative ramifications. At first, Maslow (1971) thought people could not meet the next level of needs until they had fully met the lower-level need. He later changed his thinking to believe that the needs are more interactive than he first believed. Maslow also added a sixth level of need that he called transcendence. Transcendence occurs when people use their gifts and abilities to help other people meet their needs. Some people also discuss cognitive and aesthetics needs as part of self-esteem, while others now discuss these as separate need levels. The big idea of needs is that they are what drive people to behave.

Glasser (1998) developed ideas about motivation in a similar fashion as did Maslow (1971, 2013). Glasser (1998) developed five human needs: survival, love and belonging, power, freedom, and fun. In his theory, Glasser also believed that people are motivated to meet their needs or to maintain the level of needs they have attained. Since we live in a world of people, Glasser felt that the majority problems in the world are caused by issues with their love and belonging need. His process is called choice theory, in other words, people make their own choices in life, and those choices are made based on meeting their needs. Fitzgerald and Laurian (2013) believe that there is also an existential or meaning need for people. The existential need is very similar to Maslow's transcendence need. The basis of needs theory is that to be happy people need to meet enough of their needs that they feel in balance in their lives.

Needs theory is important to understand as it relates to students and teachers in school. For teachers to be able to be fully effective, in school, they must be in balance in their professional lives. To learn effectively, students also must be in balance in school in terms of meeting their needs. In line with brain research, students' emotional and physical needs for safety and survival must be met. If students are worried about their survival or the survival of a loved one, they will struggle to learn in school. If students are food or home insecure, afraid of going home, or fearful of the well-being of a loved one, their brains will work to keep them safe, leaving much less room to concentrate on learning. If students feel sad, or voiceless, or powerless, learning is not a priority in their lives. Thus, teachers must develop an environment in school in which students: feel safe, are cared for and about, students care for each other,

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they have fun together, have a voice and feel heard, feel competent, and receive help from and give help to their peers. When life outside of school is more difficult for students, it effects their lives in school. During the pandemic, it was clear that life outside of and within school made it more difficult for everyone to meet their needs in effective ways. And, as Sousa (2017, 2022) pointed out, emotions play an import role in the teachers' ability to teach and the students' ability to learn.

2. Problem Statement

According to Sousa (2017, 2022), emotions are directly connected to learning. When student emotions are low or negative, learning is difficult to accomplish. Obviously, the stress of the pandemic placed more stress in most people's lives. In a world-wide pandemic, stress becomes almost a common state of affairs. As Sinek (2021) pointed out, people often do not feel the stress right away. Many people do what they have to do in their day-to-day lives to survive and help their families survive. We have heard from many colleagues how they thought they were fine throughout the pandemic, only to realize, when life calmed down, they were feeling sad or lonely or depressed. In our conversations with colleagues, many have discussed how their students are not as resilient in class as they used to be. Many students seem to no longer be excited about learning. Teachers have indicated many of their students struggle to pay attention, and other students now appear to struggle to keep up with their work. Finally, teachers have shared they see that their students have not developed their social skills. All of these social and emotional issues have added to the lack of time on task that has occurred during the COVID-19 crisis.

3. Research Questions

In this study, we decided to assess if the content of our conversations was accurate. This led us to develop our research question: What effects did the pandemic have on the mathematics and reading achievement of elementary students? Our hypothesis was that that the pandemic did have a negative effect on students and teachers, and that caused student achievement to diminish during the pandemic. To attempt to find the answers of our research question, we decided to review the standard test scores of second grade and fourth grade students prior to the pandemic (2019) and during the pandemic (2021). There were no scores in 2020 because the schools did not have students take standard tests due to the pandemic. The data indicated that our hypothesis, that the pandemic had a negative effect on student achievement, was correct.

4. Purpose of the Study

The purpose of our study was to assess whether or not and to what extent teaching and learning during the pandemic effected student achievement in mathematics and reading for grade two and grade four students. Once we know the answers to our research question, we can begin to develop ways to overcome issues for teachers and students to ensure all students can be successful in school.

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5. Research Methods

This study was a quantitative analysis of pre pandemic achievement scores in mathematics and reading for grade 2 and grade 4 students in one elementary school. We reviewed data for all second and fourth grade students who participated in the standardized state tests in mathematics and reading. The student data were from two years, 2019, prior to the massive changes caused by the COVID-19 pandemic, and 2021, during the pandemic. Our main research question was: What effects did the pandemic have on the mathematics and reading achievement of grade two and grade four elementary students? To answer the research question, we reviewed the standardized test scores in mathematics and reading for all grade two and grade four students in the school.

From the student scores we determined the mean score and standard deviation (SD) scores for both subjects for each grade level from student scores in 2019 and in 2021. From that data we used a one-tail t-test to determined statistical significance in the differences of scores in mathematics and reading. We also determined the effect size scores for the differences to gain more understanding of the effects of the pandemic on student learning. As displayed in Table 2, data reveal that in mathematics the comparison of grade two in 2019 to grade two in 2021 the differences in scores were statistically significant. Data also revealed that the differences in mathematics scores for grade four student between 2019 and 2021 were statistically significant. Table 1 also shows the differences in grade two scores presented a medium effect size, while the 4th grade scores resulted in a high effect size score. Similar results were displayed in the student reading scores, with both grade levels earning scores whose differences were highly statistically significant, and, in grade two earned a medium effect size, while grade four earned a high effect size.

We also reviewed the differences in scores for the grade two students in 2019 and the grade four student scores in 2021 (see Table 3). This comparison was interesting because most of the students in grade four in 2021 were the same students who were in grade two in 2019. These scores were more dramatic, as they indicated highly statistically significant differences and high effect size scores for the differences in scores in both mathematics and reading.

6. Findings

For the purposes of this study, we used two scores to determine how important the differences in scores were in terms of achievement. The first score is the p score which was determined using a one-tail t-test. A p score equal to or less than .05 is considered to be a statistically significant score. This score means that there is a 95% chance that the differences in scores occurred due to the intervention (i.e. COVID-19 pandemic) and not by chance. The second important score is the Cohen's d effect size score. For the purposes of this study a Cohen's d effect size score of 0.3 and lower is considered to be a low effect size (meaning between 50% and 60 % of differences were due to the intervention). Cohen's d scores of 0.31 to 0.6 are considered to be medium scores (meaning between 61% and 75% of the differences were caused by the intervention). Cohen's d scores of 0.61 and above are considered to be high (meaning 75% or more of the differences were caused by the intervention). Hattie (2012) explained that effect size scores of 0.41 and higher are what he calls "visible scores." Visible scores mean that teachers can actually see the differences in their students' behaviors and achievement in class.

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Our hypothesis for this study was that the COVID-19 world-wide pandemic would have a negative impact on the achievement of grade two and grade four students in mathematics and reading. As displayed in Table 1, the pandemic did have a statistically high negative impact on the achievement of grade two and grade four students in mathematics. The pretest scores and data were from 2019, and the posttest scores were from 2021. For grade two, 147 students participated in testing in 2019 and 138 students participated in testing in 2021. The pretest mean for grade two was 9.12. and the posttest mean was 8.63. The standard deviation score for grade two in 2019 was 1.2127, and in 2021 the standard deviation score was 1.5330. This data led to a t-test p score of .001514, a highly statistically significant score. These data also led to a Cohen's d score of 0.3545, a medium effect size. For grade four, 158 students participated in the pretest (2019) and 150 students participated in the posttest (2021). The pretest mean was 8.63, and the posttest mean was 7.62. The pre and posttest standard deviations were 1.4390 and 1.7355 respectively. These data led to a p score of <.00001, a highly statistically significant score, and a Cohen's d score of 0.6336, a high effect size. When we combined the scores for grade two and grade four, we determined a pre mean of 8.87 and a post mean of 8.10, with a total of 305 participants in the testing. The pretest SD was 1.3543, and the posttest SD was 1.7141. This data led to a p score of <.00001, a highly statistically significant score, and a Cohen's d score of 0.4985, a medium and visible effect size score. These scores attest to the idea that what teachers were observing in their students was real, and educators are probably going to have to develop ways to help our students recover.

Table 1. Mathematics Data

Grade	Mean		SD		N		*P* Value		Cohen's *d*	
	Pre	Post	Pre	Post	Pre	Post	*p*	Sig.	*d*	Level
2	9.12	8.63	1.2127	1.5330	147	138	.001514	Highly	0.3545	Med.
4	8.63	7.62	1.4390	1.7355	158	150	<.00001	Highly	0.6336	High
Total	8.87	8.10	1.3543	1.7141	305	288	<.00001	Highly	0.4985	Medium

Table 2 displays the scores for the reading tests in which our participating students engaged. Similar to the mathematics data, the results indicate that the pandemic had a negative effect on the achievement of grade two and grade four students in reading. As with the mathematics data, there were 159 second grade students involved in the pretest and 138 students in the posttest. In the fourth grade, there were 162 students in the pretest and 150 students in the posttest. Table 2 shows that pre mean scores for both grade two and grade four were higher than their post mean scores. For grade two the pre mean was 9.86, and the post mean was 9.55. In grade four the pre mean was 9.24, while the post mean was 7.88. The respective differences in SD for grade two were 0.4167 and 0.8182; while in grade four the SD for the pretest was 0.9439 and 1.9684 for the posttest. These data led to a p score of <.00001, highly statistically significant, and to a Cohen's d score of 0.6369, a high effect size score. The scores for the overall data include a pre mean of 9.54, a post mean of 8.68, a pre SD of 0.7940 and a post SD of 1.7366. A total of 321 students participated in the pretest and 288 students participated in the posttest. Their p value of <.00001 was highly statistically significant, and the Cohen's d score of 0.6369 was high. These reading scores, as did the mathematics scores, indicated a very negative effect of the pandemic on academic achievement.

https://doi.org/10.15405/epes.23045.92
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Table 2. Reading Data

Grade	Mean		SD		N		P Value		Cohen's d	
	Pre	Post	Pre	Post	Pre	Post	p	Sig.	d	Level
2	9.86	9.55	0.4167	0.8182	159	138	.000018	Highly	0.4775	Med.
4	9.24	7.88	0.9439	1.9684	162	150	<.00001	Highly	0.8810	High
Total	9.54	8.68	0.7940	1.7366	321	288	<.00001	Highly	0.6369	High

The students who were in Grade 2 in 2019 were mostly the same students who participated in the testing in 2021. So, we decided to compare the grade two scores from 2019 to the grade four scores in 2021. This is not a perfect comparison, because grade four scores in this school were lower in grade four than in grade two in their pre means. This is common in many schools because of the rise in complexity of the curriculum in grade four, and in grade four, students are more using the basics of reading and mathematics to learn more complex material (e.g., rather than learning to read students are reading to learn). What we saw was the differences were even more striking pre pandemic to post pandemic. As displayed in Table 3, the differences between grade two per pandemic and grade four post pandemic in mathematics, reading, and overall scores were all highly statistically significant (i.e. p <.00001), and their effect size scores were all very high (i.e. d =1.0019, 1.3916, and 1.4190 respectively). Not only were the same grade level scores significantly lower but the scores for the same group of students were even more significant.

Table 3. Compare Gr. 2 2019 & Gr. 4 2021

	Mean		SD		N		*P* Value		Cohen's *d*	
Grade	2	4	2	4	2	4	*p*	Sig.	*d*	Level
Math	9.12	7.62	1.2127	1.7355	147	150	<.00001	Highly	1.0019	High
Reading	9.86	7.88	0.4167	1.9684	159	150	<.00001	Highly	1.3916	High
Total	9.50	7.75	0.9651	1.8570	306	300	<.00001	Highly	1.4190	High

The data from this study make it clear that teacher observations about the negative effects of the pandemic were correct. We were not surprised by these results, because we understand that the people in the trenches with the students understand what is taking place in the learning experiences of and responses from their students.

7. Conclusions

To help students to learn effectively, teachers spend a great deal of time trying to find the right balance between challenging students appropriately and supporting students as much as they need. Caine (2018) called this balance relaxed alertness. According to Caine, students must be challenged or they will be bored but too much challenge may overwhelm students. As Piaget and Inhelder (1969, 2000) noted, in order to learn best, students must feel some disequilibrium. Glasser wrote about the fact that when people get out of balance, they receive an urge to act to get back into balance. Some discomfort motivates students to want to learn (Glasser, 1998; Laurian-Fitzgerald & Fitzgerald, 2019; Piaget & Inhelder, 1969, 2000). During the pandemic, students most certainly were stressed out and manty became overwhelmed (Fortin & Heyward, 2022). According to most of brain research, stress has negative effects on learning

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(Caine, 2018; Jennings, 2019; Jensen & McConchie, 2020; Robinson & Robinson, 2022; Sousa, 2017, 2022). Data from our study agrees with those conclusions.

During the pandemic, teachers were also under a great deal of stress. Teachers were on the front lines whether working face-to-face, online, or in hybrid modes. In addition to the regular stress of life during the pandemic, teachers had the added pressure of helping their students and families deal with some of their stresses. Indeed, many teachers considered quitting, and many other teachers did quit their jobs (Edelman, 2022). Just as stress makes it more difficult for students to learn, undo stress on teachers has a negative effect on teachers' ability to teach effectively (Robinson & Robinson, 2022). Relaxed alertness is just as important for teachers as it is for students. When people call teachers names like lazy, or if people yell at teachers at meetings, if people threaten teachers, those actions only harm the teachers' ability to be strong and teach effectively. The most important person in the formal educational process is the teacher (Robinson & Robinson, 2022). The most important difference is the quality of learning in school is the effectiveness of the teacher. When good teachers resign due to over stress, our students lose out in their learning. To enable the creation of the caring and avid learning environment we need (Sousa, 2017, 2022), schools must be as caring and supportive places for teachers as they are for students (Perțe & Pătroc, 2019).

The length of the pandemic has developed emotional stress that has caused teachers and students to struggle in school. Burke Harris (2018, 2020) has explained how the length and repetitiveness of the tragic events caused by something like the pandemic has lasting effects on people. Those effects are emotional, physical, and psychological, and if left unchecked, can cause emotional and medical issues for years (e.g., PTSD, depression, alcoholism, diabetes, heart attack). According to Vestal (2021):

> The grief, anxiety and depression children have experienced during the pandemic is welling over into classrooms and hallways, resulting in crying and disruptive behavior in many younger kids and increased violence and bullying among adolescents. For many other children, who keep their sadness and fear inside, the pressures of school have become too great. (para. 2)

This stress has caused less learning of academic material, social skill development, and emotional development in our elementary students. Teachers are also dealing with the results of their own social and emotional stress. Now that the pandemic appears to be moving from pandemic to endemic status, it is easy to forget the millions of families who have lost loved ones, and it is easy to forget the name calling and threats that public servants had to withstand during the pandemic.

Robinson and Robinson (2022) explained that teachers will have to continue to help students make up for lost time academically, socially, and emotionally. That will take time and effort, and everyone will have to be patient and move forward without causing more emotional harm for students, parents, and teachers. Recovery may be a slow but steady process but we have hopefully made it through the worst of the ordeal, and now we must slowly but surely regain our strength and our love for teaching and learning.

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