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COVID-19 Restrictions and Its Influence on Students' Mathematics Achievement in Spain

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Abstract: COVID-19 restrictions in schools worldwide constitute an important limitation for peer support among students. The masks, the distance between tables or the established sitting order are new challenges that both students and teachers must face in Spain. The conventional strategies that took place among students prior to the COVID-19 pandemic have been altered. In this study, the mathematics achievement of high-school students prior to the COVID-19 pandemic and during the COVID-19 pandemic is examined. Quantitative and qualitative methods were used. A total of 368 students from 9th grade (ages 14 to 15) participated in this research. Statistically significant differences were reported when comparing the mathematics achievement of pre-COVID-19 and post-COVID-19 students ($t = 22.21$, $p < 0.01$). An overall negative effect size of −2.32 was reported for those students with COVID-19 restrictions. Mathematics achievement scores were 9.90% lower for the group with restrictions. No statistically significant differences were reported when analyzing results by gender or repeating condition. The qualitative information supported the quantitative findings. Alterations in peer support was identified as one of the main factors that could explain this decrease. The main conclusion of this study is that current restrictions due to COVID-19 could be producing an important decrease in students' mathematics achievements.

Keywords: mathematics achievement; COVID-19 restrictions; secondary education; peer support

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1. Introduction

The impact of COVID-19 on the educational processes that used to take place prior to the COVID-19 pandemic has been significant. Researchers worldwide documented the huge impact school closures had on students' achievement during the first months of the pandemic [1–3]. During this first period, online learning emerged as the main solution as many families had to be confined [4–6]. After the summer of 2020, most schools returned to traditional in-person classes, but with important restrictions due to the pandemic. In this sense, masks, distance between tables and established sitting orders to control infections among students were some of the measures that had to be taken in many schools in Spain [7,8]. Hence, although students are back to class, the situation is still far from being normal. Recent studies in the field indicate that students' mathematics achievement may still be affected by the current situation [8–11]. One of the factors that may explain this phenomenon is the alteration of the peer support processes that used to take place before the pandemic [12,13].

2. Background

2.1. The Importance of In-Class Peer Support

Different definitions of peer support may be found in the literature. Brock and Huber [14] refer to peer support as the process in which students use their own experiences to help each other. Wang et al. [15] indicate that peer support takes place when people provide knowledge, experience or practical help to each other. In an educational context, peer

support often takes place without any scheduled or previously established program [16,17]. It emerges naturally given the circumstances and the human nature inside many subjects that makes him/her help the person next to them [18,19].

Some methodological strategies in education such as peer tutoring, cooperative learning or flipped classrooms facilitate and encourage students to help themselves at the same time as they learn [20–22]. Many authors encourage the use of peer support strategies even in a more informal way, that is, not integrated or specifically boosted by an educational methodological approach [23,24]. In any case, the benefits of peer support exceed the academic outcomes that it may be derived from it, as also social and psychological variables related to inclusive education must be considered [25,26].

2.2. Informal Peer-Support

Although the previous subsection refers to specific peer-supported strategies, several authors have highlighted the benefits of informal peer support in education. In this sense, Gandy-Guedes et al. [27] indicate that informal peer support does not require a specific training; that is, interactions between students and knowledge sharing arise automatically. The students define the way in which they interact and how they help themselves to learn [28]. Peters and Romero [29] refer to in-class peer support as a human factor that should not be restricted unless it is harmful for the development of the class; that is, unless teachers' explanations are interrupted or understanding of concepts may be altered. Moreover, authors such as Carter et al. [30] and Carter [31] state that informal peer support is a more natural method of inclusion than other peer-supported arranged strategies, as students are not forced to interact between themselves. In this sense, authors such as Byl et al. [32] or Poverjuc et al. [33] indicated that informal peer support contexts are better for increasing students' self-confidence and developing sharing skills than other previously arranged methodologies. Authors such as Ansong et al. [34] or Bertilsdotter Rosqvist [35] state that the mere natural helping procedures that are carried out between classmates are enough to promote students' inclusion and increase students' academic achievement if it is not a potentially harmful environment from an academic perspective.

2.3. Alterations in Teaching Strategies, Curriculum and Educational Policies Due to COVID-19

Although in-class peer support may be one of the main factors that has been altered due to COVID-19 restrictions, the pandemic has had other important implications in educational contexts. Authors such as Folkman et al. [36] or Varea et al. [37] refer to the important changes that teachers have experienced in their instructional methodologies due to this pandemic. These changes have important effects on students' acquisition of contents and motivation. Moreover, authors such as de Boer [38] or Dasgupta and Umar [39] refer to the important changes in educational policies that have taken place around the world to cope with this pandemic. As stated by Grewening et al. [40] and Kaffenberg [41], reductions and adapatations of educational curriculums have been common across educational levels during the last year.

2.4. Current Context in Spain, Peer Support Restrictions and Literature Research Gap

For the current school year (2021–2022), schools in Spain are open and students take in-person classes. Students must wear masks in primary, secondary and higher education. Distance between students in the classroom is compulsory and tables must be separated at least 1.5 m. [42]. In some schools, students must sit in an established order to facilitate the tracking of the virus by health institutions in case of contagion. All these facts imply important limitations for peer support, as communication between peers is much more difficult than before the pandemic [43,44]. Before COVID-19, in most classrooms students used to sit in pairs and were allowed to talk between themselves if the teacher was not explaining concepts. Academic interactions between them were natural and relatively easy. Although, as indicated above, some recent studies by Coyle et al. [12] and Ronen et al. [13] have addressed the peer support problems in educational contexts due to COVID-19, the

literature is still scarce in the field. Hence, given the current context, research on COVID-19 restrictions and mathematics achievement emerges as a potentially interesting field of research.

3. Methods

3.1. Objectives of the Study and Research Questions

Two main objectives were defined in this study: (1) to determine the quantitative differences in students' academic achievement before COVID-19 and during COVID-19, and (2) to qualitatively determine the difficulties that students are experiencing.

Given these two objectives, the following research questions for this study were defined:

1. Are there any significant differences in students' mathematics achievement before and during the pandemic?
2. Do gender (male vs. female) or repeating conditions (repeaters vs. non-repeaters) act as significant moderators of students' mathematics achievement before and during the pandemic?
3. What are students' opinions on the current situation regarding their helping strategies?

3.2. Sample

A total of 368 students participated in the study. Students were accessed through convenience sampling; that is, because they were easily accessible for the researchers [45]. All of them were 9th grade students; that is, 14 to 15 years old. Data were gathered during six school years. Four of these years were before the pandemic (2016 to 2019) and the other two after the pandemic (2020 and 2021). Of these students, 196 had taken 9th grade mathematics without restrictions (prior to the COVID-19 pandemic) and the other 172 were enrolled in 9th grade mathematics with restrictions; that is, after the COVID-19 lockdown that took place in Spain between March and June of 2020. The sample of 196 students that had not experienced restrictions consisted of 51 students from year 2016, 49 students from year 2017, 48 students from year 2018 and another 48 students from year 2019. An ANOVA was carried out to detect any differences in mathematics achievement for these four groups of students. No statistically significant differences were reported, F (3, 192) = 0.55, p = 0.46. Females represented 54.08% of the total sample of students without restrictions and 51.74% of those with restrictions. A total of 20 students in the without restrictions group and 18 in the with restrictions group had repeated one school year in primary or secondary education.

3.3. The High-School Context

The high school in which this research took place is located in a population of approximately 60,000 people in the Valencian Community, Spain. The socioeconomic and sociocultural status of the students' families is average, taking into account the national standards. The national standards refer to an individual annual gross salary of EUR 18,100 as average. Most of the students' families are qualified workers in different sectors. It is a public high-school and is located in a suburban area. The same teacher taught all the students participating in this research.

3.4. Instruments Used to Collect Data

As quantitative and qualitative methods were used in this research, different instruments were used for different purposes in each case.

3.4.1. Quantitative Instruments

Mathematics achievement scores were taken from the official app provided by the Valencian government for all high schools in the Valencian Community. Students are qualified in a scale from 1 to 10 points. A higher score means a higher achievement. As schools closed after the second term of the 2019–2020 school year due to the COVID-19 pandemic, right after second terms qualifications were introduced in the app and did not

open until the next school year in September, the qualifications for the second term were used in all cases. The app also includes the student's information, such as name or year of birth.

3.4.2. Qualitative Instruments

Discussion groups [46] were held with those students enrolled in mathematics during the pandemic. A total of 15 discussion groups with 6 students in each group were carried out. The protocol for selecting these students was as follows. Seven discussion groups were carried out for students in the year 2020 and eight discussion groups were arranged for students in the year 2021. All students were assigned to each group on a probabilistic basis; that is, a draw was performed to determine the students that participated and the discussion group they were put in. MAXQA software was used to compile all the qualitative information and a qualitative content analysis [47] was employed to identify the main factors present in these discussion groups. In the results section qualitative results are reported as follows: STD_1_3 refers to student number three in the discussion group number 1.

3.5. Statistical Analysis

SPSS software version 27 was used to perform the statistical analysis of the quantitative results. Mathematics achievement scores between those students with restrictions (post-COVID-19) and those without restrictions (pre-COVID-19) were compared using Student's *t*-test [48]. Differences between male and female within the same group and between repeaters and non-repeaters were also analyzed using this statistical parameter. Effect sizes were reported using Hedge's g [49].

4. Results

4.1. Quantitative Results

Descriptive results for this research may be found in Table 1 for the experimental and control groups.

Table 1. Overall results by group.

	Pre-COVID-19	Post-COVID-19
Mathematics achievement	7.68	6.92
Standard deviation	0.34	0.31
Number of subjects	196	172

Regarding research question 1. (Are there any significant differences in students' mathematics achievement before and during the pandemic?) Statistically significant differences were reported as the pre-COVID-19 group outscored the post-COVID-19 group ($t = 22.21$, $p < 0.01$). Overall, mathematics achievement scores were 9.90% lower for the post-COVID-19 group. Overall, a Hedge's g negative effect size of −2.32 was reported. Regarding research question 2. (Do gender (male vs. female) or repeating conditions (repeaters vs. non-repeaters) act as significant moderators of students' mathematics achievement before and during the pandemic?) No statistically significant differences were reported when considering scores by gender within each group ($t = 1.10$, $p = 0.27$ for the pre-COVID-19 group and $t = 0.31$, $p = 0.75$ for the post-COVID-19 group). When analyzing the differences between the repeating and non-repeating students between groups, no statistically significant differences were reported ($t = 0.94$, $p = 0.35$).

4.2. Qualitative Results

The qualitative information obtained from the discussion groups were consistent with the quantitative information reported above. The qualitative content analysis identified difficulties of peer support as one of the main factors that affected students' mathematics

achievement. Many of the students belonging to the without peer support group referred to the situation as "strange" or "awkward" even though some of them had been dealing with the situation for more than a year. Regarding research question 3 (What are students' opinions on the current situation regarding their helping strategies?) According to the students, not being able to interact easily with other peers was affecting their achievement in the class. As STD_12_3 stated, "I used to sit next to Eve (invented name for anonymity issues) and we helped each other a lot before the pandemic. Now we can do it, but it is not the same. I can't see her notebook to compare the exercises and problems and communicating with her is much more difficult in this way". Many students highlighted the fact that, in order to control the possible transmission of COVID-19, they were sitting in alphabetical order or other established order for health reasons. That fact was annoying for many of them and had important implications for mutual support. As STD_3_4 stated, "I don't have a problem sitting here, but it was better when I could sit wherever I wanted. Matt (invented name) always helped me a lot and now he is four arrows beyond me". Other students indicated that masks were also playing an important role as many times it was difficult to understand what a peer was saying just a meter and a half away from them. As STD_5_2 indicated, "It is not only the distance, it is also the masks. The other day he (referring to a peer) asked me about the result of a problem. I told him twice and the third time I had to shout so that he could understand what I was saying". In this sense, sitting in pairs next to one another, as usually happens in 9th grade classrooms, and not wearing masks was pointed out as many students as extremely necessary so that they could follow the class. STD_7_5 stated "If we were together as it used to be with no masks and sitting in pairs, most of the times you can ask someone next to you, behind you or in front of you. Someone always has the right procedure and can help you with if you get stuck, but now things are much more complicated". Moreover, students also referred to other issues different than peer support that could explain this phenomenon. As stated by STD_3_2, "Last year we couldn't finish all the contents in the book. Now, we are supposed to know certain concepts that we need in order to understand this year's concepts. We tell the teacher and he tries to explain it to us, but we are always in a hurry as there is almost no time to go back to refresh things. It is stressful". In this line, as STD_11_1 stated, "we are struggling this year with geometry, but that is because there are procedures we should know from last year but we didn't study them due to the pandemic. Now it is a mess because we have to advance but we don't know the previous concepts that we need".

5. Discussion

Authors such as Attard and Holme [50], Chiu et al. [51] or Chirinda et al. [52] referred to the peer support problems that the COVID-19 situation had derived in the classrooms and that have also been reported in this research. It is not only the social presence that plays a vital role in support among students, but also organizational issues such as the distribution of students along the class and the restrictions of interactions among them. Although many experiences referred to online peer support as a possible solution in this context [53–55], many authors have pointed out the superiority and benefits of in-person peer support over distance peer support [56–58]. In this sense, some authors refer to the "together alone" feelings that some students reported in the discussion groups; that is, your peers are there with you but they cannot help you as they used to [59,60].

Regarding the quantitative results, recent studies have also documented the academic problems that has been caused by the COVID-19 restrictions in classrooms [61,62]. Studies around the world refer to a decrease in students' mathematics achievement due to the pandemic with similar decreases in students' achievement to those reported in this research [63–66]. In this sense, many researchers in the field state that the in-person support prior to COVID-19 without restrictions produced higher achievement results than the online solutions or in-person adaptations that are currently taking place [67,68]. In this context, student engagement in the mathematics classroom is seen as major concern by many researchers [69–72]. As some students indicated in the discussion groups of this

research, it is much more difficult for them to follow the explanations and do the proposed exercises and problems now that there are COVID-19 restrictions in the classrooms. An increase in disruptive behavior has also been linked to this situation [73–75]. Lack of motivation and feeling alone although being surrounded by the peers were also factors that may explain the decrease and significant differences reported in this research [76–78].

The fact that no statistical significant differences were reported by gender or repeating conditions seems to be consistent with the recent literature in the field [79–82]. According to these authors, the COVID-19 situation and the restrictions in peer support affect mathematics students regardless of their gender or their previous skills. The need for a change in mathematics instruction given the current situation has been acknowledged by many researchers in the field [83–85] given the fact that peer support has now been highly limited.

Limitations

Although results from this research are consistent with the results of recent studies in the field, this study has important limitations that must be considered by the readers of this manuscript. Among many possible limitations that may be listed, some of the most important are indicated above. First of all, although peer support limitation has been referred to as the main problem by students participating in this research that explains the decrease in their mathematics achievement, other factors could have influenced these results. Many authors referred to the school closures of several months as the main reason for the academic problems that many students are experiencing worldwide [86–89]. Hence, not only restrictions in peer support, but also other factors such as the prolonged period of time that schools were closed the year before may explain this decrease in students' mathematics achievement. Although the sample of this study may not be considered small, it also cannot be considered either as large or as representative of a big population [90,91]. For this reason, caution is advised when interpreting the results obtained from this research. Moreover, the fact that the same teacher had taught all the students participating in this research through the years could also be considered as an important limitation as the professional skills and personal circumstances of the teacher may have influenced the results [92,93]. In this sense, although there was an attempt to avoid variances in the results due to different teaching methods or teachers' mathematics knowledge given the fact that the same teacher taught all the students participating in this research, some factors could not be controlled. During the most serious health emergency of the last one hundred years and with notable difficulties in teaching, is it unlikely for an instructor to teach in the same way before and during the pandemic [94,95]. At the beginning of the last school year investigated, students' prerequisites in mathematics were somewhat lower than in the previous years. Experienced teachers may have taken this problem into account, so certain changes may have taken in their teaching methods.

6. Conclusions

The main conclusion of this research is that the current restrictions due to COVID-19 could be producing a decrease in students' mathematics achievement. Students experiencing these restriction may be affected regardless of their gender or repeating condition. The masks, the distance restrictions between tables and the established sitting orders, among other factors, have significantly altered the prior to COVID-19 peer support that students used to carry out in mathematics classrooms. The impact of these limitations is considerable from a quantitative perspective as significant negative effect sizes and percentage decreases of over 10% may be expected. Future research is needed not only to address this phenomenon, but also to propose possible educational solutions to this situation in which many students are experiencing a "together alone" situation in mathematics classrooms, lacking the necessary peer support or previous mathematics knowledge they used to have before the COVID-19 pandemic started.

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