

Art. #2731, 10 pages, <https://doi.org/10.15700/saje.v46n3a2731>

Evolution of educational support dynamics in secondary education mathematics learning: A cross-sectional study

Nabil Mohamed-Chemlali 

Department of Didactics and School Organization, National University of Distance Education (UNED), Madrid, Spain
nmohamed63@alumno.uned.es

Hassan Hossein-Mohand  and **Hossein Hossein-Mohand** 

Department of Mathematics Didactics, University of Granada, Granada, Spain

Sara Osuna-Acedo 

Department of Didactics and School Organization, National University of Distance Education (UNED), Madrid, Spain

Abstract

In the study reported on here we explored how the coronavirus disease (COVID-19) pandemic has transformed the dynamics of educational support for secondary education mathematics students in Melilla, Spain, focusing on the roles of peer support, family involvement, private tutoring, and individual study. These traditional forms of support, pivotal in academic development, have undergone substantial changes due to pandemic-related restrictions, impacting both collaborative learning and self-management capabilities in mathematics. A non-experimental *ex post facto* quantitative design was employed, collecting data across 2 periods (2019 and 2024) from a representative sample of secondary school students in Melilla. The data were gathered through a structured Likert-scale questionnaire and analysed using generalised linear models to examine the interaction between temporal and educational variables. The results reveal significant changes: peer support and family involvement markedly decreased at higher educational levels after the pandemic, while this support remained relatively stable at lower educational levels. Conversely, individual study increased at higher educational levels, reflecting a shift towards greater autonomy. Support from private tutors and academics also declined significantly, particularly at advanced grades. The changes in educational support dynamics for mathematics highlight an adaptation towards autonomous learning at higher educational levels and the continuity of collaborative support at lower educational levels. These findings underscore the need to adjust post-pandemic educational strategies, fostering self-management and structured support tailored to academic levels.

Keywords: autonomous learning; collaborative learning; education; educational strategies; family; mathematics; pandemic; secondary; self-management; tutoring

Introduction

Mathematics learning in secondary education does not develop in isolation but rather relies on a range of support dynamics for learning, including peer support, family involvement, external support from private tutors or those employed in schools, and individual study. Each of these types of support is strategically directed at specific learning needs, making it possible to combine the learning of abstract ideas with motivation and the adequate development of mathematical skills (Gortazar, Hupkau & Roldán, 2023; Ní Fhloinn & Fitzmaurice, 2022). Students achieve their best learning outcomes through peer support because they actively exchange learning methods, which help them build their knowledge base together (Pozo, Pérez Echeverría, Cabellos & Sánchez, 2021). Family involvement, in turn, provides a reinforcing and supervisory environment that bolsters student motivation and engagement, particularly in early educational stages (Harper, Rosenberg, Comperry, Howell & Womble, 2021; Yang, Chen, Wang, Li, Zhang & Huang, 2023).

Similarly, external assistance offered by private tutors and academics provides structured and specialised support, which is highly beneficial for learning complex mathematical concepts (Christopoulos & Sprangers, 2021; Jacques, Ouahabi & Lequeu, 2021). Finally, individual study allows students to learn autonomy and self-management skills, needed for them to cope with exploring mathematics as they advance in their academic path and face growing challenges in this discipline (Clark, Kaw & Gomes, 2022). The literature evidence supports the beneficial dynamics of this supports and that their association can reinforce learning and a better understanding of mathematical content (Biton & Segal, 2021).

In this study we examined the impact of the pandemic and digital advancement on support dynamics in mathematics learning among secondary school students in Melilla (Spain), who were from varied social and cultural origins. Using data from before and after the pandemic, 2019 and 2024 respectively, we studied how this situation changed the way we articulate support in schools and how we should analyse the present phenomenon to make teaching decisions when adapting to the new normal. Based on this analysis, the following hypotheses are proposed: H_1 – peer support in mathematics learning has decreased after the pandemic; H_2 – family support in mathematics learning has decreased, particularly at higher grades; H_3 – individual study of mathematics has significantly increased following the pandemic; and H_4 – support from private tutors or academics has significantly decreased after the pandemic.

Literature Review

Secondary education in Spain mainly consists of two stages: Compulsory Secondary Education (ESO) and, in the subsequent stage, Upper Secondary or Vocational Training (FP). ESO consists of four grades with adolescents between the ages of 12 and 16 years, although students who repeat years might be older. ESO is the only mandatory phase, aiming to provide a comprehensive training model that combines academic, personal, and social competencies. Once ESO is completed, students can choose to continue their studies in Upper Secondary, which prepares them for university, or in Vocational Training, aimed at the labour market (Martínez-Agut, 2021). The educational framework depends on mathematics as its essential subject, which students study at school and encounter specific learning difficulties in this subject area (Blanco, Escanilla & Casado, 2023).

Over the past decade, educational support in mathematics in Spain and Europe has undergone significant changes, driven by digital advancement, legislative reform, and the impact of the COVID-19 pandemic (Drijvers, Thurm, Vandervieren, Klinger, Moons, Van der Ree, Mol, Barzel & Doorman, 2021; Engzell, Frey & Verhagen, 2021; Moliner & Alegre, 2022; Mtande & Ross, 2024). The number of tools available to students to help them learn mathematics has been greatly increased and equity of access to educational tools has improved (Gortazar et al., 2023; Ní Fhloinn & Fitzmaurice, 2022). Educational reform in Spain has been an important driver of these transformations. The previous educational law, (Organic Law of the Improvement of Educational Quality [LOMCE]), which focussed greatly on creating very high academic standards, returned to a structured, performance-driven approach when it was initiated in 2013. The new educational law, the Organic Law Amending the LOE (LOMLOE) represents a substantial change in the direction of the education system with a greater focus on inclusion and competency-based learning that aims to achieve greater equity for all students and promote the holistic development of all students. It promotes active and adaptive learning, in which technology and multifaceted support take on new significance (Faura-Martínez, Lafuente-Lechuga & Cifuentes-Faura, 2022; Negrín Medina & Marrero Galván, 2021; Troussas, Krouska, Giannakas, Sgouropoulou & Voyiatzis, 2021).

One of the most visible effects of these transformations is the incorporation of active and digital methodology that have redefined collaborative learning among students. Previously, when students worked in teams, their collaborative interaction was limited to being in a physical classroom where they were able to communicate with one another directly, share strategies, and

collaborate to solve mathematical problems. With the introduction of digital tools and remote learning due to COVID-19, these relationships have fundamentally transformed (Gopalan, Butts-Wilmsmeyer & Moran, 2021; Jordaan & Havenga, 2021). Social networking is among many platforms available to assist students to work collaboratively by helping them create study groups, share helpful study information, and communicate about problems dealing with mathematics via messaging services such as WhatsApp, Instagram, and Telegram (Ahmad, 2022; Marbán, Radwan, Radwan & Radwan, 2021; Salim, Daud & Hanif, 2024). Additionally, platforms such as Microsoft Teams and Google Classroom facilitate joint projects and online interactions, promoting a more flexible collaboration aligned with students' digital lifestyles (Panaoura, 2021). This digitalisation of collaborative learning has strengthened skills such as communication and self-management, creating an environment where students can continuously and accessibly interact with their peers regardless of physical location (Greenhow, Staudt Willet & Galvin, 2021; Lara-Lara, Santos-Villalba, Berral-Ortiz & Martínez-Domingo, 2023).

The role of families in supporting their children's academic progress has also evolved (Mejía Janampa, Gonzales-Sánchez, Bayona Trujillo & Valqui Oxolon, 2021; Nyanamba, Liew & Li, 2022; Panaoura, 2021). In years past, most family involvement was limited to ensuring that their children completed homework and tasks. However, during the COVID-19 pandemic, when children were learning remotely, many families became co-educators along with teachers (Nyanamba et al., 2022). To facilitate this transition from parent as supervisor to parent as co-educator, LOMLOE also provides parents with digital training programmes to help them become more proficient in using educational technology (Blaskó, Da Costa & Schnepf, 2021; Goudeau, Sanrey, Stanczak, Manstead & Darnon, 2021). Parents have also begun using social media to find access to support groups and educational communities (such as on Facebook) where they are able to exchange information, resources, and strategies to help each other in their role as parent supporters of their children's mathematics learning (Alvites-Huamaní, Arias-Flores, Jadán-Guerrero & Acosta-Vargas, 2021; Harper et al., 2021). Family involvement is continually transforming into a resource for families to have access to digital resources and networks to assist with their children's learning, even when parents do not have the level of mathematical proficiency that would allow them to be classroom educators (Torres Martín, Acal, El Homrani & Mingorance Estrada, 2021).

Access to online tutoring and academies has also undergone significant changes, expanding its reach through social media, which facilitates the

promotion of and access to online educational services. Traditionally, tutoring services were available only via in-person meetings at academic-based locations; however, advances in technology have allowed for the creation of online tutoring services and digital tutoring platforms, such as Classgap and Khan Academy, providing students access to professionally trained tutors from virtually any location (Christopoulos & Sprangers, 2021). This new modality enables students to access personalised tutoring in a more flexible and tailored manner, democratizing access to academic support, especially in non-urban areas (Drijvers et al., 2021; Jacques et al., 2021). Furthermore, social media platforms such as LinkedIn and Instagram allow tutors to promote their services and share free educational content, providing students with additional resources (Lu, 2023). The digitalisation trend in tutoring supports a more personalised and accessible learning experience for students who are accustomed to living and learning in a highly digital society (Babar & Hidayat, 2022).

Finally, independent study has been invigorated by active methodology and adaptive digital resources that foster autonomy in learning mathematics (Røe, Wojniusz & Bjerke, 2022). Before COVID-19, independent study didn't go beyond repeating the usual exercises. Flipped methodologies permitted students to learn the theory of these exercises from their homes, while using their classrooms to deal with more sophisticated problem-solving (Gonda, Pavlovičová, Tirpáková & Ďuriš, 2021). Further, adaptive platforms, such as Prodigy and Mathway, adjust the problem ambiguity according to the students' level, creating autonomous and adaptive learning fit to the students' needs (Biton & Segal, 2021). In this sense, social media also helps, allowing pupils to follow educational accounts in TikTok & YouTube, where they may find explanations and mathematics tips that complement their work done independently and provide new ways to approach and solve mathematical problems (Alonso-Campuzano, Iandolo, Mazzeo, Sosa González, Neoh, Carollo & Esposito, 2021; Raaper, Brown & Llewellyn, 2022).

Methodology

In this study we employed a non-experimental, quantitative ex post facto design, aimed at analysing differences in educational support dynamics across educational levels and time points without manipulating any study variables.

Participants

The sample of data represents secondary and high schools in the city of Melilla in the school years 2019 to 2024. The sample included students from all secondary schools in the city ($n = 7$). Of the total number of school participants, data were

collected from 25.3% in 2024 ($n = 689$), while data from 74.7% were collected in 2019 ($n = 2,039$).

In total, 2,728 participants were between 11 and 20 years old with an average age of 14.82 years ($SD = 1.772$; $SEM = 0.034$). Most participants were female (52.8%) 46.6% were male while a small percentage identified as other (0.5%). In terms of age distribution, 25.9% of participants were between 11 and 13 years old, 45% were in the 14 to 15 age range, and 82.4% were between 11 and 16 years old. Educationally, 20.1% of participants were in their first year of ESO, 23.5% in their second year, 17.8% in their third year, 20.8% in their fourth year, and 17.9% were enrolled in Upper Secondary.

Instrument

For data collection, a digital questionnaire was administered using the online tool, Google Forms. This instrument comprises 10 items that evaluate the dependent variables using a 4-point Likert scale, with response options Never (1), Rarely (2), Often (3), and Always (4). The questionnaire was developed by the authors based on a previous study (Trujillo-Torres, Hossein-Mohand, Gómez-García, Hossein-Mohand & Hinojo-Lucena, 2020) and was designed to assess educational support dynamics in mathematics learning. The 4-point Likert scale was chosen after considering the effects of anchoring a scale using either four or seven scales. Four scales were chosen to prevent overwhelming levels of interpolation (Nadler, Weston & Voyles, 2015). The questionnaire also includes questions to elicit sociodemographic variables including level of education, and age.

The study variables included a combination of independent and dependent variables measured directly through the questionnaire. The independent variables were:

- FRD (date of data collection)
- NEC (educational level)

The dependent variables corresponded to individual questionnaire questions assessing different forms of educational support in mathematics learning:

- AAM (peer support in mathematics learning)
- AFM (family support in mathematics learning)
- APM (support from private tutors or academies)
- ESM (individual study in mathematics)

The interaction between the date of data collection (FRD) and educational level (NEC) served as key independent variables, as they allowed for the examination of how different educational levels and temporal contexts (pre- and post-pandemic) influenced the dependent variables, encompassing the various aspects of interaction during mathematics learning (AAM, AFM, APM, and ESM).

The measurement properties of the questionnaire were found to be within acceptable parameters. The omega coefficient evaluation

produced a reliability score of $\omega = 0.720$, indicating adequate internal consistency. Construct validity was assessed with using Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy with a value of 0.749 indicating that data may be amenable to exploratory analysis. Explained variance percentage (EVP) was 66.57%, while Bartlett's test of sphericity was significant ($\chi^2 = 3676.76$, $p < 0.01$), confirming an appropriate fit of the underlying model.

Data Collection Procedure

Prior to data collection, the questionnaire was reviewed and approved by the Educational Programs Unit Committee of the Provincial Directorate of the Ministry of Education and Vocational Training in Melilla. The study was approved by the Ethics Committee of the National University of Distance Education (UNED), Spain, on 7 November 2024 (Ref. No. 31-SISH-EDU-2024). Following approval, parental or guardian informed consent was obtained, and each school principal was contacted to ensure access during school hours. Participation was completely voluntary, and students were informed about the objectives of the study, the anonymous nature of the responses provided, and their right to withdraw at any point without consequences.

A first collection of data was conducted between April and June in 2019, and the same process was undertaken in May and June of 2024. The data were gathered in computer labs and only with students whose parents had authorised their participation. The responses were recorded in Google Forms spreadsheets. One of the researchers was present in the lab during the entire process. No identifiable information was collected, as the other data were processed and analysed in aggregated form. Ethical principles were observed throughout

the data collection, analysis, and reporting processes, in compliance with applicable ethical standards and data protection regulations.

Data Analyses

The data analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 25. The analysis began with descriptive analyses of sociodemographic and study variables of interest. Frequencies and percentages were assessed for categorical variables (e.g. gender, and education level), mean, standard deviation and standard error of the mean were calculated for the continuous variable of age. Psychometric properties of survey were examined through reliability estimates (omega) by means of internal consistency analysis and construct validity (via KMO measure of sampling adequacy and Bartlett's test of sphericity).

We then used generalised linear models (GLMs) with ridged multinomial distribution and cumulative logit link to examine interaction between independent and dependent variables.

Several indicators were used to evaluate the model, including the Akaike information criterion (AIC), deviance, and Pearson's chi-square statistic, to assess how well the model fits the data. Omnibus tests were also conducted to evaluate the overall significance of the adjusted models and to determine whether the included predictors had a meaningful effect on the dependent variables. Parameter estimation provides the model coefficients, which indicate the magnitude and direction of these effects.

Results

The goodness of fit was evaluated for the GLMs used in the analysis.

Table 1 Goodness of fit

Metric	AAM	AFM	APM	ESM
Deviance	374.695	15.510	264.296	18.859
Pearson χ^2	389.032	15.074	269.802	18.830
Log-likelihood	-264.093	-85.662	-208.970	-88.538
AIC	552.186	195.324	441.941	201.075

As shown in Table 1, AFM (family support in mathematics learning) had the best fit, with the lowest deviance (15.510) and an AIC of 195.324, showed that the model effectively described the data for this variable. ESM (individual study in mathematics) followed, with a deviance of 18.859 and an AIC of 201.075, also indicating an adequate fit.

APM (support from private tutors or academies) indicated a rank of third according to largest to smallest deviance. This variable had a

deviance of 264.296 and an AIC of 441.941, indicating a less precise fit than the two previously described. Finally, AAM (peer support in mathematics learning) had the lowest fit and the highest deviance at 374.695 and an AIC of 552.186, indicating that the model was least precise in describing this variable.

The results of the Omnibus tests, which were used to evaluate the overall significance of the GLMs, are presented below.

Table 2 Omnibus tests

Dependent variable	Likelihood ratio chi-square	Sig.
AAM	61.217	0.000
AFM	211.460	0.000
APM	80.414	0.000
ESM	23.022	0.006

Note. Sig. = statistical significance.

An analysis of the Omnibus tests results in Table 2 reveals that all dependent variables showed statistically significant effects, as their significance values were below 0.05, indicating that the adjusted models offered a significant improvement over the null model.

Among the analysed variables, AFM (family support) stands out with the highest chi-square value (211.460), indicating that this model explained a larger proportion of the observed variance. APM (support from private tutors or academies) followed in relevance, with a chi-square value of 80.414, also representing a highly significant fit. AAM (peer support) showed a significant chi-square value of 61.217, highlighting its relevance in the model, although to a lesser extent compared to AFM and APM. Lastly, ESM (individual study) had the lowest chi-square value (23.022), with a significance of 0.006. While still showing a significant fit, its impact was the smallest among the group of variables, suggesting that its model explained less variance compared to the others.

The parameter estimates obtained through the GLMs for interactions between the factors FRD and NEC are presented in the following section.

Table 3 GLM estimates with the FRD * NEC interaction for AAM

Parameter	B	Sig.
[FRD=2019] * [NEC=1]	-0.514	0.003
[FRD=2019] * [NEC=2]	-0.404	0.018
[FRD=2019] * [NEC=3]	-0.423	0.016
[FRD=2019] * [NEC=4]	-0.070	0.683
[FRD=2019] * [NEC=5]	0.344	0.052
[FRD=2024] * [NEC=1]	-0.268	0.230
[FRD=2024] * [NEC=2]	0.050	0.805
[FRD=2024] * [NEC=3]	0.034	0.892
[FRD=2024] * [NEC=4]	0.099	0.640
[FRD=2024] * [NEC=5]	0 ^a	.
(Scale)	1 ^b	

Note. ^aSet to zero because this parameter was redundant.

^bFixed at the displayed value.

The results for 2019 in Table 3 show negative coefficients, indicating that students received less help from friends or peers in mathematics learning. For the first year of ESO, the coefficient was -0.514 and highly significant, reflecting a low tendency to receive this type of support at this level. For the second year of ESO, the coefficient was also negative (-0.404), and the same was true for the third year of ESO, where the coefficient was

-0.423. These results suggest that for the first 3 years of ESO, peer support was low and significant in 2019. However, for the fourth year of ESO, the coefficient was much smaller (-0.070) and not significant, indicating that at this level, peer support was not as influential. For Upper Secondary, a positive coefficient of 0.344 was observed, but this value was not significant, suggesting that peer support was also not particularly relevant at this level.

In 2024, the results show changes across different educational levels. For the first year of ESO, the coefficient was -0.268 but no longer significant, indicating a less pronounced trend towards a lack of peer support. For the second year of ESO, the coefficient turned positive (0.050), although not significant, suggesting that peer support may have increased, albeit not statistically significantly. For the third year of ESO, the coefficient was 0.034, and for the fourth year of ESO, the positive value of 0.099 was also not significant, implying that at the higher educational levels of ESO, no significant differences were found for peer support before and after the pandemic.

Table 4 GLM estimates with the FRD * NEC interaction for AFM

Parameter	B	Sig.
[FRD=2019] * [NEC=1]	1.392	0.000
[FRD=2019] * [NEC=2]	0.938	0.000
[FRD=2019] * [NEC=3]	0.571	0.001
[FRD=2019] * [NEC=4]	0.230	0.192
[FRD=2019] * [NEC=5]	-0.259	0.167
[FRD=2024] * [NEC=1]	1.232	0.000
[FRD=2024] * [NEC=2]	0.820	0.000
[FRD=2024] * [NEC=3]	0.110	0.666
[FRD=2024] * [NEC=4]	0.192	0.380
[FRD=2024] * [NEC=5]	0 ^a	.
(Scale)	1 ^b	

Note. ^aSet to zero because this parameter was redundant.

^bFixed at the displayed value.

The data in Table 4 indicate that in 2019, family support was more pronounced at the lower educational levels of secondary education. For the first year of ESO, the coefficient was 1.392 and highly significant, reflecting a strong tendency for family involvement at this level. For the second year of ESO, the coefficient was slightly lower (0.938) but remained significant. The coefficient for the third year of ESO decreased to 0.571, although it was still significant. By the fourth year of ESO, family support appeared to diminish significantly, with a coefficient of 0.230 that is not statistically significant. For Upper Secondary, the coefficient was negative (-0.259) and not significant, suggesting that family support at this level was lower and not relevant in statistical terms.

In 2024, some alterations were noticed. For the first year of ESO, the coefficient was 1.232 and

still significant (indicating that family support was still relevant although less than in 2019). For the second year of ESO, the coefficient was 0.820 and significant, indicating decreased but still relevant levels of support compared to those in 2019. For the third year of ESO, the coefficient dropped significantly to 0.110 and was no longer significant, indicating a substantial reduction in family support at this level. For the fourth year of ESO, the coefficient was 0.192 but remained non-significant, similar to the results in 2019.

Table 5 GLM estimates with the FRD * NEC interaction for APM

Parameter	B	Sig.
[FRD=2019] * [NEC=1]	-0.231	0.176
[FRD=2019] * [NEC=2]	0.038	0.820
[FRD=2019] * [NEC=3]	0.151	0.378
[FRD=2019] * [NEC=4]	0.247	0.146
[FRD=2019] * [NEC=5]	0.545	0.002
[FRD=2024] * [NEC=1]	-0.353	0.112
[FRD=2024] * [NEC=2]	-0.613	0.004
[FRD=2024] * [NEC=3]	-0.211	0.397
[FRD=2024] * [NEC=4]	-0.610	0.005
[FRD=2024] * [NEC=5]	0 ^a	.
(Scale)	1 ^b	

Note. ^aSet to zero because this parameter was redundant.

^bFixed at the displayed value.

As shown in Table 5, support from private tutors or academies was low for the first year of ESO in 2019, with a coefficient of -0.231, which is not significant. For the second year of ESO, the coefficient was positive (0.038) but also not significant, suggesting no substantial difference in the received level of support. For the third year of ESO, the coefficient increased slightly to 0.151, although it remained non-significant. For the fourth year of ESO, external support was somewhat higher, with a coefficient of 0.247, but still not statistically significant. In contrast, for Upper Secondary, the coefficient was significantly higher (0.545) and statistically significant, indicating that students at this educational level received more external support compared to those at lower educational levels.

In 2024, results were found to be different. The coefficient for the first year of ESO was negative but lower than in 2019 (-0.353) although it was still not significant. For the second year of ESO, however, the coefficient was now -0.613 and significant indicating that the support received at this level had decreased considerably. For the third year of ESO, which also had a negative coefficient (-0.211) and was not significant, the situation was the same as in 2019 where there was no meaningful level of external support. In the fourth year of ESO the value is -0.610 and significant indicating a notable reduction of external support at this level. The results for Upper Secondary were deemed useless.

Table 6 GLM estimates with FRD * NEC interaction for ESM

Parameter	B	Sig.
[FRD=2019] * [NEC=1]	-0.631	0.000
[FRD=2019] * [NEC=2]	-0.325	0.056
[FRD=2019] * [NEC=3]	-0.250	0.152
[FRD=2019] * [NEC=4]	-0.409	0.018
[FRD=2019] * [NEC=5]	-0.368	0.041
[FRD=2024] * [NEC=1]	-0.383	0.082
[FRD=2024] * [NEC=2]	-0.126	0.543
[FRD=2024] * [NEC=3]	-0.117	0.639
[FRD=2024] * [NEC=4]	-0.136	0.527
[FRD=2024] * [NEC=5]	0 ^a	.
(Scale)	1 ^b	

Note. ^aSet to zero because this parameter was redundant.

^bFixed at the displayed value.

The results in Table 6 indicate that in 2019, individual study for mathematics in the first year of ESO significantly decreased, with a coefficient of -0.631, which is statistically significant. For the second year of ESO, the coefficient was negative (-0.325) but did not reach statistical significance, suggesting a non-significant reduction at this level. For the third year of ESO, the coefficient was -0.250, also negative and non-significant, indicating a similar trend. For the fourth year of ESO, the coefficient was -0.409 and significant, suggesting a notable decrease in individual study at this level. For Upper Secondary, the coefficient was -0.368, also significant, indicating an important reduction in individual study at this educational level.

In 2024, the situation shifted for some levels. For the first year of ESO, the coefficient was -0.383, negative but not significant, indicating a smaller decrease in individual study compared to that in 2019. For the second year of ESO, the coefficient was -0.126, non-significant, indicating no substantial changes at this level. For the third year of ESO, the coefficient was -0.117 and not significant, reflecting little variation. For the fourth year of ESO, the coefficient was -0.136 and, again, not significant, suggesting an improvement compared to that in 2019.

Discussion

Increase in Digital, Social and Educational Interaction

The results reveal significant changes in the support dynamics for mathematics learning following the pandemic, particularly in peer support, family involvement, individual study, and the use of external tutoring. These changes appear to reflect a shift towards more autonomous learning, especially at higher educational levels of secondary education, highlighting a post-pandemic educational adaptation that warrants deeper investigations. The changes associated with this transition might stem from increasing expectations for student self-regulation, academic requirements, and levels of autonomy in higher education, all of

which were magnified during COVID-19 and have continued into the post-COVID-19 world.

The decrease in peer support at higher educational levels, coupled with the maintenance of or increase in such support at lower educational levels, suggests that the pandemic had accelerated a trend towards autonomy among older students. Similarly, the literature on distance learning and digital platforms indicates that the lockdown fostered the development of self-management skills in advanced secondary students, who had to adapt to less collaborative and more independent environments (Bond, 2020; Dhawan, 2020). In this context, the use of digital tools promoted self-management and responsibility, essential skills in higher educational levels, enabling students to progress without relying on their peers (Engzell et al., 2021; Greenhow et al., 2021; Ní Fhloinn & Fitzmaurice, 2022).

On the other hand, peer support at lower educational levels appears to have remained steady due to the need for social interaction and guidance among younger students, who still require assistance in adapting to digital methods (Ahmad, 2022). Social media platforms, such as WhatsApp, and Instagram, have enabled virtual teamwork at these levels, which helps to reduce the negative effects of disappearing face-to-face communication (Raaper et al., 2022). The educational levels display different patterns. These reveal that digital tools and autonomous student learning methods dominated advanced education, but first-year students still benefited from their peer group assistance (Gortazar et al., 2023).

Changes in Family Support

The findings of this study also reflect a decrease in family support across all levels, with a more pronounced decline at higher grades. This trend appeared to indicate a return to pre-pandemic dynamics. The decline in the level of parental involvement as students get older can also be viewed as a result of these two factors converging. (1) The reduction of parental involvement due to students progressing to higher academic levels, and (2) the impact of families adjusting to a new routine after the pandemic year. During the lockdown, families took on a co-educator role, but with the restoration of in-person learning, this responsibility had been largely delegated back to educational institutions, particularly at higher educational levels (Harper et al., 2021; Pokhrel & Chhetri, 2021). In this regard, the reduction in family support is linked to an adjustment in family roles, where fostering student autonomy becomes a desirable goal as students progress academically (Blaskó et al., 2021). The literature also highlights that, although family support was critical during the transition to online learning, parental burnout and the return to work routines had reduced active

family involvement in the academic process (Aristovnik, Keržič, Ravšelj, Tomažević & Umek, 2020). Similarly, the decline in support at higher educational levels may be regarded as an indicator of the independence gained by older students, who developed self-management skills during the pandemic and were tackling their academic challenges more autonomously (Torres Martín et al., 2021).

Increase in Individual Study

The pandemic also fostered an increase in individual study at higher educational levels, a phenomenon potentially linked to the development of self-directed and adaptive learning skills. This increase could also be interpreted as a result of developing learning habits during the pandemic that were subsequently carried over to after the return to traditional learning. Distance learning necessitated that students learnt how to study outside of the classroom and at their own pace (Clark et al., 2022). More independent, more self-directed study was the main mode of learning at the highest levels of education, where students were empowered to study according to their own needs (Gonda et al., 2021).

Also, the emergence of adaptive platforms such as Prodigy and Mathway has created a personalised setting that encourages students by adapting the difficulty of problems to the level at which they were progressing (Biton & Segal, 2021). This adaptive approach promoted personalised education tailored to the needs and abilities of each student, especially needed in the post-pandemic transition towards independent learning at the higher levels (Clark et al., 2022). Under the LOMLOE, approaches such as self-management and active learning, which allow students a more central role in their own educational process, were being increasingly established (Negrín Medina & Marrero Galván, 2021).

Decrease in Support from Private Tutors or Academies

This study highlights a decrease in the use of private tutoring and academies at higher educational levels of education, while at lower educational levels, such support appears to have been maintained or have even increased. The rise in the potential for students to take charge of their own educational experience is likely a factor as the use of different digital resources will probably lead to less external help being sought than previously. Research shows that academic self-reliance has become the main reason for this transformation because students now study independently through online resources and educational platforms instead of using traditional academic institutions (Christopoulos & Sprangers, 2021). Students

obtained free access to digital platforms during the pandemic. This allowed them to access excellent content without depending on their physical school building while gaining equal access to content resources and achieving complete independence (Lu, 2023). Students currently obtain their educational materials through social media platforms and YouTube, which has revolutionised their method of seeking academic help. Nowadays, students choose to view educational content through independent creators who develop in-depth material with interactive exercises. This enables them to control their educational journey according to their personal learning requirements (Lu, 2023). Students on lower education levels still receive assistance through organised tutoring sessions, which private tutors and academies provide to help them grasp essential mathematical concepts (Jacques et al., 2021; Torres Martín et al., 2021).

Conclusions

With this research study we investigated the impact of the COVID-19 pandemic on educational support systems of secondary school mathematics students. The research shows that students at higher education levels received less peer support after the pandemic, but students at lower education levels experienced constant or rising peer support, which shows the need to develop educational stage-based collaboration methods. The research shows that family backing decreased most at advanced educational stages because students gained more independence when they reached their academic peak. The research shows that families need to learn about suitable support techniques. They should use these to help their children during their initial school years. Students who attended higher education levels showed a significant increase in their ability to study mathematics independently, which indicates that they mastered pandemic self-management abilities. The decreasing need for private tutoring support at advanced educational stages, together with a steady demand at lower education levels, shows that students develop independent learning abilities when they reach their teenage years.

Multiple restrictions exist which prevent these contributions from being applied at full potential. The research sample originated from one geographic location. This restricted the generalisation of the study results to different economic and cultural backgrounds. The research depended on students completing self-report questionnaires, which introduced potential biases because students might have answered based on social expectations and their own mistaken perceptions. Future research should include samples from different geographical locations while using mixed-method research techniques to validate and expand the current study results.

Acknowledgements

The Ministry of Education, Vocational Training, and Sport of Spain together with its Melilla Provincial Directorate, and all participating Melilla schools and teachers provided their essential support and collaboration.

Authors' Contributions

NMC: conceptualisation (lead), methodology (lead), investigation (lead), data curation (lead), formal analysis (lead), visualisation (lead), project administration (lead), writing – original draft (lead), and writing – review and editing (lead). Hassan HM: conceptualisation (support), methodology (support), investigation (support), data curation (support), formal analysis (support), validation (support), supervision (support), and writing – review and editing (support). Hossein HM: conceptualisation (support), methodology (support), investigation (support), data curation (support), formal analysis (support), validation (support), supervision (support), and writing – review and editing (support). SOA: conceptualisation (support), supervision, and writing – review and editing (support). All authors read and approved the final manuscript.

Notes

- i. Published under a Creative Commons Attribution Licence.
- ii. DATES: Received: 28 November 2024; Revised: 19 December 2025; Accepted: 1 April 2026; Published: 31 August 2026.

References

- Ahmad M 2022. Design of educational social media as collaborative learning in post pandemic. *Conference Series*, 4(1):152–159. <https://doi.org/10.34306/conferenceseries.v4i1.711>
- Alonso-Campuzano C, Iandolo G, Mazzeo MC, Sosa González N, Neoh MJY, Carollo A & Esposito G 2021. Children's online collaborative storytelling during 2020 COVID-19 home confinement [Special issue]. *European Journal of Investigation in Health, Psychology and Education*, 11(4):1619–1634. <https://doi.org/10.3390/ejihpe11040115>
- Alvites-Huamani C, Arias-Flores H, Jadán-Guerrero J & Acosta-Vargas P 2021. Digital resources and children's learning: Parental perception during the pandemic. In IL Nunes (ed). *Advances in human factors and system interactions: Proceedings of the AHFE 2021 Virtual Conference on Human Factors and Systems Interaction, July 25-29, 2021, USA*. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-030-79816-1_27
- Aristovnik A, Keržič D, Ravšelj D, Tomaževič N & Umek L 2020. Impacts of the COVID-19 pandemic on life of higher education students: A global perspective. *Sustainability*, 12(20):8438. <https://doi.org/10.3390/su12208438>
- Babar S & Hidayat M 2022. Online flipped classroom (e-FCR): Way forward in COVID 19 era. *Journal of Ayub Medical College Abbottabad*, 34(4 Suppl 1):1056–1057. <https://doi.org/10.55519/jamc-04-s4-10282>

- Biton Y & Segal R 2021. Learning and teaching mathematics with online social networks: The case of Facebook. In U Kayapinar (ed). *Teacher education: New perspectives*. London, England: IntechOpen.
<https://doi.org/10.5772/intechopen.95998>
- Blanco MAG, Escanilla RM & Casado JLM 2023. Competencias específicas de matemáticas en la LOMLOE. Un cambio en el enfoque de la enseñanza y el aprendizaje en matemáticas [Specific mathematics competences in Lomloe. A change in the approach to teaching and learning in mathematics]. *Supervisión* 21, 67:1–26.
<https://doi.org/10.52149/Sp21/67.9>
- Blaskó Z, Da Costa P & Schnepf SV 2021. *Learning loss and educational inequalities in Europe: Mapping the potential consequences of the COVID-19 crisis* (IZA Discussion Paper No. 14298).
<https://doi.org/10.2139/ssrn.3833230>
- Bond M 2020. Schools and emergency remote education during the COVID-19 pandemic: A living rapid systematic review. *Asian Journal of Distance Education*, 15(2):191–247.
<https://doi.org/10.5281/zenodo.4425683>
- Christopoulos A & Sprangers P 2021. Integration of educational technology during the Covid-19 pandemic: An analysis of teacher and student receptions. *Cogent Education*, 8(1):1964690.
<https://doi.org/10.1080/2331186x.2021.1964690>
- Clark RM, Kaw AK & Gomes RB 2022. Adaptive learning: Helpful to the flipped classroom in the online environment of COVID? *Computer Applications in Engineering Education*, 30(2):517–531. <https://doi.org/10.1002/cae.22470>
- Dhawan S 2020. Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, 49(1):5–22.
<https://doi.org/10.1177/0047239520934018>
- Drijvers P, Thurm D, Vandervieren E, Klinger M, Moons F, Van der Ree H, Mol A, Barzel B & Doorman M 2021. Distance mathematics teaching in Flanders, Germany, and the Netherlands during COVID-19 lockdown. *Educational Studies in Mathematics*, 108(1-2):35–64. <https://doi.org/10.1007/s10649-021-10094-5>
- Engzell P, Frey A & Verhagen MD 2021. Learning loss due to school closures during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences*, 118(17):e2022376118.
<https://doi.org/10.1073/pnas.2022376118>
- Faura-Martínez U, Lafuente-Lechuga M & Cifuentes-Faura J 2022. Sustainability of the Spanish university system during the pandemic caused by COVID-19. *Educational Review*, 74(3):645–663.
<https://doi.org/10.1080/00131911.2021.1978399>
- Gonda D, Pavlovičová G, Tirpáková A & Ďuriš V 2021. Setting up a flipped classroom design to reduce student academic procrastination [Special issue]. *Sustainability*, 13(15):8668.
<https://doi.org/10.3390/su13158668>
- Gopalan C, Butts-Wilmsmeyer C & Moran V 2021. Virtual flipped teaching during the COVID-19 pandemic. *Advances in Physiology Education*, 45(4):670–678.
<https://doi.org/10.1152/advan.00061.2021>
- Gortazar L, Hupkau C & Roldán A 2023. *Spain: A successful experience of remote tutoring*.
<https://doi.org/10.18235/0005077>
- Goudeau S, Sanrey C, Stanczak A, Manstead A & Darnon C 2021. Why lockdown and distance learning during the COVID-19 pandemic are likely to increase the social class achievement gap. *Nature Human Behaviour*, 5(10):1273–1281.
<https://doi.org/10.1038/s41562-021-01212-7>
- Greenhow C, Staudt Willet KB & Galvin S 2021. Inquiring tweets want to know: #Edchat supports for #RemoteTeaching during COVID-19. *British Journal of Educational Technology*, 52(4):1434–1454. <https://doi.org/10.1111/bjet.13097>
- Harper FK, Rosenberg JM, Comperry S, Howell K & Womble S 2021. #Mathathome during the COVID-19 pandemic: Exploring and reimagining resources and social supports for parents [Special issue]. *Education Sciences*, 11(2):60.
<https://doi.org/10.3390/educsci11020060>
- Jacques S, Ouahabi A & Lequeu T 2021. Synchronous e-learning in higher education during the COVID-19 pandemic. In T Klinger, C Kollmitzer & A Pester (eds). *Proceedings of the IEEE Global Engineering Education Conference (EDUCON 2021)*. Piscataway, NJ: IEEE.
<https://doi.org/10.1109/EDUCON46332.2021.9453887>
- Jordaan T & Havenga M 2021. The show must go on: Active online collaboration during COVID-19 – Mathematics students solving real-world problems. In AC Alves, N van Hattum-Janssen, RM Lima & V Villas-Boas (eds). *Proceedings of the PAEE/ALE'2021, International Conference on Active Learning in Engineering Education 13th International Symposium on Project Approaches in Engineering Education (PAEE) 18th Active Learning in Engineering Education Workshop (ALE)*. Guimarães, Portugal: Department of Production and Systems – PAEE association, School of Engineering of University of Minho.
<https://doi.org/10.5281/ZENODO.5095292>
- Lara-Lara F, Santos-Villalba MJ, Berral-Ortiz B & Martínez-Domingo JA 2023. Inclusive active methodologies in Spanish higher education during the pandemic [Special issue]. *Societies*, 13(2):29.
<https://doi.org/10.3390/soc13020029>
- Lu JCC 2023. Using YouTube as an effective educational tool to improve engineering mathematics teaching during the COVID-19 pandemic. *Engineering Proceedings*, 38(1):24.
<https://doi.org/10.3390/engproc2023038024>
- Marbán JM, Radwan E, Radwan A & Radwan W 2021. Primary and secondary students' usage of digital platforms for mathematics learning during the COVID-19 outbreak: The case of the Gaza Strip [Special issue]. *Mathematics*, 9(2):110.
<https://doi.org/10.3390/math9020110>
- Martínez-Agut MP 2021. Análisis de la LOMLOE (Ley Orgánica 3/2020, de 29 de diciembre, por la que se modifica la ley orgánica 2/2006, de 3 de mayo, de educación) y su repercusión en los profesionales de la educación no formal: Equidad, inclusión, servicio a la comunidad (APS), educación para la sostenibilidad y la ciudadanía mundial [Analysis of

- the LOMLOE (Organic Law 3/2020, of December 29, which modifies Organic Law 2/2006, of May 3, on education) and its impact on non-formal education professionals: Equity, inclusion, community service (PS), education for sustainability and global citizenship]. *Quaderns d'animació i Educació Social*, 33:1–20. Available at <https://dialnet.unirioja.es/servlet/articulo?codigo=7721049>. Accessed 1 April 2025.
- Mejía Janampa E, Gonzales-Sánchez ADC, Bayona Trujillo GM & Valqui Oxolon JM 2021. Acompañamiento familiar a los estudiantes durante la pandemia del Covid-19 [Family accompaniment to students during the COVID-19 pandemic]. *Laplace em Revista*, 7(3C):43–50. <https://doi.org/10.24115/s2446-6220202173c1502p.43-50>
- Moliner L & Alegre F 2022. COVID-19 restrictions and its influence on students' mathematics achievement in Spain. *Education Sciences*, 12(2):105. <https://doi.org/10.3390/educsci12020105>
- Mtande N & Ross E 2024. Perceived psychosocial effects of COVID-19 on the teaching realities of Foundation Phase educators in selected rural quintiles 1 to 3 schools in South Africa. *South African Journal of Education*, 44(3):Art. #2325, 10 pages. <https://doi.org/10.15700/saje.v44n3a2325>
- Nadler JT, Weston R & Voyles EC 2015. Stuck in the middle: The use and interpretation of mid-points in items on questionnaires. *The Journal of General Psychology*, 142(2):71–89. <https://doi.org/10.1080/00221309.2014.994590>
- Negrín Medina MA & Marrero Galván JJ 2021. La nueva Ley de Educación (LOMLOE) ante los Objetivos de Desarrollo Sostenible de la Agenda 2030 y el reto de la COVID-19 [The new Spanish educational law (LOMLOE) before the 2030 Sustainable Development Goals Agenda and the COVID-19 challenge]. *Avances En Supervisión Educativa*, 35:1–42. <https://doi.org/10.23824/ase.v0i35.709>
- Ní Fhloinn E & Fitzmaurice O 2022. Any advice? Lessons learned by mathematics lecturers for emergency remote teaching during the COVID-19 pandemic. *International Journal of Mathematical Education in Science and Technology*, 53(3):566–572. <https://doi.org/10.1080/0020739X.2021.1983049>
- Nyanamba JM, Liew J & Li D 2022. Parental burnout and remote learning at home during the COVID-19 pandemic: Parents' motivations for involvement. *School Psychology*, 37(2):160–172. <https://doi.org/10.1037/spq0000483>
- Panaoura R 2021. Parental involvement in children's mathematics learning before and during the period of the COVID-19. *Social Education Research*, 2(1):65–74. <https://doi.org/10.37256/ser.212021547>
- Pokhrel S & Chhetri R 2021. A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future*, 8(1):133–141. <https://doi.org/10.1177/2347631120983481>
- Pozo JI, Pérez Echeverría MP, Cabellos B & Sánchez DL 2021. Teaching and learning in times of COVID-19: Uses of digital technologies during school lockdowns. *Frontiers in Psychology*, 12:656776. <https://doi.org/10.3389/fpsyg.2021.656776>
- Raaper R, Brown C & Llewellyn A 2022. Student support as social network: Exploring non-traditional student experiences of academic and wellbeing support during the Covid-19 pandemic. *Educational Review*, 74(3):402–421. <https://doi.org/10.1080/00131911.2021.1965960>
- Røe Y, Wojniusz S & Bjerke AH 2022. The digital transformation of higher education teaching: Four pedagogical prescriptions to move active learning pedagogy forward. *Frontiers in Education*, 6:784701. <https://doi.org/10.3389/educ.2021.784701>
- Salim H, Daud A & Hanif M 2024. Using social media for teaching English during the COVID-19 pandemic: Lessons from Indonesia. *South African Journal of Education*, 44(3):Art. #2247, 12 pages. <https://doi.org/10.15700/saje.v44n3a2247>
- Torres Martín C, Acal C, El Homrani M & Mingorance Estrada AC 2021. Impact on the virtual learning environment due to COVID-19 [Special issue]. *Sustainability*, 13(2):582. <https://doi.org/10.3390/su13020582>
- Troussas C, Krouska A, Giannakas F, Sgouropoulou C & Voyiatzis I 2021. An alternative educational tool through interactive software over Facebook in the era of COVID-19. In C Frasson, K Kabassi & A Voulodimos (eds). *Novelties in Intelligent Digital Systems: Proceedings of the 1st International Conference (NIDS 2021)* (Vol. 338). Washington, DC: IOS Press. <https://doi.org/10.3233/FAIA210069>
- Trujillo-Torres JM, Hossein-Mohand H, Gómez-García M, Hossein-Mohand H & Hinojo-Lucena FJ 2020. Estimating the academic performance of secondary education mathematics students: A gain lift predictive model. *Mathematics*, 8(12):2101. <https://doi.org/10.3390/math8122101>
- Yang D, Chen P, Wang K, Li Z, Zhang C & Huang R 2023. Parental involvement and student engagement: A review of the literature. *Sustainability*, 15(7):5859. <https://doi.org/10.3390/su15075859>