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Relationship between attitudes toward mathematics and perceptions of virtual teaching in the COVID-19 context

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Background: The shift to virtual education from 2019 to 2021 in response to COVID-19 necessitated both teachers and students to adapt to new technological skills, thereby impacting the teaching and learning dynamics. With limited existing research on this evolving domain, our study aimed to gauge attitudes toward mathematics, and perceptions of virtual education during the COVID-19 era and explore potential correlations between these variables.

Methods: In this cross-sectional quantitative correlational primary study, secondary school students at a public school were asked to rate their attitudes toward mathematics and their perceptions of virtual teaching in the context of COVID-19 using two validated questionnaires. We used linear regression analysis to respond to our objectives.

Results: The findings show that perceptions of virtual teaching (34.65%) and attitudes toward mathematics (40.16%) are both low. The dimensions of attitudes toward mathematics and perceptions of virtual education have a positive association and influence on one another ($B = 0.464, p < 0.001$).

Conclusion: Both study variables show a low level and found a significant relationship between the dimensions of virtual learning perception and attitudes toward mathematics. More research is required to grasp how cognitive processing influences attitudes toward mathematics. This understanding can improve the proficiency of math educators, benefiting students at all educational stages.

KEYWORDS

attitudes, mathematics, perception, virtual teaching, COVID-19

1 Introduction

The "attitude toward mathematics" refers to an individual's overall assessment, contentment, curiosity, and interest in the topic, with an emphasis on the emotional rather than cognitive aspects (Flores and Auzmendi, 2018; Rojas et al., 2018). Dörfer and Ullao (2016) describe five types of attitudes toward mathematics: worry or apprehension, enjoyment or liking, motivation, projected utility for future pursuits, and confidence. Effective teaching requires educators to prioritize thorough curriculum design, different instructional approaches, constructive feedback, clear communication, access to learning materials, and social contact (García et al., 2022). Students' openness to learning is substantially influenced by their educators' attitudes toward the things they teach, and academic performance frequently benefits from a more positive viewpoint (Isaza and Henao, 2012; Rodríguez and Sánchez, 2021; Capote et al., 2022).

Due to the COVID-19 pandemic, education transitioned to a virtual format between 2019 and 2021 (UNICEF, 2021). During this period, attitudes toward mathematics among students in basic and secondary education in Honduras were assessed. Findings revealed that, while students acknowledged the importance of mathematics, those in urban areas exhibited more positive attitudes toward "liking mathematics" compared to their rural counterparts. This disparity is likely attributed to urban students having better access to resources and being more accustomed to technology during the pandemic (Pineda-Ramírez et al., 2021). In contrast, primary school children in Spain reported favorable attitudes toward mathematics, and those with more positive perceptions had teachers with higher levels of self-efficacy in the subject (Segarra and Julià, 2021). Additionally, studies conducted by Peña and Berrio (2022) on Colombian university students revealed an understanding of the significance of mathematics and the numerical method. However, students expressed feeling demotivated due to inadequate resources or the challenges associated with distance learning. Despite recognizing the value of mathematics, students encountered obstacles such as a lack of motivation, limited resources, minimal utilization of technology, and insufficient commitment from teachers to foster students' cognitive growth.

Regarding online education during the pandemic, teachers and students were required to have technological skills in teaching and learning (UNICEF, 2021). University students from Colombia and Chile indicated that during the pandemic they did not feel prepared for virtual education; they stated that they did not have the necessary skills for the advanced use of virtual technologies for learning (Londoño-Velasco et al., 2021; Romero et al., 2021) and Peruvian university students reported an indifferent attitude toward virtual education (Estrada-Araoz et al., 2020). Likewise, Indonesian university students reported that during the pandemic they had problems using e-learning for distance learning in mathematics (Ramadhani et al., 2021). Due to their lack of basic mathematical knowledge, students at a high school in Portugal point out that, although using a platform is advantageous, they prefer to study alongside the teacher (García et al., 2020). In a study conducted in a private school in the Philippines, the change of modality caused stress and adjustment difficulties related to teaching and learning, including connectivity, time management,

lesson planning, classroom management, and social interactions (De Gracia et al., 2022). On the other hand, Ortega et al. (2021) reported that the most disadvantaged were those who did not have devices connected to the Internet, the disabled, those who had special educational needs, those who did not interact with their teachers and classmates, and those whose teachers did not use virtual resources or taught material not related to their needs. Overall, the shift to online learning highlighted disparities in access and support for students with diverse needs. Educators must address these challenges and provide equitable opportunities for all learners.

Views toward mathematics and independent virtual learning vary depending on several factors, including educational levels, the kind of school or institution, the caliber and efficacy of the teachers, and the instructors' readiness to adapt to the needs of the learning community. It is evident that, in the framework of COVID-19, no research has been conducted at the national or international level regarding the connection between attitudes toward mathematics and virtual instruction. Therefore, the study aimed to determine the levels of attitudes toward mathematics, perceptions of virtual education during the COVID-19 pandemic, and the correlation between these research variables. To statistically assess the correlation between the research variables, an alternative hypothesis was formulated, positing a positive and significant relationship between attitudes toward mathematics and perceptions of virtual teaching during the COVID-19 era. Conversely, the null hypothesis suggests that there is neither a positive nor significant relationship between attitudes toward mathematics and perceptions of virtual teaching in the context of COVID-19.

2 Materials and methods

2.1 Study design

The present study was a cross-sectional quantitative correlational primary study conducted with high school students in a public school in northern Peru during the COVID-19 pandemic. This research design aims to describe and assess the relationship between variables (Hernández et al., 2014). Instruments with reliable psychometric indicators were used to measure attitudes toward mathematics and perceptions of virtual teaching during the period from November to December 2021.

2.2 Participants

The study population consisted of 137 second-grade secondary school students from four sections (A, B, C, and D) at a public institution in a city in northern Peru, during November to December 2021. The entire student population was included; thus, no sampling was conducted. However, 10 students did not provide informed assent and were consequently excluded, resulting in a final sample of 127 students. We are aware of the small sample size and assume it to be a limitation of this study, however, it turns out to be larger than in other research studies (Huda et al., 2021; Capote et al., 2022). Most students were male (55.40%), from section

B (38.30%), and from a medium-low socioeconomic background (67.37%). Inclusion criteria required students to have participated in virtual learning during 2021, as per the regulatory document "Provisions for the work of teachers and educational assistants that ensure the development of the educational service of public educational institutions and programs in the face of the COVID-19 outbreak" (2021), and to have obtained voluntary informed assent from their parents or guardians.

2.3 Variables and instruments

The variables in the study were attitudes toward mathematics and perceptions of virtual teaching. To measure attitudes toward mathematics, we used the Mathematics Attitude Scale (EAM), originally developed by [Auzmendi et al. \(1992\)](#). This instrument consists of 25 items with response options ranging from 1 (disagree) to 5 (strongly agree), distributed across five dimensions: anxiety, liking, usefulness, motivation, and engagement. The total score ranges from 25 to 125 points ([Dörfer and Ullao, 2016](#)). The EAM is one of the most comprehensive tools for assessing attitudes toward mathematics, as it covers emotional, cognitive, and behavioral aspects. It has been validated in its Spanish version within a Mexican population, showing acceptable reliability ($\alpha = 0.667$) and validity, with 64.29% of the variance explained and an adequate Kaiser-Meyer-Olkin test ($KMO = 0.764$) ([Dörfer and Ullao, 2016](#)). For our study, we achieved a high level of reliability through Cronbach's alpha ($\alpha = 0.836$) and confirmed its validity through expert judgment, demonstrating that the instrument is suitable for the Peruvian context. This clarification regarding the instrument for measuring attitudes toward mathematics underscores its utility in similar contexts.

The Virtual Teaching Perception Instrument, developed in Peru, was used to assess the perception of virtual teaching. This instrument includes 24 items measured on a Likert-type scale with 5 response categories (1 = very little; 5 = always) across ten dimensions: teaching communication, content programming, learning materials, use of teaching methods, evaluation, feedback, assignments, socialization, technology, and technical skills for virtual teaching. The total score ranges from 24 to 120 points ([García et al., 2022](#)). This instrument is unique for its multidimensional format, including novel dimensions such as school bonding. It was validated for the Peruvian population, showing good reliability levels for the dimensions using ordinal alpha ($\alpha = 0.82\text{--}0.94$) and validity through confirmatory factor analysis with appropriate goodness-of-fit indicators ($CFI = 0.95$, $TLI = 0.93$, $RMSEA = 0.07$) ([García et al., 2022](#)). In our study, we obtained a high-reliability score with a Cronbach's alpha of 0.930.

2.4 Procedure

The process carried out for the investigation requested the corresponding permission from the authority of the public educational institution in northern Peru. Afterwards, having obtained permission, the participation of the students was requested through the parents of the classrooms of the 2nd grade of secondary school in sections "A, B, C, and D," including

only the students who obtained the signed consent. Then, the survey was completed in an average of 30 min for the student. Finally, two independent investigators partially collected surveys and partially generated two data bases; at the conclusion of the crossing of such bases, tests were conducted to validate randomly placed information and were finally unified. If subsequent inconsistencies were found in the database, these were reviewed by the entire research team.

2.5 Statistical analysis

For the present study, the database was generated in Microsoft Excel 2016 and exported for analysis using the statistical program Stata 15.0 ([StataCorp, 2017](#)). The following analyses were conducted: (i) descriptive analysis, reported in tables of absolute and percentage frequencies with their respective graphs for the variables; (ii) relational analysis, where the magnitude and significance of the association between the variables on a quantitative measurement scale—notes and scores obtained in the instruments—were reported using linear regression analysis to present the relationships between the independent variables separately with the dependent variable (crude model), being significant at $p < 0.05$. Additionally, the impact of significant independent variables with the dependent variable was evaluated jointly (adjusted model). For the descriptive analysis of the variables and their study dimensions, they were categorized by percentile ranking. Moreover, the normality of the study variables was assessed using the Kolmogorov-Smirnov test (see [Supplementary Table 1](#)).

Reliability analysis was conducted for all variables and dimensions using Cronbach's Alpha (see [Supplementary Table 2](#)).

2.6 Ethics statement

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Universidad Nacional del Santa (N°102-UNS-CFEH). All subjects gave informed consent for their inclusion before participating in the study.

3 Results

3.1 Level of attitudes toward mathematics in the context of COVID-19

An attitude toward mathematics was generally low among second-year high school students, with 40.16% of them falling into this category. [Table 1](#) illustrates that this trend holds for the following specific dimensions: motivation (39.37%), usefulness (41.73%), confidence (42.52%), anxiety (38.58%), and liking (48.52%). These results imply that students might experience difficulties in the classroom, struggle to comprehend how mathematics is used in real-world situations and lack confidence when solving numerical problems. Cultural influences may also have an impact on how pupils approach learning mathematics.

TABLE 1 Levels of attitudes toward mathematics according to dimensions and total.

Variables	<i>n</i>	%
D1: Anxiety		
Low	49	38.58
Medium	46	36.22
High	32	25.2
D2: Liking		
Low	62	48.82
Medium	30	23.62
High	35	27.56
D3: Usefulness		
Low	53	41.73
Medium	36	28.35
High	38	29.92
D4: Motivation		
Low	50	39.37
Medium	42	33.07
High	35	27.56
D5: Confidence		
Low	54	42.52
Medium	33	25.98
High	40	31.5
Total		
Low	51	40.16
Medium	37	29.13
High	39	30.71

Own elaboration.

3.2 Level of perception of virtual teaching

Students' perception of virtual teaching was generally low, with 34.65% rating it poorly. This trend was also evident in specific dimensions: learning materials (51.97%), use of teaching methods (50.39%), and content programming (48.03%) (see Table 2). Notably, students find academic materials less engaging in a virtual format. Additionally, issues with class scheduling and assignment deadlines contribute to their negative perception of the subjects, which can lead to poor academic performance or course failure.

3.3 Relationship between attitudes toward mathematics and perceptions of virtual teaching in the context COVID-19

In examining the relationship between virtual teaching perception dimensions and attitudes toward mathematics, all variables showed significance ($p < 0.05$) in the crude model. Notably, technical skills for virtual teaching ($B = 0.533$, $p < 0.001$), feedback ($B = 0.481$, $p < 0.001$), and use of teaching methods

TABLE 2 Levels of perception of virtual teaching according to dimension and total.

Variables	<i>N</i>	%
D1: Teaching communication		
Low	52	40.94
Medium	56	44.09
High	19	14.96
D2: Content programming		
Low	61	48.03
Medium	27	21.26
High	39	30.71
D3: Learning materials		
Low	66	51.97
Medium	37	29.13
High	24	18.9
D4: Use of teaching methods		
Low	64	50.39
Medium	21	16.54
High	42	33.07
D5: Evaluation		
Low	58	45.67
Medium	35	27.56
High	34	26.77
D6: Feedback		
Low	59	46.46
Medium	44	34.65
High	24	18.9
D7: Assignments		
Low	52	40.94
Medium	43	33.86
High	32	25.2
D8: Socialization		
Low	43	33.86
Medium	46	36.22
High	38	29.92
D9: Technology		
Low	54	42.52
Medium	38	29.92
High	35	27.56
D10: Technical skills for virtual teaching		
Low	54	42.52
Medium	32	25.2
High	41	32.28
Total		
Low	44	34.65
Medium	42	33.07
High	41	32.28

Own elaboration.

($B = 0.408, p < 0.001$) emerged as the dimensions with the greatest impact, all positively associated with attitudes toward mathematics. However, in the adjusted model, only technical skills for virtual teaching, learning materials, use of teaching methods, and feedback retained significance ($p < 0.05$), with learning materials exhibiting an inverse impact. Specifically, the dimensions of virtual teaching perception with the most significant impact on attitudes toward mathematics were technical skills for virtual teaching ($B = 0.528, p < 0.001$), use of teaching methods ($B = 0.409, p = 0.003$), and learning materials ($B = -0.407, p = 0.001$) (Table 3). These findings suggest that enhancing teaching technical skills, employing effective teaching methodologies, and providing quality learning materials can contribute to fostering a more positive attitude toward mathematics.

3.4 Relationship of the virtual teaching perception with the dimensions and variables of attitude toward mathematics in the context of COVID-19

In exploring the relationship between dimensions of attitudes toward mathematics and virtual teaching perception, all variables demonstrated significance ($p < 0.05$) in the crude model. Notably, the dimensions with the strongest impact were usefulness ($B = 0.500, p < 0.001$), confidence ($B = 0.480, p < 0.001$), and liking ($B = 0.480, p < 0.001$), all positively associated with virtual teaching perception. However, in the adjusted model, only usefulness ($B = 0.256, p = 0.011$), confidence ($B = 0.218, p = 0.047$), and motivation ($B = -0.193, p = 0.038$) remained significant with virtual teaching perception, with motivation demonstrating an inverse impact (Table 4). Specifically, an increase of one point in the belief in the usefulness of mathematics corresponds to a 0.256 increase in virtual teaching perception, while a one-point increase in confidence in mathematics leads to a 0.218 increase. Conversely, an increase of one unit in motivation toward mathematics results in a 0.193 decrease in virtual teaching perception.

Additionally, it was reported that the relationship and impact between the variables of total score of attitudes toward mathematics and perception of virtual teaching are positively related to each other ($B = 0.464, p < 0.001$).

4 Discussion

The study uncovered a concerning trend of low attitudes toward mathematics and perceptions of virtual teaching, revealing a positive correlation between these two variables.

The level of perception of virtual teaching and attitudes toward mathematics have a favorable link ($r = 0.464; p < 0.05$). These findings demonstrate that there is a favorable association between students' perceptions and attitudes. There are no comparable studies. However, a study conducted in the Philippines found that the change in modality created stress and adaptation challenges in teaching and learning. However, the students' performance improved as a result of everyone's hard work (De Gracia et al., 2022). Students who have positive impressions of mathematical subjects in online learning have positive learning outcomes.

Previous research found a favorable and substantial association between students' perceptions of mathematics and mathematics learning achievement (Huda et al., 2021). Although students' perceptions of mathematics learning are very good, this does not imply that their mathematical learning outcomes are equally good. Furthermore, learning quality is a crucial factor in effective learning. Effective learning is determined not only by teachers' skills and competencies but also by the entire learning strategy (Lizzio et al., 2002). Students improve their critical thinking abilities as well as their ability to reason and seek solutions in their professional and personal lives by strengthening their mathematics skills and increasing their sense of responsibility and freedom in learning. The study identified low levels of attitudes toward mathematics and the perception of virtual teaching in the context of Covid-19 and its positive relationship between both variables.

The perception of virtual teaching was notably low (34.65%), mirroring similar sentiments across various dimensions, including learning materials, teaching methods, and content programming. Our findings resonate with those of studies conducted in other regions. For instance, university students in Indonesia reported difficulties in continuing mathematics learning during the COVID-19 pandemic due to insufficient skills in utilizing information technologies (Ramadhani et al., 2021). Similarly, Colombian university students faced challenges with e-learning, including resource constraints, technological proficiency, and adaptability to online teaching modalities (Londoño-Velasco et al., 2021; Peña and Berrio, 2022). Likewise, Portuguese students expressed dissatisfaction with online learning, citing a lack of face-to-face interaction with teachers and classmates and struggles with assessment modifications (Júlia et al., 2021). Indonesian students, lacking access to data packages, favored traditional face-to-face classes, highlighting the importance of cooperative learning methods, competitive environments, self-efficacy, and innovative teaching approaches (Nasution et al., 2021). Our findings are further supported by the observation that the comprehension process in online learning is slower compared to face-to-face instruction (Edwards, 2012; Bringula et al., 2021). In virtual settings, students often require additional time to grasp concepts, necessitating revisions to teacher and student interactions in WhatsApp group discussions (Erkan, 2022). Furthermore, understanding practice questions presented as images poses challenges, and students typically require step-by-step guidance to independently solve such questions, unlike in traditional classroom settings where verbal explanations from teachers facilitate comprehension.

On characteristics such as anxiety, liking, usefulness, motivation, and engagement, less than half of the students show attitudes toward mathematics. Similar findings were presented in Honduras, students in primary and secondary education report a negative attitude for their "liking of mathematics", and this is especially true for students in remote areas that lack essential resources for virtual teaching (Pineda-Ramírez et al., 2021). On the contrary, primary school children in Spain exhibited a positive attitude toward mathematics, which was attributed to having effective teachers (Segarra and Julià, 2021). Meanwhile, students' opinions about mathematics in discovery learning with concrete and virtual manipulatives are pleasant and carefree (Hidayah and Prayoga, 2021). The nature of the problems, problem-solving experiences, feelings encountered in solving difficulties, and

TABLE 3 Relationship between attitudes toward mathematics and perceptions of virtual teaching.

Variables	Crude model			Adjusted model		
	Unstandardized coefficient	<i>B</i>	<i>p</i> -value	Unstandardized coefficient	<i>B</i>	<i>p</i> -value
D1: Teaching communication	1.174	0.375	<0.001	0.177	0.057	0.502
D2: Content programming	1.059	0.323	<0.001	0.176	0.054	0.589
D3: Learning materials	0.879	0.264	0.003	-1.355	-0.407	0.001
D4: Use of teaching methods	1.554	0.408	<0.001	1.557	0.409	0.003
D5: Evaluation	1.543	0.373	<0.001	0.068	0.016	0.873
D6: Feedback	2.168	0.481	<0.001	1.564	0.347	<0.001
D7: Assignments	0.823	0.299	0.001	-0.47	-0.171	0.152
D8: Socialization	0.712	0.292	0.001	0.093	0.038	0.656
D9: Technology	0.522	0.197	0.026	-0.475	-0.179	0.072
D10: Technical skills for virtual teaching	2.12	0.533	<0.001	2.098	0.528	<0.001

Own elaboration.

TABLE 4 Relationship between perceptions of virtual teaching and attitudes toward mathematics.

Variables	Crude model			Adjusted model		
	Unstandardized coefficient	<i>B</i>	<i>p</i> -value	Unstandardized coefficient	<i>B</i>	<i>p</i> -value
D1: Anxiety	-0.495	-0.188	0.034	0.044	0.017	0.871
D2: Liking	2.059	0.480	<0.001	0.637	0.148	0.183
D3: Usefulness	1.861	0.500	<0.001	0.954	0.256	0.011
D4: Motivation	-1.747	-0.289	0.001	-1.169	-0.193	0.038
D5: Confidence	2.849	0.480	<0.001	1.291	0.218	0.047

Own elaboration; *B*: standardized coefficient.

the importance of problem-solving influence students' attitudes (Saadati et al., 2023). The data highlights that teaching and learning mathematics through online platforms presents unique challenges compared to other subjects or disciplines, leading to a decline in students' enthusiasm for learning and comprehension of mathematics during virtual classes.

4.1 Strengths and limitations

The study's strength lies in its substantial sample size of high school students during the COVID-19 pandemic, despite facing challenges posed by restrictions on participant interaction. On the other hand, one notable limitation is the inability to generalize the findings beyond the scope of a single public institution in a specific Peruvian city, which restricts broader regional or national implications.

4.2 Implications for education

It is recommended that the Ministry of Education invest in training programs for teachers to enhance their proficiency in utilizing technological tools that can facilitate and enrich the teaching and learning of mathematics. This includes empowering teachers to independently develop educational resources such as instructional videos and electronic modules. Additionally,

educational authorities must assess teachers' mathematical competencies and qualities to ensure effective instruction.

5 Conclusion

The study used validated instruments and is the first to report levels and relationships between attitudes toward mathematics and virtual instruction in the context of COVID-19 among high school sophomores at a public institution. Our findings show a consistent favorable association between attitudes toward mathematics and perceptions of virtual teaching. Similarly, they exhibit negative attitudes toward mathematics and a negative opinion of virtual instruction. Further research is needed to understand the impact of cognitive processing on attitudes toward mathematics, which can ultimately enhance the competency levels of mathematics educators, thereby benefiting students across various educational levels.

Data availability statement

The original contributions presented in this study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the Universidad Nacional del Santa (N°102-UNS-CFEH). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

IS-C: Conceptualization, Writing – original draft, Writing – review and editing. MR-O: Conceptualization, Writing – original draft, Writing – review and editing. WA-I: Conceptualization, Writing – original draft, Writing – review and editing. MI-Z: Methodology, Writing – original draft, Writing – review and editing. SA-I: Conceptualization, Writing – original draft, Writing – review and editing. JB-P: Conceptualization, Writing – original draft, Writing – review and editing.

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Conflict of interest

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1414114/full#supplementary-material>

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