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The unified state examination in mathematics in urban and rural schools: The impact of the 2020-2021 pandemic

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Abstract

This mixed methods study investigates the impacts of the COVID-19 pandemic on outcomes and perceptions related to the high-stakes unified state exam (USE) mathematics assessment in Russia. Quantitative descriptive analyses of USE scores from 2018-2021 revealed statistically significant distributional differences over time, with progressive increases in higher performance tiers. However, while a positive trend was discernible, strength of association tests indicated it was marginally moderate across years. Stratified pass rate analyses illuminated between-group variances, with specialized schools strongly rebounding after initial 2020 declines observed universally. To gain stakeholder insights, surveys were administered to students and teachers from urban versus rural regions. Attitudes regarding the mandatory USE removal diverged between groups; optimism permeated small rural schools despite hardships, while skepticism was pronounced among urban teachers citing accountability concerns. Stress perceptions revealed dissonances signaling wellbeing impacts. Overall, while achievement markers show positive trajectories, attitudinal variations based on school-types underline social dimensions shaping high-stakes test experiences. Results implicate targeted support policies and context-sensitive analytical approaches for optimal crisis mitigation. Granular investigations of less-understood equity gaps, expanding methodologies and detailed demographic profiling would enrich these findings. By quantifying exam trends alongside experiential nuances, the study develops a contextualized understanding of mathematical assessment transformations, informing localized continuity planning for uncertain futures.

Keywords: COVID-19 pandemic, outcomes in mathematics, unified state exam, urban and rural schools, regional specifics

INTRODUCTION

The COVID-19 pandemic that emerged in 2020 disrupted education systems globally, necessitating an abrupt shift to online or hybrid models. These rapid transitions have raised critical questions around the impacts on student learning, assessment, and equity that remain underexplored within pedagogical research (Atteberry & McEachin, 2021; DeCoito & Estaiteyeh, 2022; Murphy, 2020; Radina & Balakina, 2021). This study specifically examines the effects of the pandemic on outcomes and perceptions related to the high-stakes

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Contribution to the literature

- It provides one of the first multi-year analyses specifically tracking the progression of USE mathematics outcomes before, during, and after the peak disruption phases.
- Stratifying trends by school types is also unprecedented in the Russian context, elucidating variability in institutional capacities based on resources, settings and student demographics. Additionally, the integration of perceptual data from both students and teachers enriches typical exam-centric investigations, capturing stakeholder attitudes and experiential realities often overlooked.
- Facts and trends characterizing the process of teaching mathematics in the Russian school, which are important in the context of applying the interpretive potential of information about the quality and results of teaching a subject in a comparative context for rural and urban schools.

unified state exam (USE) mathematics exam across different school types in Russia.

USE mathematics exam plays a pivotal role in students' academic and professional trajectories (Federal Service in Supervision in the Filed of Education and Science, 2020). Thus, investigating how pass rates and score distributions have changed during this time is vital. Additionally, variations in subjective attitudes can provide valuable insights into how different educational institutions are interpreting these impacts (Gutsu et al., 2020). While existing literature has explored overall challenges in mathematics education wrought by the pandemic (Castro et al., 2020; Doz, 2021; Saadati et al., 2021), analyses differentiated by urban and rural schools remain scarce (Higher School of Economics [HSE], 2020).

This mixed methods study therefore addresses two key gaps:

(1) tracking USE mathematics results through the pandemic period, including the pre-pandemic (2018-2019), emergency transition (2020) and post-transition (2021) phases, and

(2) juxtaposing objective performance data and perceptual survey data across rural versus urban schools.

The conceptual framework integrates ideas around "security pedagogy" and "family pedagogy" as conditions that can mediate online learning efficacy and exam outcomes depending on the school context (Krotenko, 2020; Radina & Balakina, 2021).

USE mathematics exam represents a high-stakes test that shapes students' academic and career trajectories. Gaining insight into how pass rates and score distributions have changed through the pandemic period is therefore essential. Additionally, investigating variations in subjective viewpoints can further elucidate how these impacts are interpreted across rural versus urban schools.

Accordingly, this mixed methods study is guided by the following research questions:

RQ1. How do the distributions of score ranges in USE mathematics exams change between 2018-2021 during the pre-pandemic and pandemic period?

RQ2. How do passing rates in USE mathematics exams change between 2018-2021 when comparing the pre-pandemic and pandemic timeframe?

RQ3. Does students' perception of USE mathematics exam itself vary depending on the type of school (rural, urban, specialized) they graduated from?

RQ4. Do students' perceptions of the removal of USE mathematics exam requirement during the pandemic differ based on their school background (rural, urban, specialized)?

RQ5. Are there variations in mathematics teachers' definitions of USE mathematics exam across different school types (rural, urban, elite)?

RQ6. Do opinions among mathematics teachers regarding the pandemic's impact and removal of the mandatory USE mathematics exam differ across school types (rural, urban, and elite)?

By consolidating mathematical analyses of achievement trends with cross-sectional survey perspectives, the study aims to develop a nuanced, contextualized understanding of how this high-stakes mathematics assessment and Russian mathematical education overall is being shaped by the enduring pandemic constraints. Findings can in turn inform pedagogical practices and strategic decisions related to supporting learning continuity and student success across diverse settings both presently and in future crisis situations (Cusi et al., 2023; Saadati et al., 2021).

LITERATURE REVIEW

Global Aspects of Research on Problems of Certification Tests in Mathematics During the Pandemic

In the contemporary academic discourse on the impacts of the COVID-19 pandemic on mathematics education, a number of pivotal studies have emerged, elucidating various methodological challenges and transformations. This paper seeks to synthesize these significant contributions, providing a comprehensive overview of the field.

The research by Khodyreva et al. (2021) delves into the metamorphosis of educational activity assessment and the preparation of prospective natural science educators in the pandemic era. Central to this study is the exploration of multifaceted themes such as the objectivity and complexity of assessments, the technical and transparent nature of assessment procedures, and the harmonization of standard and non-standard evaluative criteria. Cusi et al. (2023) address the development of mathematics assessments within the framework of ensuring pedagogical continuity. The study underscores the growing necessity for teachers to possess evaluative and qualimetric competencies, enabling them to conduct pedagogical assessments effectively and make informed decisions regarding student learning activities. Emphasis is placed on the evolution of assessment practices, including the introduction of novel scales, criteria, and systems, with a particular focus on the specificities of pedagogical measurement tools in mathematics.

Focusing on the research trajectory in mathematics education in Latin America during the pandemic, Castro Walter et al. (2020) use Mexico, Colombia, and Chile as case studies. They highlight the regional research agendas in response to pandemic-induced challenges, acknowledging the amplification of the social perspective in mathematics education. The research brings to light issues such as educational inequities, the portrayal of mathematics as a cultural interface, and the significance of mathematics in understanding worldviews. It also addresses the interplay between family and school in mathematics mastery and communication.

Saadati et al. (2021) investigate the beliefs and practices of Chilean mathematics teachers regarding remote learning during the pandemic. They reveal high self-efficacy among teachers in personal technology use, contrasted with moderate incorporation of digital tools in teaching. Notably, the study observes gender-based differences in remote teaching practices, with female educators displaying greater engagement. Furthermore, it identifies the socio-economic context as a significant influencer of teachers' beliefs and practices, highlighting disparities between urban and rural educational settings. The study advocates for resources to alleviate stress and anxiety in students, as well as for the inclusion of parental education programs in distance learning models.

DeCoito and Estaiteyeh (2022) provide insights into the online teaching approaches of Canadian science teachers, noting a preference for curriculum-aligned content delivery over creative, student-centered methods. The study underscores the predominance of a minimum standard approach, potentially leading to a loss in meta-subjective outcomes and a deviation from personalized learning strategies. It also reflects on the teachers' perceptions of online learning, particularly regarding student engagement and educational outcomes.

In summary, these studies collectively highlight a complex array of influences on mathematics education during the pandemic. They reveal a spectrum of experiences among mathematics teachers concerning the shift to compulsory remote learning, underscored by the significant influence of parental and familial factors in the organization of remote education for students.

Russian Specifics of USE in Mathematics & Possibility of Analyzing Its Results

The Russian Federation has established a comprehensive internal mechanism for assessing the quality of education of which USE is a pivotal component. Initiated in 2009, USE serves dual functions: firstly, as the final examination in a given subject, and secondly, as a facilitator for university admissions, as detailed in "Unified system for assessing the quality of school education in Russia" (2020). However, due to the inherent regional diversity within the Russian educational landscape, USE results should not be utilized as a benchmark for comparing the performance of schools, educators, or regions. Instead, these results should be contextually interpreted within each specific territory, leveraging their analytical potential. This approach is particularly beneficial for educational development institutes and other entities providing scientific and methodological support to regional teachers.

Despite its critical role, the dissemination of USE results, both regionally and nationally, has been criticized for its lack of transparency and incomplete representation on official websites, as observed by Nurieva and Kiselev (2017) and Zelenina and Krutikhina (2019). This inadequacy hampers the acquisition of a comprehensive database necessary for in-depth analysis and practical educational applications.

Ilyukhin et. al (2019) have articulated two primary concerns regarding final examinations. The first is the prevalent focus on merely recording achievements, overshadowing the intended formative assessment of students. The second pertains to the need for developing scenarios that consider various influencing factors on educational outcomes, particularly evident in disparate USE results between urban and rural schools, notably in regions like Tomsk.

Nurieva and Kiselev (2016, 2018), through their works from 2016 to 2018, have identified crucial factors impacting regional USE outcomes. These include the quality of control and measuring materials (KIM), adherence to test conduction protocols, and the level of student preparedness, especially in tackling simpler problems. Their findings illuminate a stark disparity in scores between general and elite schools, which subsequently led to the bifurcation of the exam into basic

and profile levels (Nurieva & Kiselev, 2016). They advocate for the transparent dissemination of exam statistics across all contexts and regions, and the involvement of university researchers in the analytical review of regional USE outcomes. They further note that USE results vary significantly across the Russian Federation due to socio-economic, demographic, and cultural factors unique to each territory. Hence, evaluating the quality of local educational systems should be context-sensitive, considering the available resources and specific conditions of school operations (Nurieva & Kiselev, 2018).

Studies of Impact of the Pandemic on Results of Final Tests Including in Comparative Terms for Urban & Rural Schools

Recent academic works have focused on the impact of the COVID-19 pandemic on final examinations and educational outcomes. Research conducted by HSE (2020) revealed that during the pandemic, approximately 70.0% of students were engaged in distance learning, with half of them lacking a computer and 43.0% without internet access at home (Zvyagintsev et al., 2020). This situation initially directed attention towards the technical challenges of facilitating distance learning, overshadowing concerns about its effectiveness. However, the majority of studies, including those by Tishchenko (2020), Yakobyuk (2020), and Jan (2020), acknowledge the reduced efficacy of distance learning compared to traditional classroom instruction.

The academic setbacks experienced by students from families with low socio-economic status, such as migrant families, students with disabilities, and those in rural areas, are particularly noteworthy. These groups traditionally achieve lower educational outcomes even in conventional settings, as compared to their counterparts from higher socio-economic backgrounds (Kuhfeld & Tarasawa, 2020; Marcotte & Hemelt, 2007). The magnitude of these academic losses varies by subject, with mathematics suffering the greatest impact, equating to approximately 1.5 months of the academic year (Kuhfeld & Tarasawa, 2020; Marcotte & Hemelt, 2007). The pandemic's effect on learning is likened to the educational losses typically observed during summer breaks (Cooper et al., 1996; Kuhfeld, 2019), with primary school students being particularly vulnerable, potentially equating to a year's worth of missed education (Kuhfeld & Tarasawa, 2020; Zhdanov et al., 2022; Zvyagintsev et al., 2020).

Radina and Balakina (2021) discuss similar pandemic effects, emphasizing the decline in the quality of preschool and additional education spaces due to digitalization (Tishchenko, 2020) and noting the decreased educational mobility among graduates (Artemenkov & Suhova, 2020). Yakobyuk (2020) provides insights into the performance of students from the Northern Trans-Urals in the 2020 USE in profile mathematics, comparing "expected" and "actual" results among urban and rural students. While both groups anticipated higher scores, the actual results were lower than expected, with no statistically significant differences between urban and rural students.

Before the pandemic, only about 80.0% of Russian children aged seven to 16 had the technological means for distance learning, with this figure dropping to 30.0%-50.0% in rural areas (Zair-Bek et al., 2020). The professional community has expressed diverse opinions regarding the transformations in the education system during the pandemic. Traditional teaching methods have been perceived as outdated, while technological advancements have ushered in new educational formats. However, concerns about the quality of distance learning persist, particularly regarding the diminished personal and emotional interaction between teachers and students. Another research focus during the pandemic has been on the health and self-regulation challenges faced by students in self-isolation.

Publications highlight the unique challenges faced by rural schools, such as geographic isolation, small size, and limited resources, which impact the professional and personal development of teachers and the educational opportunities for students (Rural School Education and Educational Outcomes, 2020). However, these challenges also present innovative potential, suggesting resilience in rural schools when utilizing available resources effectively. In OECD countries, rural students typically show lower outcomes in natural sciences and lower participation in extracurricular activities compared to urban students. This disparity is linked to the lower rates of higher education attainment among rural students.

In conclusion, while the exploration of the pandemic's consequences on education has begun, there remains a dearth of comparative studies across different regions and between urban and rural areas in Russia.

METHODOLOGY

This study utilized a mixed methods approach, combining statistical analysis of test score data with survey methods to gather perceptual information from students and teachers. By integrating quantitative data with qualitative perspectives, this methodology aimed to provide a comprehensive evaluation of the impacts of the COVID-19 pandemic and policy changes on USE mathematics outcomes.

The quantitative component involved descriptive and inferential statistical analyses of USE mathematics scores over a four-year period (2018-2021) using specialized software. Descriptive statistics enable summarization of trends, while statistical tests examine the significance of observed differences (Zlokovich et al., 2023). Specifically, variations in year-to-year test score

distributions were quantified through percentages of scores within defined ranges. Tests like gamma, Kendall's Tau-B, and Chi-square were then employed to evaluate the statistical significance of distribution discrepancies, as appropriate for ordinal data (Kim, 2017).

Additionally, passing rates were stratified by school type to discern potential patterns, with Chi-square and contingency coefficients used to detect distribution variations across groups. As noted by McHugh (2013), such inferential statistics are vital for making data-driven comparisons. Throughout the analysis, differences with $p<0.05$ were considered statistically significant.

The qualitative aspect entailed surveys of students and teachers to gather perceptions of USE mathematics exam and the pandemic's impacts. Surveys provide valuable subjective insights to supplement quantitative findings. Convenient sampling was utilized, with voluntary online participation. Survey data facilitated graphical representation of perspective variations across educational institutions (Fowler Jr, 2014; Groves et al., 2009).

By consolidating mathematical analysis of achievement data with attitudinal survey findings, this mixed methodology enabled a nuanced investigation from both objective and subjective vantage points. As Poncheri et al. (2008) discuss, such complementary approaches strengthen the validity and comprehensiveness of research outcomes.

Sample

There are two sample group in the study. The student sample is 161 and teacher sample is 184. The student participants were recent school graduates from various Russian regions, all of whom had enrolled at the peripheral university, VyatSU. Student selection for the survey was randomized, with mandatory classification based on whether they attended an urban or rural school and whether they passed USE in mathematics.

To facilitate a more nuanced analysis of USE outcomes, a cluster-based strategy was adopted. This approach involved grouping educational organizations into clusters with shared characteristics such as the type of institution, urban or rural location, and student population. Notably, this clustering process at the Center for Assessing the Quality of Education in the region-43 was initiated in 2020, marking a first in the region and warranting particular attention.

The student sample distribution reflected 32.0% from rural schools and 68.0% from urban schools, aligning with the national urban-rural student ratio in Russia. Participants included secondary school graduates from 2014-2019 (pre-pandemic), accounting for 43.4% of the sample, 5.0% from the 2020 cohort, and 51.6% from 2021 (post-pandemic). Regarding mathematics examination results, 51.6% of the students had taken the advanced mathematics exam, 34.2% the standard exam, and 12.4% had not taken the exam due to its cancellation.

Teacher participants were selected using quota sampling from five Russian regions, ensuring representation from each of the five educational clusters. These clusters included small rural schools with fewer than 100 students, larger rural schools with more than 100 students, typical urban schools, urban schools with specialized subject tracks, and elite institutions such as lyceums and gymnasiums. Among the mathematics teachers, 49.0% were from rural schools, and 51.0% from urban schools, with specific distributions of 19.0% from standard urban schools, 10.9% from specialized urban schools, and 17.4% from lyceums and gymnasiums.

The survey aimed to gather perceptions regarding the nature of USE and evaluate the impact of the 2020 and 2021 pandemic restrictions on USE outcomes by comparing different school clusters. Representation from each cluster was, as follows: 5.0% and 15.8% for students and teachers from small rural schools, 28.0% and 33.2% from larger rural schools, 31.1% and 19.0% from regular urban schools, 21.7% and 10.9% from specialized urban schools, and 13.0% and 17.4% from lyceums and gymnasiums, respectively.

Data Collection Tools

The study contains three sources of data. The first data source is the statistical data of student scores for USE Mathematics exam 2018-2021. The second source of data is the survey administered to students. The survey consists of two parts. In the first part, information was obtained from which type of school they graduated in which year they graduated, and whether they took USE mathematics exam and whether they passed the exam. In the second part, two questions were asked to determine perception. The first question is "for me personally, USE in mathematics looks like:" The second question is "in your opinion, what impact–negative or positive–did restrictive measures during the pandemic (2020-2021) and the abolition of the requirement to pass USE in mathematics for all graduates have?" Survey data was collected via online Google Form. The third data source is the survey applied to teachers. The survey questions were "what type of school are you studying at?", "for me personally, USE in mathematics looks like:" and "in your opinion, what impact–negative or positive –did restrictive measures during the pandemic (2020-2021)" and "The abolition of the requirement to pass USE in mathematics for all graduates have?" Teacher surveys were also collected via Google Form.

Data Analyses

In the study, we quantified the year-over-year variations in score distributions by calculating the percentages of scores within predefined ranges. To

Table 1. Percentage distribution of student grades by range over four years

Years/grade range	0-20	21-40	41-60	61-80	81-100
2018	4.6	25.8	35.3	32.1	2.1
2019	2.3	17.6	26.6	45.7	7.8
2020	5.2	18.3	26.7	43.9	6.0
2021	3.8	17.0	23.9	44.8	10.5

Note. χ^2= 528; df=12; p< .001; Gamma=0.168; Standard error=0.00999 (0.148-0.188); Kendall's Tau-B=0.122; t=16.6; & p<.001

investigate potential discrepancies in these percentage distributions, we employed statistical tests such as gamma and Kendall's Tau-B. These tests, typically used in conjunction with Chi-square tests for ordinal data, helped us assess if the observed differences in score distributions were statistically significant. Additionally, we scrutinized the success rates of students passing the examination, stratifying the data by school types to discern any patterns or disparities. To further explore how the perceptions of mathematics exams varied among students and teachers from different educational institutions, we graphically represented these percentage distributions. This visual analysis aimed to elucidate the nuances in attitudes and outcomes associated with the mathematics exam. To ensure a robust examination of the data, Chi-square tests and the contingency coefficient were calculated for nominal distributions, aiming to detect any distinct variations across the datasets. For the purpose of data visualization and to facilitate an intuitive understanding of these distributions and patterns, we utilized Tableau software, version 2023. This choice was motivated by Tableau's advanced graphical capabilities, which enable the creation of clear and informative visual representations of complex data sets. For the statistical analysis, Jamovi software version 2.4 was employed. Jamovi is known for its user-friendly interface and powerful statistical tools, which are essential for conducting reliable and precise statistical operations. The use of Jamovi underpinned our analytical processes, allowing us to conduct the necessary tests to draw informed conclusions from our data (The Jamovi Project, 2023).

FINDINGS

Descriptive Statistics Unified State Exam in Mathematics Between 2018-2021

Table 1 presents the percentages of students who received various grade ranges in USE over the span of four years, from 2018 to 2021. In 2018, the majority of students (35.3%) scored in the 41-60 range. The next highest group (32.1%) scored in the 61-80 range. A significant portion (25.8%) scored in the 21-40 range. Only a small percentage scored at the extremes: 4.6% in the zero-20 range and 2.1% in the 81-100 range. In 2019, there was a notable increase in the percentage of students scoring in the 61-80 range (45.7%), indicating improved performance. The percentage of students scoring in the 81-100 range also increased substantially to 7.8%. There was a decrease in the percentage of students scoring in the zero-20 and 21-40 ranges, to 2.3% and 17.6%, respectively. In 2020, the trend of a high percentage of students scoring in the 61-80 range continued, though slightly lower than 2019, at 43.9%. The percentages in the zero-20 range increased to 5.2%, which is the highest among the four years. The 81-100 range saw a decrease to 6.0%, indicating fewer top scorers compared to 2019. In 2021, The percentage of students scoring in the highest range (81-100) increased significantly to 10.5%, the highest of all four years. The 61-80 range remained the most common score range with 44.8%. The zero-20 range decreased again to 3.8%, and the 21-40 and 41-60 ranges also saw decreases to 17.0% and 23.9%, respectively.

The data shows a positive trend in higher scoring ranges over the years, particularly in the 61-80 and 81-100 ranges. There was a marked improvement in top-tier scores (81-100) in 2021, which more than doubled from 2018. The proportion of students in the lowest scoring range (zero-20) fluctuated but did not show a consistent trend. The mid-range scores (21-60) generally decreased, suggesting that fewer students are scoring in the middle ranges over time. The data suggests that over these four years, the performance of students in the national math exam has improved, with more students moving into higher score ranges.

Chi-square and likelihood ratio tests have p-values of less than .001, which is highly significant statistically. This suggests that there is a statistically significant difference in the distribution of exam scores across the four years. The χ^2 value of 528 with 12 degrees of freedom support the conclusion that the observed distribution of scores is unlikely due to chance. The gamma value of 0.168, with a standard error of 0.00999 and a 95% confidence interval ranging from 0.148 to 0.188, indicates a weak positive correlation. This suggests there is a slight tendency for students' scores to improve over time, but this trend is not strong. The Kendall's Tau-B value of 0.122 with a t-value of 16.6 and a p-value of less than .001 also indicates a weak positive association between the years and the exam scores. The positive value suggests a trend of improvement in grades over time, although the strength of this relationship is relatively weak.

Combining the data from the contingency table with the results from the statistical tests, it seems there is a trend of changing distributions in the math exam scores over the years, with some improvements in the higher

Table 2. Distribution percentage of student passed exam by range over four years based on school type

School type/years	2018	2019	2020	2021
Rural secondary schools with less than 100 students	93.88	100	94.40	94.80
Rural secondary schools with 100 or more students			92.80	96.40
Urban secondary schools	96.65	99.89	92.90	93.70
Secondary schools with secondary educational qualifications	95.96	99.89	94.10	96.70
Lyceums & gymnasiums	98.99	99.78	98.10	98.40

score ranges as time progresses. The decrease in total number of students taking the exam each year could be due to various factors, which are not explained by the data provided. The statistical tests suggest that these changes are significant and not due to random variation. However, the associations indicated by gamma and Kendall's Tau-B, while statistically significant, are weak, indicating that while there is a positive trend, it is not strongly pronounced.

Passing Exam

Table 2 shows the proportion of participants from different clusters of schools who passed USE in mathematics across four academic years. For rural secondary schools, regardless of size, the combined pass rate for the years 2018 and 2019 is very high, suggesting a strong performance in those years. For schools with less than 100 students, the rate slightly declined from a perfect score in 2019 to 94.4% in 2020, and then slightly increased to 94.8% in 2021. For rural schools with 100 or more students, the data starts from 2020, showing an improvement from 92.8% in 2020 to 96.4% in 2021, indicating a positive upward trend in performance. Urban secondary schools show a decrease after an almost perfect pass rate in 2019, dropping to 92.9% in 2020 and then slightly increasing to 93.7% in 2021. This suggests a resilience in bouncing back from whatever challenges may have caused the dip in 2020. Secondary schools with secondary educational qualifications also show a similar pattern to urban schools, with an exceptional pass rate in 2019, a dip in 2020, followed by a recovery in 2021, ending with a pass rate of 96.7%. Lyceums and gymnasiums maintain consistently high pass rates across all four years, with a slight decrease from 2019's peak of 99.78% to 98.1% in 2020, and a marginal improvement to 98.4% in 2021.

Overall, data suggests that 2019 was an outstanding year for mathematics exam pass rates across most school types, with a common decline in 2020, possibly due to external disruptions. By 2021, there seems to be an overall trend of recovery, with pass rates approaching or surpassing those of 2018. The consistent high performance of lyceums and gymnasiums suggests that these institutions have strong mathematics programs.

Perception on USE in Mathematic

The responses from students across various school types regarding USE in mathematics reveal a spectrum of attitudes towards its function and impact. For students in small rural schools, USE is predominantly seen as a measure of mathematical literacy, with over a quarter considering it an objective assessment. This group also appreciates USE as a necessary step towards higher education, yet there's a palpable sense of the examination's psychological toll. **Figure 1** shows distribution percentage of students' perception on mathematics in USE.

In rural schools, there's a slightly stronger emphasis on USE as an evaluative tool for mathematical skills, but here too, the stress associated with the exam is evident. The perspective that USE reflects the quality of a tutor's work receives minimal endorsement, suggesting a possible undervaluation of personalized tutoring in these regions.

Urban school students distribute their views more evenly across the categories, with no single perception overwhelmingly dominant. They equally recognize USE as a benchmark for personal academic readiness and as a stressor, suggesting a balanced acknowledgment of the exam's challenges and its role in educational progression.

Students from secondary schools with IMEP exhibit the highest levels of perceived stress associated with USE, indicating a significant pressure felt in these educational settings. They also attribute a fair amount of significance to the exam as a monitor of school activities, perhaps reflecting a critical view of institutional accountability.

Lyceums and gymnasiums' students report the highest rates of USE as a stressful event, overshadowing its role as an academic assessment. However, they also place substantial value on the exam as a marker of independent work and self-education, indicating a strong belief in self-reliance and personal effort.

Across the board, while the grand total reflects a common view of USE as a tool for assessing mathematical literacy, the prominence of stress and emotional strain points to a widespread recognition of the examination's psychological demands. The variability in perceptions also hints at underlying differences in educational experiences, expectations, and the support structures available to students in different school settings.

Chi-square test value is 17.0 with 24 degrees of freedom and a p-value of 0.849. Since the p-value is greater than the conventional alpha level of 0.05, there is

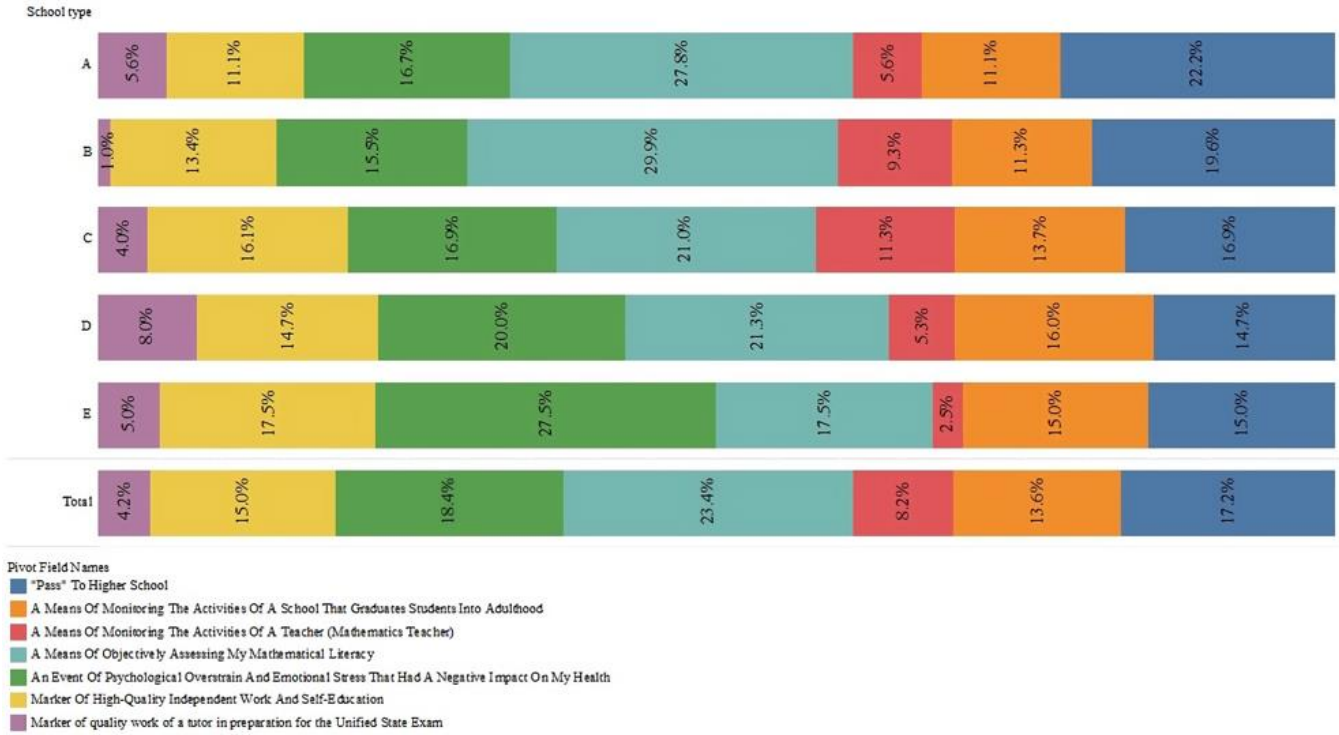

Figure 1. Distribution percentage of students' perception on mathematics in USE (χ^2=17; df=24; p=0.849; & Contingency coefficient=0.214) (Source: Authors' own elaboration based on research data)

not enough evidence to reject the null hypothesis. This suggests that there is no statistically significant association between school type and the perceptions of USE in mathematics.

The contingency coefficient is a measure of association for nominal variables and its value here is 0.214. This indicates a weak association between the different school types and the various perceptions of USE. A value closer to zero indicates no association, and values closer to one indicate a strong association. Thus, the perceptions of students regarding USE are relatively similar across the different school types.

Figure 2 reflects teachers' opinions on USE in mathematics across various educational settings, revealing a nuanced view of the exam's purpose and repercussions.

Teachers at small rural schools regard USE primarily as a means to objectively assess mathematical literacy, with a significant number also acknowledging its role as a gateway to higher education. However, they are less likely to consider USE as a reflection of a tutor's contribution to a student's preparation.

In rural schools, while there's a similar emphasis on USE as a pathway to higher education and an objective assessment tool, teachers place greater importance on its role as a marker of high-quality independent work and self-education. There's also a recognition of USE as a tool for monitoring school activities, indicating an awareness of its broader institutional implications.

Urban schoolteachers perceive USE differently, with a stronger focus on monitoring the school's and teachers' performance. Interestingly, the impact on students' health due to stress is acknowledged to the same extent as in rural schools, but urban teachers appear to assign less value to USE as an objective measure of mathematical literacy.

Teachers from secondary schools with IMEP highlight USE's function in facilitating access to higher education more than those in other school types. They also regard the examination as a significant indicator of the school's performance, but like their peers, they less frequently mention the influence of tutors.

Lyceums and gymnasiums stand out with their strong emphasis on USE as a steppingstone for students' higher educational aspirations. Yet, these institutions also report the highest perception of the examination as a stressor, raising concerns about the psychological burden on students. The view of USE as an objective assessment of mathematical skills is notably less prevalent here compared to other school types.

Overall, the collective data suggest that while teachers generally see USE as a critical facilitator for higher education and an assessment tool, there are notable differences in how they perceive its role in evaluating educational entities and its psychological impact on students. The minimal emphasis on the role of tutors across the board could imply a lesser acknowledgment of personalized coaching in the preparation for USE.

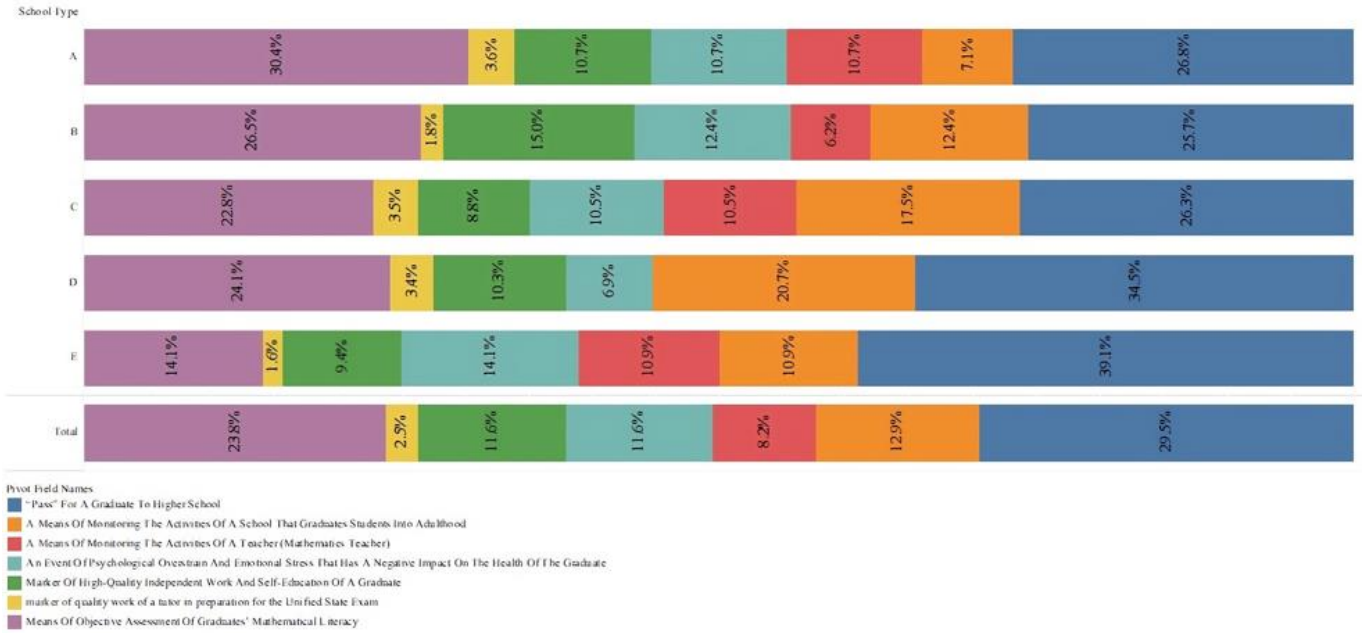

Figure 2. Distribution percentage of teachers' perception on mathematics in USE (χ^2=19.4; df=24; p=0.730; & Contingency coefficient=0.239) (Source: Authors' own elaboration based on research data)

Chi-square test value is 19.4 with 24 degrees of freedom and a p-value of 0.730. Given that the p-value is greater than the conventional alpha level of 0.05, we can conclude that there is no statistically significant difference in the distribution of perceptions across different school types. In other words, teachers' perceptions of USE do not significantly vary based on the type of school. The Contingency Coefficient is 0.239, which suggests a weak association between school type and teachers' perceptions of USE. The value is closer to zero than to one, indicating that the relationship is not strong and that perceptions are relatively consistent across school types.

Comparing the views of teachers and students on the second question concerning USE in mathematics reveals a divergence in perceptions based on their roles in the educational process.

Students tend to view USE in a more personal and immediate context. They see it as an objective assessment of their mathematical literacy, a pass to higher education, and significantly, as a source of stress and emotional strain. The student perspective is intrinsically linked to their individual experiences, with the examination often viewed through the lens of personal achievement and its direct impact on their future opportunities and well-being.

Teachers, on the other hand, while also recognizing the exam's role in facilitating higher education and assessing mathematical literacy, tend to focus more on USE's broader implications. They consider the exam as a means of monitoring the activities of both the school and the teaching staff, reflecting a professional concern for accountability and educational standards. Teachers are also attentive to the examination's role as a marker of high-quality independent work and self-education, indicating a recognition of the student's effort outside of classroom instruction.

While both teachers and students acknowledge the stressful nature of USE, teachers appear to have a more nuanced appreciation of the examination's multifaceted impact. They are more likely to consider the examination's role in evaluating the educational system, whereas students focus on the immediate effects of the examination on their own lives and futures. This difference highlights the contrast between the lived experience of students who are directly subjected to the pressures of the exam and the teachers who view the exam as one element in a larger educational ecosystem.

Students View Restrictive Measures During the Pandemic (2020-2021)

Figure 3 reflects diverse opinions among graduates from various types of schools regarding the impact of the pandemic's restrictive measures and the elimination of the mandatory USE in mathematics. Graduates from small rural schools reported the most positive impact, with half of the respondents viewing the changes favorably, although a significant minority still perceived it negatively. In contrast, rural schools and urban schools showed a more uncertain stance, with the majority finding it difficult to rate the impact and only about one-fifth acknowledging a positive effect. Interestingly, specialized secondary schools with IMEP and more academically focused institutions like lyceums and gymnasiums demonstrated a relatively optimistic outlook, with 40.0% considering the impact positive. Across the board, there seems to be a considerable amount of uncertainty, as indicated by the high

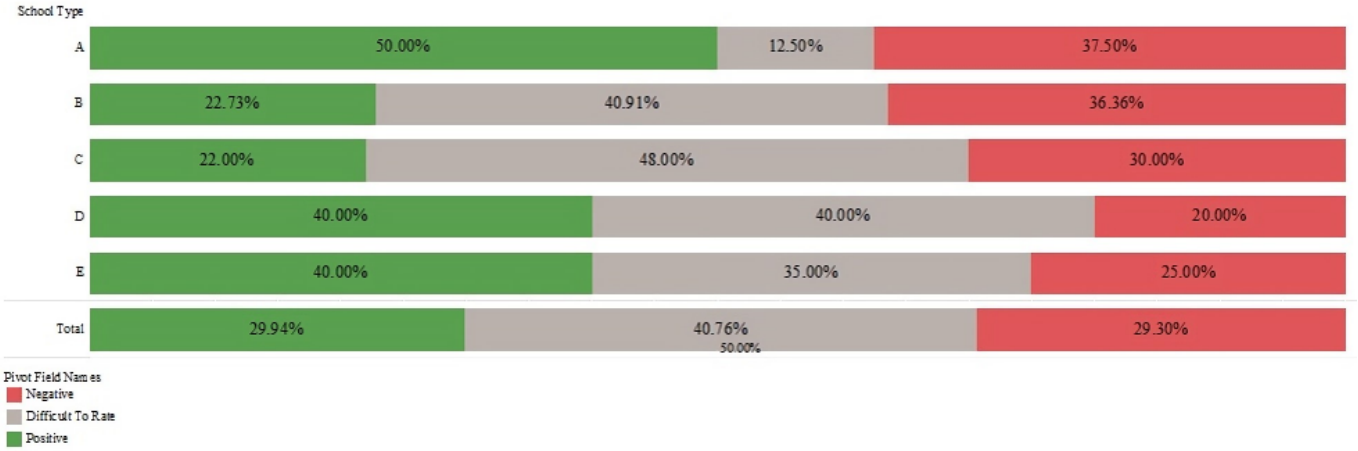

Figure 3. Distribution percentage of students' perception on restrictive measures (χ^2=9.23; df=8; p=0.323; & Contingency coefficient=0.236) (Source: Authors' own elaboration based on research data)

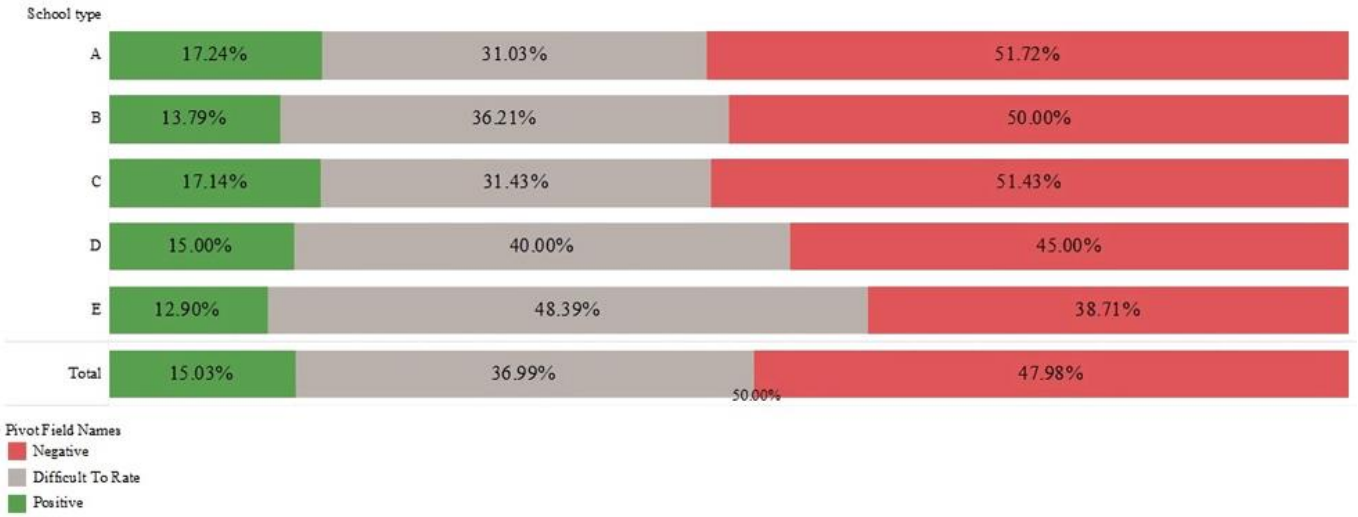

Figure 4. Distribution percentage of teachers' perception on restrictive measures (χ^2=3.16; df=8; p=0.924; & Contingency coefficient=0.134) (Source: Authors' own elaboration based on research data)

percentage of graduates finding it difficult to rate the impact. Overall, while there's a clear divide in perceptions based on school types, a shared sense of ambiguity regarding the long-term implications of these educational changes is evident.

Chi-square test has a value of 9.23 with eight degrees of freedom and a p-value of 0.323. The p-value is greater than 0.05, which indicates that there is no statistically significant difference in the distribution of views across different school types. This means that students' views are not strongly associated with the type of school they attend. The contingency coefficient is 0.236, suggesting a weak association between school types and student views. This coefficient ranges from zero (no association) to one (perfect association), so a value of 0.236 indicates that there is only a slight relationship between variables.

The data presented in **Figure 4** offers insight into teachers' perspectives on the effects of the pandemic's restrictive measures and the abolishment of the mandatory USE in mathematics, across various school types. A negative sentiment predominates among teachers from small rural schools, where over half view the impact unfavorably. This sentiment is echoed in rural and urban schools, where approximately half of the teachers also report a negative impact. Despite the less optimistic view, a small percentage of teachers from these schools still recognize positive outcomes. Secondary schools with IMEP and lyceums and gymnasiums show a slightly different pattern, with fewer teachers perceiving a negative impact, although still the most common response. Notably, at lyceums and gymnasiums, nearly half of the teachers find it difficult to assess the impact, indicating a significant level of uncertainty. The overall totals consolidate these findings, with a considerable majority of teachers (nearly 48.0%) viewing the impact as negative, only about 15.0% seeing a positive side, and a substantial proportion remaining uncertain. This paints a picture of a teaching community that is largely skeptical about pandemic's educational measures, with a pervasive sense of ambivalence regarding their long-term implications.

Chi-square test results in a value of 3.16 with eight degrees of freedom and a p-value of 0.924. Since the p-value is greater than 0.05, it indicates that there is no statistically significant difference in the distribution of teachers' perceptions across different school types. This means that the type of school a teacher is associated with does not significantly influence their perception in the context of this study. The contingency coefficient is 0.134, suggesting a very weak association between school types and teachers' perceptions. This coefficient indicates the strength of association between two nominal variables, and a value closer to 0 suggests a weaker association.

When comparing the responses from teachers and students regarding the impact of the pandemic's restrictive measures and the cancellation of the mandatory USE in mathematics, notable differences emerge. Students from small rural schools appeared more optimistic, with a higher percentage reporting a positive impact compared to their teachers. This contrasts sharply with the teachers' perspectives, where a majority viewed the impact negatively across all school types. Rural and urban schools show a similar disparity, with students being slightly more positive than teachers, but still, a significant number of students found it difficult to rate the impact. Teachers in these schools predominantly perceived the impact as negative. Secondary schools with IMEP and lyceums, gymnasiums, have a lower negative perception among teachers compared to students, but again, a high percentage of teachers found it difficult to rate the impact. Overall, while both students and teachers show a trend towards viewing the impact negatively, students from small rural schools stand out with a more positive outlook than their teachers, who express greater negativity and uncertainty.

DISCUSSION

The findings from this mixed methods study underscore nuances in how USE in mathematics, considered a high-stakes assessment, has transformed through COVID-19 disruption. Quantitative examination of USE score distributions from 2018-2021 revealed statistically significant differences, indicating progressive increases in student success particularly in higher performance tiers. However, strength of association tests clarified that while a positive trend is evident, it remains marginally moderate over time. Stratified analyses elucidated between-group variances, with specialized schools sustaining exceptional pass rates despite an initial pandemic-related decline observed across all clusters in 2020 (**Table 2**). These mathematically proficient cohorts likely accessed greater support structures to adapt more fluidly during the emergency transition.

Such assumptions gained further credence in light of intriguing perceptual differences between student groups. Among graduates, optimism regarding policy changes was pronounced within small rural schools, contrasted by skepticism from larger, better-resourced institutions, where expectations and pressures could be higher (**Figure 3**). Rural schools often cultivate resilience by leveraging communal resources and environments conducive for creativity (Li & Yeung, 2019; Rural School Education and Educational Outcomes, 2020), perhaps engendering resilience. Yet, skepticism was rife within the teaching community, potentially reflecting concerns around compromised quality, equitable standards and diminished monitoring of institutional performance (Gumerova et al., 2023; Maphalala et al., 2023).

Notably, while almost half of urban schoolteachers cited USE's accountability role, they simultaneously acknowledged associated stress–an aspect rated significantly lower by students (**Figure 1** & **Figure 2**). Specialized schools presented an anomaly in this respect–high stress perceptions aligned between both groups. This signals issues that warrant addressing through appropriate mechanisms to ensure student wellbeing. Research stresses an urgent need for student counseling and rapid development of educators' professional skills to mitigate pandemic-related losses (Cusi et al., 2023; Saadati et al., 2021). Our study reinforces these imperatives, while adding nuances regarding school-types that shape attitudes.

Overall, discernible trends in USE mathematics outcomes and attitudinal variations based on school clusters underscore that standardized assessments serve sociocultural purposes, over and beyond gauging competencies (Radina & Balakina, 2021). However, sustained positive shifts will likely require concerted efforts to elevate mathematical literacy holistically across diverse educational settings, supported by strategic state policies (Nurieva & Kiselev, 2018). Utilizing evidence-based, context-appropriate strategies will be key, necessitating deeper investigation of less-understood challenges permeating marginalized areas. As Zelenina and Krutikina (2019) emphasized, transparent dissemination of granular data can guide localized pedagogic calibrations. Hence, rather than national comparisons, it would be prudent for regional authorities to interpret USE analytics meaningfully for strengthening area-specific mathematics education.

Our exploratory examination revealed nuances between student achievement markers and perceptions among key stakeholders within remote regions and elite urban clusters. Significant questions remain unaddressed that future studies across diverse geographic samples could valuably illuminate. Examples include exploring variations among disadvantaged socioeconomic groups hidden within broad categories and how mathematics anxiety in students potentially associates with technology barriers

or reduced interactivity (DeCoito & Estaiteyeh, 2022). Such insights would further knowledge regarding optimal crisis management and continuity policies for radically transformed future education ecosystems.

CONCLUSIONS

This mixed methods study investigating pandemic-era impacts on the high-stakes USE for mathematics consolidates objective score data and attitudinal insights from students and teachers across Russia's complex educational terrain. Statistically, while an overall upward achievement trend was observable, differences between student cohorts imply variances in access to necessary support mechanisms during the crisis transition. Specialized schools and clusters, where pass rates strongly rebounded after initial dips had likely leveraged their advantages.

However, perceptions reveal a more nuanced tapestry, with positivity permeating unexpected pockets like small rural schools despite resource constraints. Meanwhile, urban institutions and elite establishments reported unanticipated uncertainties around long-term consequences. The study therefore highlights the need for granular, context-sensitive analysis when interpreting the usefulness of standardized assessments for equitability goals.

Moreover, notable dissonances in stress perceptions between stakeholder groups signal issues requiring urgent redressal to promote wellbeing. Specifically, targeted mitigation measures for student anxiety and rapid skill development for educators emerge as top priorities from this investigation. Regional disparities in technological readiness also warrant attention, especially concerning populations at higher disadvantage.

By uncovering divergent experiential realities, the study thus expands comprehension of the pandemic's enduring influences on mathematics education. It signals potential pathways via differentiated policy and practice for system-wide resilience. In encapsulating a spectrum spanning remote villages to metropolitan hub schools, the research maps variability in crisis coping capacities across constituency typologies. Findings can thereby inform structured, context-specific plannings with inbuilt buffers that communities nation-wide could utilize during future disruptions. Nevertheless, several critical questions percolated through the analyses that future explorations should illuminate. How mathematical proficiency interplays with technology barriers, student interactions and other intangible factors could be investigated for consolidating a robust knowledge base to guide equity-centered mathematics education through coming uncertainties.

One limitation of the study is the use of convenience sampling for the survey data, which may introduce sampling bias and limit generalizability. The voluntary nature means that the survey respondents may not represent the overall student and teacher populations. Additionally, while the student sample size was reasonably large at 161, the teacher sample size of 184 may be underpowered for more complex statistical analyses and inferences. Stratifying findings based on the five school types also results in relatively small sample sizes within each category. A larger, randomized sample would yield more robust, generalizable outcomes. Furthermore, the study employed a cross-sectional survey design for attitudinal data, only providing a snapshot versus longitudinal tracking of evolving perspectives through the pandemic's phases. The study also focused exclusively on mathematical assessments, without evaluating knock-on impacts across wider academic performance. Finally, lack of detailed demographic profiling within groups weakens the analyses, as disparities along dimensions like gender, socioeconomic status and ethnicity remain unmapped. Addressing these study limitations through expanded methodologies and analytics would enrich the resultant findings and interpretations.

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Ethical statement: The authors stated that the study was approved by the institutional ethics committee of Vyatka State University on 26 November 2022 (Approval code: VS2226017). Prior to completing the Online Survey, participants were provided with an explanatory document detailing the purpose of the research and information regarding data security. Participants were requested to voluntarily consent to their participation in the study by endorsing an online consent form. It was explicitly stated that they had the option to withdraw from the study at any stage they desired.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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