

EXPLORING CONTRIBUTING FACTORS TO PISA 2022 MATHEMATICS ACHIEVEMENT: INSIGHTS FROM INDONESIAN TEACHERS

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ABSTRACT

As an international benchmark, the Programme for International Student Assessment (PISA) 2022 evaluates the educational performance of 15-year-old students across various countries. It has been observed that the average mathematics score globally declined in 2022. Understanding the responses of mathematics teachers, as practitioners, to the PISA 2022 results is crucial for evaluating the reasons behind this decline in mathematics scores. This research aims to explore and understand the perspectives of Indonesian mathematics teachers on the factors contributing to the low PISA 2022 mathematics scores. This study employs a qualitative approach, with participants being randomly selected and includes interviews with 36 mathematics teachers in Indonesia. According to the statements provided by teachers, the decline in mathematics scores in the 2022 PISA, relative to the years 2018 and 2015, can be attributed to six primary factors: pandemic-related issues, curriculum, individual factors, resource limitations, student factors, and parental involvement. Subsequently, mathematics teachers provided several recommendations for the government, schools, and parents that might enhance student mathematics achievement. These recommendations include conducting more training, improving ICT facilities in schools, and strengthening parental knowledge about the importance of parental support. The findings of this study offer various recommendations that could be implemented by the government, schools, and mathematics teachers to improve student mathematical achievement and potentially increase PISA scores in 2025.

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1. INTRODUCTION

The Programme for International Student Assessment (PISA), coordinated by the Organization for Economic Co-operation and Development (OECD), serves as a crucial tool in the global evaluation of educational systems (OECD, 2019). Conducted triennially by the OECD, PISA evaluates the proficiency of 15-year-old students from participating countries in key areas: reading, mathematics, and science (Foster & Schleicher, 2022). The triennial assessments of PISA provide invaluable insights into the efficacy of educational policies and practices. These assessments facilitate a comprehensive understanding of the strengths and weaknesses of educational systems globally, offering a lens through which the impact of different educational strategies can be evaluated and understood.

Indonesia's engagement in the Programme for International Student Assessment (PISA) has been instrumental in elucidating the nation's educational contours, particularly in the realm of mathematics (Lestari et al., 2020). Historically, Indonesian students have encountered difficulties in securing high scores in the PISA mathematics assessments (Afgani & Paradesa, 2021; Kartianom & Ndayizeye, 2017; Sistyawati et al., 2023). Notably, the PISA 2022 results indicated a significant decline in mathematics proficiency when compared to the 2018 and 2015 assessments (Foster & Schleicher, 2022). Specifically, the decline in mathematical literacy scores in the 2022 PISA was 13 points relative to 2018 and showed a decrease of 20 points from 2015. This downward trajectory in performance is a source of concern and underscores the urgency for comprehensive analysis. Such an analysis is imperative to discern the underlying factors contributing to these outcomes and to devise potential strategies for educational enhancement.

Consequently, this study aims to delve into the perspectives of Indonesian mathematics teachers regarding the PISA 2022 results. Teachers, as the frontline facilitators of learning, hold invaluable insights into the educational processes and challenges faced by students. Their viewpoints and recommendations are crucial in understanding the complexities behind the declining scores and in formulating effective strategies to enhance mathematics literacy (Attard & Busuttill, 2020; Dewantara et al., 2023; Ekawati et al., 2020; Harisman et al., 2023; Hidayat & Husnussalam, 2019; Kaur et al., 2019; Supianti et al., 2022; Umbara et al., 2023).

Moreover, this research seeks to bridge a gap in the existing literature by focusing specifically on teacher responses and insights, which are often underrepresented in academic discourse surrounding PISA results. By highlighting the voices of those directly involved in the educational process, this study may contribute to a more nuanced and comprehensive understanding of the factors influencing Indonesia's mathematics performance in PISA 2022.

This study is anchored in two primary objectives. Firstly, it aims to analyze the decline in mathematics scores in the 2022 PISA from a teachers' perspective. This analysis seeks to offer insights into the factors contributing to this downturn as perceived by educators. Secondly, the study endeavors to ascertain recommendations from teachers directed towards the government, schools, and mathematics educators. These recommendations are intended to facilitate the improvement of students' mathematics performances. Notably, this research represents the inaugural effort to examine the decline in mathematics scores in the 2022 PISA through the lens of teachers' perspectives.

1.1. The Significance of PISA Scores

The first significant application of PISA scores is in informing educational policy (Crato, 2021). These scores provide a data-driven basis for governments and educational authorities to evaluate and reform their educational strategies (Kaur et al., 2019). For

instance, if PISA results indicate a particular weakness in a subject area, this can trigger targeted policy responses, such as curriculum adjustments or teacher training programs (Crato, 2021; Sjøberg & Jenkins, 2022). This policy-oriented approach ensures that reforms are not based on conjecture but on concrete performance indicators.

PISA scores also play a pivotal role in identifying disparities in education. By highlighting differences in achievement based on socio-economic status, ethnicity, or gender, these assessments provide a clear picture of inequality within education systems (Ma et al., 2021; Wang et al., 2023). This information is crucial for developing targeted interventions aimed at reducing gaps and promoting equity in education. For instance, lower performance in certain demographics could lead to more focused resource allocation or specialized educational programs to uplift these groups (Al-Tameemi et al., 2023).

The impact of PISA extends into classrooms, influencing teaching methodologies and curriculum design (Hopfenbeck et al., 2018; Sjøberg & Jenkins, 2022). PISA's emphasis on real-world application of knowledge encourages educators to incorporate more practical, skills-based learning into their teaching (Navarro-Martinez & Peña-Acuña, 2022). This shift not only aligns education with real-world requirements but also ensures that students are better prepared for the challenges of the modern world. The data from PISA can guide teachers in modifying their approach to more effectively impart both knowledge and essential skills (Meroni et al., 2015; OECD, 2019).

Moreover, PISA fosters a global perspective in education. By assessing students from diverse cultures and countries, it underscores the importance of preparing students for a globalized society (Navarro-Martinez & Peña-Acuña, 2022; Wang et al., 2023). This global outlook encourages educators to integrate international content and perspectives into their teaching, thus preparing students not just for local or national challenges but for global ones as well (OECD, 2019).

The triennial nature of PISA allows for the tracking of educational trends over time (OECD, 2019). This long-term perspective is invaluable for assessing the impact of educational policies and changes. Trends and patterns observed over successive PISA assessments provide insights into the evolving nature of education systems and the long-term effectiveness of reforms and interventions.

Finally, PISA data is a catalyst for academic research and community engagement. Researchers utilize this rich dataset to delve into various educational issues, contributing to a deeper understanding of the factors influencing educational outcomes (Khine et al., 2023). At the same time, the public availability of PISA results can engage communities, prompting parents and local groups to participate more actively in educational discussions and initiatives (Lewis, 2017).

In summary, the analysis of PISA scores is a multifaceted tool with profound implications for education globally. From shaping policy and curriculum to fostering equity and global awareness, these scores provide a comprehensive overview of educational success and challenges. They serve as a guide for continuous improvement, ensuring that educational systems evolve to meet the needs of a changing world.

1.2. Indonesia Performance in mathematics achievement in PISA

Indonesia has participated in the PISA since its inaugural cycle in the year 2000. Participation in PISA has enabled Indonesia to monitor and compare the quality of its education system over time with other nations. For the 2022 PISA cycle, the data collection for Indonesia was conducted in May-June 2022, a period immediately following the COVID-19 pandemic. This timing is particularly significant, as it offers an opportunity to assess the impact of the pandemic on educational outcomes, especially in the domain of mathematics.

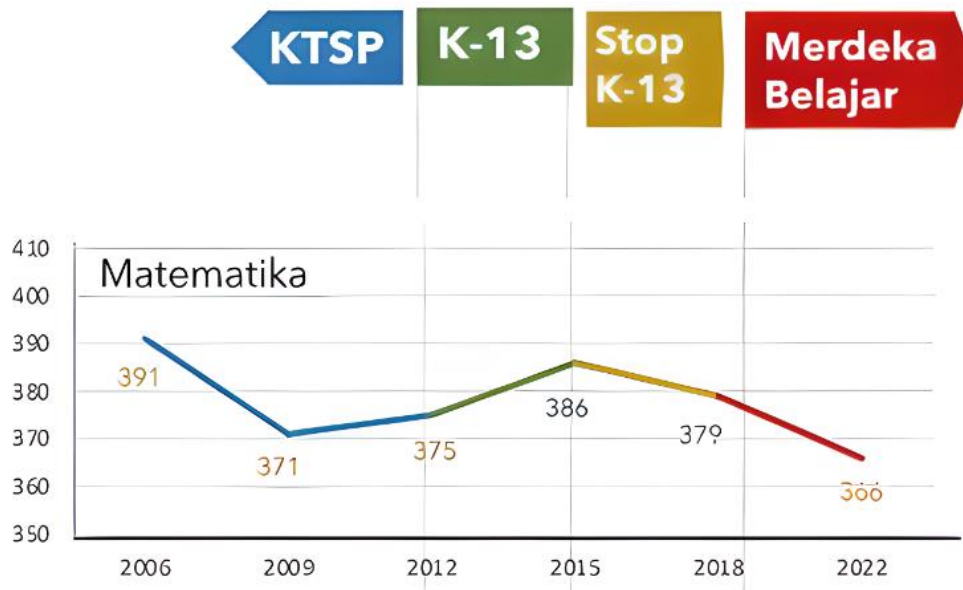


Figure 1. Detailing Indonesia's PISA mathematics scores from 2006 to 2022

Figure 1 presents a comprehensive visual representation of the trajectory of Indonesia's performance in mathematics, as evaluated by the Programme for International Student Assessment (PISA) scores, spanning from 2006 to 2022 (Kemdikbudristek, 2023). This period marks significant transitions through various educational curricula in Indonesia, beginning with the KTSP, followed by the K-13, and concluding with the current Merdeka Belajar phase. During the KTSP era, from 2006 to 2012, the PISA mathematics scores showed notable fluctuations, starting at 391, declining to 371 in 2009, and then slightly recovering to 375 by 2012. This volatility could be indicative of the adjustment periods inherent in the implementation of new curricula and shifts in educational policy. With the introduction of the K-13 curriculum in 2012, a gradual improvement in scores was observed, reaching a peak of 386 in 2015. This increase suggests a positive response to the K-13 educational reforms, which may have introduced pedagogical advancements beneficial for mathematics learning. However, the phase labeled 'Stop K-13,' spanning from 2015 to 2018, witnessed a regression in this positive trend, with scores decreasing to 379. The terminology 'Stop K-13' implies a cessation or significant alteration of the K-13 curriculum, possibly leading to a lack of consistency in teaching methodologies, which is reflected in the declining scores. The most recent phase, Merdeka Belajar, has shown a stark decline in scores to 300 by 2022, a deviation that markedly contrasts with the previous patterns.

2. METHOD

To accomplish the objectives of this study, interviews were conducted with 36 teachers from different provinces in Indonesia. These interviews were subjected to both qualitative and quantitative analyses. The qualitative analysis focused on contextual interpretation, examining the perspectives of the mathematics teachers in depth. This approach provides a comprehensive understanding of the data, thereby facilitating a more nuanced and robust analysis of the teachers' perspectives on the decline in mathematics scores in the PISA 2022. Furthermore, A frequency count was performed for each constructed subcategory to capture an overarching view of the mathematics teachers' responses. This involved quantifying how frequently each subcategory was mentioned by

the teachers. These quantitative insights were then contextualized with quotes from the interviews, which were carefully selected to elucidate each subcategory, particularly those relating to challenges in teaching and learning activities. This integrative approach of combining frequency analysis with qualitative data from the interviews allowed for a comprehensive understanding of the themes and patterns emerging from the teachers' perspectives.

2.1. Teacher Interview

We contacted the principals of schools to request permission for conducting interviews. Between December 5th and 19th, we successfully recruited 36 teachers who voluntarily participated in interviews about the PISA 2022 results. The consenting teachers were contacted to arrange online interviews, each lasting approximately 30 minutes. Initially, researchers provided an overview of the mathematics literacy results from PISA 2022. This was followed by the main questions aimed at understanding their analysis of the factors contributing to the decline in Indonesia's mathematics literacy scores in PISA 2022. Furthermore, we inquired about their recommendations and specific steps that mathematics teachers could take to enhance students' mathematical literacy skills. [Table 1](#) displays detailed participant information.

Table 1. Mathematics teacher basic information

Demographic		N	Percentage (%)
Gender	Male	7	19.44
	Female	29	80.55
Age	Below 25 years	8	22.22
	25-30 years	10	27.77
	30-40 years	7	19.44
	Above 40 years	11	30.55
Level education	Bachelor degree	31	86.11
	Master degree	5	13.88
Teaching experiences	Below 5 years	7	19.44
	5 -10 years	20	55.55
	Above 10 years	9	25.00

In this study, a total of 36 mathematics teachers participated, offering a diverse range of perspectives (see [Table 1](#)). The gender distribution was predominantly female, with 29 female teachers (80.55%) and 7 male teachers (19.44%). Age-wise, the participants were well-distributed across different brackets, ensuring a broad range of experiences: 8 were below 25 years (22.22%), 10 fell into the 25-30 years category (27.77%), 7 were between 30-40 years (19.44%), and 11 were above 40 years (30.55%). This diversity in age suggests a mix of both relatively newer and more experienced educators in terms of age. Regarding educational background, the vast majority of participants held undergraduate degrees (31 teachers or 86.11%), while a smaller segment had attained master's degrees (5 teachers or 13.88%). This indicates a strong foundational academic preparation among the participants.

In terms of teaching experience, the group was again diverse: 7 teachers had less than 5 years of experience (19.44%), 20 had between 5 to 10 years (55.55%), and 9 had more than 10 years (25.00%). This range suggests a blend of fresh perspectives and seasoned insights within the cohort.

2.2. Data Analysis

In the analysis of interview data regarding mathematics teachers' perceptions of the factors contributing to the decline in mathematics scores in PISA 2022 and their recommendations for enhancing student mathematics achievement, we employed a combination of semi-structured interviews and open coding methods. The semi-structured interviews consisted of a mix of predetermined questions and the flexibility to explore emerging topics in depth. This approach allowed us to gather detailed and context-rich information from the teachers, facilitating a comprehensive understanding of their views and experiences.

Initially, two researchers meticulously reviewed the transcriptions of these semi-structured interviews, highlighting all responses, relevant information, and ideas pertinent to achieving the objectives of this study. Subsequently, we engaged in open (data-driven) coding. In this phase, we identified and coded specific incidents evident in the teachers' statements, ensuring that the analysis was grounded in the actual data. In instances where coding results differed, the two researchers engaged in a rigorous discussion to resolve these discrepancies. This collaborative process was aimed at reaching a consensus on the inductive coding, allowing the codes, categories, and themes to emerge organically from the data. Through deliberative dialogue, the researchers examined the divergent interpretations, considering the context and nuances of each coded instance, thereby ensuring the highest level of accuracy and consistency in the coding process.

3. RESULT AND DISCUSSION

This section provides an in-depth analysis of the factors contributing to the decline in student mathematics scores compared to the years 2015 and 2018, as perceived from the perspective of mathematics teachers. Additionally, it explores the recommendations of these teachers for enhancing students' mathematical literacy. To align with the research objectives, this section is bifurcated into two distinct parts. The first part focuses on the mathematics teachers' perspectives regarding the factors that have led to the decrease in students' mathematics scores. This involves a detailed examination of various elements identified by the teachers that may have influenced student performance. The second part addresses the recommendations put forward by mathematics teachers for improving students' mathematics performance. This segment aims to articulate practical and strategic measures that educators believe could bolster students' proficiency in mathematics.

3.1. The mathematics teachers' perspective on the determinants of the observed decline in student mathematics scores in the 2022 PISA assessment

The focal point of the interview questions posed to the teachers centered on identifying the factors that contributed to the decline in the 2022 PISA mathematics scores compared to the assessments in 2018 and 2015. The aim of these interview questions was to garner the perspectives of the mathematics teachers regarding the various elements that could have led to a decrease in students' mathematical abilities as reflected in the 2022 PISA test results. To systematically present the insights gathered from these interviews, the following [Table 2](#) has been compiled. It encapsulates the responses of the teachers, thereby

highlighting the factors they perceive as instrumental in influencing the downward trend in student mathematics scores.

Table 2. Factors contributing to the decline in student mathematics scores

Factor	Number of Teacher	Sub-factor	Example of statement
Pandemic-Related Factors	31	Transition of remote learning	T1 - During the pandemic, our school experienced a complete cessation of learning for six months, followed by a year of ineffective educational engagement.
	28	Disruptions to Academic Progress	T3 - The pandemic disrupted teaching and learning activities, resulting in many students missing out on critical learning periods.
Education System Challenges	19	Frequent changes in curriculum and educational policies	T5 - Educators in Indonesia struggle to understand the constantly changing curriculum, resulting in failure to effectively implement it
			T6 - Teaching methods in the 'Merdeka Belajar' curriculum have not yet been 100% integrated
Teacher-Related Issues	19	Low Teacher qualifications	T12 - It cannot be denied that the quality of mathematics teachers is still lacking, and we need to upgrade ourselves
		Low Pedagogical Technological Knowledges	T19 - mathematics teachers have not yet been able to effectively utilize ICT-based learning
Educational Resource Limitations	27	Lack of Technological Resources	T4 - technology-based learning media in mathematics lessons are still insufficient
		Lack of Material Resources	T20 - Mathematics teaching and Learning is still traditional, using blackboards and chalk
Individual Student Factors	21	High Levels of Mathematics Anxiety	T25 - Children are not enthusiastic when attending mathematics lessons
		Negative Attitude toward mathematics	T29 - Children feel that mathematics is a subject they no longer want to explore further.
Parental Involvement	17	Lack of Parental Support	T33 - the lack of parental involvement in motivating students to learn mathematics
			T14 - parents do not understand the importance of supporting their children both academically and emotionally

Table 2 elucidates the factors identified by mathematics teachers in Indonesia as contributing to the decline in student mathematics scores in the 2022 Programme for International Student Assessment (PISA), in comparison with the 2018 and 2015 assessments. The teachers pinpointed six principal factors that they believe have significantly impacted student mathematics achievement. These factors encompass a range of issues stemming from the pandemic, systemic challenges within the education system, teacher-related issues, limitations in educational resources, individual student factors, and parental involvement.

The pandemic situation leads to reduced learning Effectiveness. The responses from 36 mathematics teachers (see **Table 2**) in the study offer a multifaceted perspective on the challenges impacting student mathematics performance in the 2022 PISA. A significant proportion of teachers, 31 (86.11%) to be precise, reported substantial difficulties associated with the transition to remote learning during the pandemic. They highlighted that a six-month suspension of conventional learning methods, followed by a year of ineffective educational engagement, severely compromised the quality of mathematics education. Furthermore, 28 teachers (77.77%) emphasized that the pandemic caused major disruptions in teaching and learning activities. This led to students missing essential periods crucial for developing a robust foundation in mathematics, resulting in noticeable gaps in their knowledge and understanding (Betthäuser et al., 2023; Kilenthong et al., 2023). These teacher statements are consistent with reports suggesting that the decline in PISA 2022 scores was due to the pandemic (Foster & Schleicher, 2022). In many countries, educational activities were either hindered or ineffective during the pandemic, which contributed to a decline in the quality of the interruption of conventional learning methods for an extended period led to a disruption in the continuity of education (Kilenthong et al., 2023; Putra et al., 2020; Wijaya et al., 2021). This disruption was not merely about the change in the medium of instruction (from in-person to online) but also pertained to the effectiveness of the educational engagement (Pandey et al., 2022). Many teachers and students found themselves unprepared for this sudden transition, lacking in resources, training, and experience in remote teaching and learning methodologies (Edumadze et al., 2023; Muhaimin et al., 2023; Pokhrel & Chhetri, 2021).

Challenges related to constant changes in the curriculum were highlighted by 19 teachers (52.77%) (see **Table 2**). These frequent shifts led to confusion and inconsistency in teaching practices, thus undermining the effective implementation of new educational strategies. The integration of the 'Merdeka Belajar' curriculum also posed difficulties, with its objectives not being fully realized in classroom practices. The teachers underscored a gap in professional development, particularly in adopting updated pedagogical strategies and effectively utilizing ICT-based learning tools. This gap was especially pronounced during the period of remote learning, emphasizing the need for better integration of technology in mathematics instruction (Aydin et al., 2017). The learning curriculum is a pivotal factor that correlates with student learning achievement. However, too frequent changes in the curriculum do not yield positive effects on student learning outcomes (Puad & Ashton, 2023). Teachers require time to understand and apply learning methods in accordance with new curricula. The implementation of the 'Merdeka Belajar' curriculum, a recent initiative in Indonesia, further illustrates these challenges. While the curriculum aims to foster a more holistic and flexible learning environment, the transition has not been seamless (Alfaruki, 2022). The gap in realizing its objectives in classroom practices can be attributed to a lack of alignment between the curriculum goals and the actual teaching and learning processes.

Moreover, the need for professional development is accentuated in the context of these curriculum changes (Aydin et al., 2017). Educators need to be equipped with the skills and knowledge to navigate these changes effectively, particularly in adopting new

pedagogical strategies and integrating technology into their teaching (Hidayat & Aripin, 2023; Hidayat et al., 2022; Hidayat et al., 2023; Kurniansyah et al., 2022; Pertiwi et al., 2021; Rohaeti et al., 2023; Tamur et al., 2023). This need became even more pronounced during the shift to remote learning, where the effective use of technology was crucial.

The statement that the learning curriculum is a pivotal factor in student learning achievement underscores the importance of stability and continuity in educational planning (Ajjawi & Boud, 2023). Rapid changes can disrupt the learning process, preventing students from building a coherent understanding of mathematical concepts. Teachers, as the primary facilitators of learning, require adequate time and resources to align their teaching practices with the evolving curriculum to ensure positive student learning outcomes. Therefore, any curriculum change should be carefully planned, with adequate support and training provided to teachers for a smooth and effective transition (Andrietti & Su, 2019).

The observation by 27 teachers 75% of the teachers about the lack of technology-based resources highlights a significant challenge in the integration of modern educational tools into mathematics education, especially in Indonesia (see Table 2). In remote and underdeveloped areas, the absence of adequate technology-based learning media is not merely a matter of resource allocation but also reflects broader systemic issues (Bustomi et al., 2021). These include limited access to digital infrastructure, a lack of trained educators in utilizing technology in teaching, and economic factors that prevent the adoption of modern educational tools. This situation results in a reliance on traditional teaching methods, which may not be as effective in fostering mathematical understanding and skills in the contemporary context.

The disparity in educational resources and teaching methods may have a significant impact on student learning outcomes, as evidenced by PISA 2022 scores. Students in areas with limited access to technology-based learning tools are likely to lag their peers in more developed regions, both nationally and internationally (Onitsuka et al., 2018). This situation underscores the need for targeted interventions to bridge the digital divide in education, focusing on professional development for teachers, infrastructure improvements, and resource allocation that prioritizes underrepresented and disadvantaged regions.

Twenty-one teachers (58.33%) observed a lack of enthusiasm among students for mathematics, attributing this to high levels of anxiety related to the subject and a general disinterest, which hampered the engagement and willingness to explore mathematical concepts (see Table 2). This observation by a notable proportion of teachers sheds light on the psychological barriers that students face in mathematics education. The high anxiety levels mentioned can be linked to a variety of factors, including societal perceptions of mathematics as inherently difficult, previous negative experiences with the subject, or teaching methods that may not align with students' learning styles (Harisman et al., 2020; Laelasari et al., 2019; Xiao & Sun, 2021).

The general disinterest in mathematics is equally problematic, as it can be a symptom of the disconnect between the way mathematics is taught and the interests or real-life experiences of students. This disinterest can significantly impact students' motivation to engage with mathematical concepts, which is essential for deep learning and understanding (Hutajulu et al., 2019; Rotgans & Schmidt, 2012).

These issues are interrelated and can create a cycle where anxiety leads to disinterest, and disinterest further exacerbates anxiety (Curtis, 2006). Breaking this cycle requires a comprehensive approach that involves rethinking the way mathematics is taught and perceived (Ying et al., 2017). This could include integrating more real-world applications of mathematics to demonstrate its relevance, employing varied instructional strategies to cater to diverse learning preferences (Limaymanta et al., 2021), and creating a supportive classroom environment that normalizes struggle and mistakes as part of the learning process.

Moreover, there's a need for professional development for teachers focusing on how to reduce mathematics anxiety and increase student engagement. Such training can equip teachers with the tools to create a positive and inclusive learning environment, fostering a more positive attitude towards mathematics (Chatterjee & Bhattacharjee, 2020; Lawson-Body et al., 2020). Addressing these emotional and psychological aspects of mathematics learning is crucial for improving both engagement and performance in the mathematics.

The role of parental involvement was also a critical theme. 17 teachers (47.22%) highlighted the crucial impact of parental support on students' mathematics learning (see Table 2). They observed that many parents did not fully comprehend the importance of providing academic and emotional support, contributing to students' struggles in mathematics. The observation by nearly half of the teachers underscores the significant role of parental involvement in students' academic success, particularly in mathematics (Atasoy et al., 2022). Parental support extends beyond helping with homework or attending school meetings (Wijaya et al., 2022); it encompasses a broader scope of academic and emotional support. When parents are actively engaged in their child's education, it can boost the child's confidence, motivation, and interest in learning (Guo et al., 2022; Hendriana et al., 2022; Mustafa & Salim, 2012). When many parents did not fully understand the importance of their role suggests a gap in communication and awareness. This lack of comprehension can lead to inadequate support for children, especially in a subject like mathematics, which many adults find challenging. The absence of a supportive home environment can exacerbate students' struggles, particularly if they are already facing challenges in the classroom.

To address this issue, it is essential to foster stronger partnerships between schools and families. Schools could implement initiatives to educate parents on the significance of their involvement and provide them with strategies to support their children's learning effectively. This could include workshops, parent-teacher meetings focused on discussing ways to aid children's learning at home, and resources that help parents understand the curriculum and teaching methods.

3.2. The mathematics teachers' recommendations for enhancing student mathematics performance considering the declining PISA 2022 scores

The second key question posed to the mathematics teachers in this study sought to elicit their recommendations for improving student mathematics achievement. This question was particularly pertinent given their awareness of the continuous decline in mathematics scores in the PISA 2022, as compared to the 2018 and 2015 cycles. The aim was to understand the teachers' perspectives on effective strategies and approaches that could potentially reverse this downward trend in student performance in mathematics.

To systematically present the insights garnered from these educators, Table 3 has been compiled. Table 3 showcases various examples of statements provided by the mathematics teachers, outlining their recommendations for enhancing student mathematics performance. These recommendations are reflective of the teachers' professional experience and understanding of the factors influencing student learning outcomes in mathematics.

Table 3. Mathematics teachers' recommendations

Recommendations for	Example of statement
Government	T7 - Improve training in the use of ICT-based learning media.
	T12 - Provide hands-on training and workshops for teachers to fully understand and integrate the 'Merdeka Belajar' teaching methods into their practice.

Recommendations for	Example of statement
	T15 - Establish channels for teachers to provide feedback on curriculum effectiveness and challenges.
	T20 - Implement regular professional development programs focused on modern pedagogical strategies, especially in mathematics teaching.
	T22 - Establish mentorship and peer support systems where experienced and skilled teachers can guide and support their colleagues in improving their teaching practices.
Schools	T23 - Increase the availability of ICT-based learning tools for mathematics.
	T26 - modernizing classrooms with the necessary infrastructure to support interactive and engaging teaching methods
Parents	T30 - Enhance parents' awareness of the importance of emotional support for students.
	T31 - Encourage parents to increase academic support by being more involved when students are doing homework.

Based on the mathematics teachers' statements, there are several recommendations for the government, schools, and parents to improve student mathematics achievement (see [Table 3](#)). The recommendations provided by mathematics teachers to the government include Enhanced ICT Training. Mathematics teachers recommend that the government should increase training in the use of ICT-based learning media. This involves equipping mathematics teachers with the skills and knowledge to effectively integrate technology into mathematics teaching practices. Secondly, mathematics teachers suggest the need for hands-on training and workshops to help them fully comprehend and implement the 'Merdeka Belajar' teaching methods, ensuring these new strategies are effectively used in classrooms. Thirdly, teachers mention that establishing channels for teachers to provide direct feedback on the effectiveness and challenges of the current curriculum is advised. Training and workshops can be crucial for refining and improving educational strategies (Habibi et al., 2020; Hsiao et al., 2016). Fourthly, regular professional development programs are recommended, focusing on contemporary pedagogical strategies, especially in mathematics teaching. This will aid teachers in staying updated with the latest educational trends and methods (Ames et al., 2018; Martinovic & Manizade, 2020).

Next, mathematics teachers provide several suggestions for schools, including Increased ICT Resources for Mathematics Learning. Teachers recommend that schools should invest in more ICT-based learning tools for mathematics. This includes software and hardware that can make mathematics more interactive and engaging for students. Additionally, there is a call for modernizing classrooms with the necessary infrastructure to support interactive and engaging teaching methods. This involves creating learning environments that are conducive to the use of modern technology and teaching practices.

Lastly, teachers provide recommendations for parents to help improve student mathematics achievement. First, Enhancing Knowledge on Emotional Support. It is recommended that parents increase their understanding of the importance of emotional support for their children. Awareness programs or workshops could be helpful in educating parents about the role of emotional well-being in academic success. Secondly, mathematics teachers suggest that parents should be more involved in providing academic support. This

can include spending more time with children during homework sessions, helping them understand and engage with the subject matter more deeply.

4. CONCLUSION

This research has successfully explored the perceptions and opinions of Indonesian mathematics teachers regarding the factors contributing to the decline in mathematics scores in the 2022 PISA compared to 2018 and 2015. The findings highlight six principal factors influencing this decline: issues related to the pandemic, curriculum, individual factors, resource limitations, student-related factors, and parental involvement. Additionally, the mathematics teachers have provided a series of recommendations aimed at the government, schools, and parents as strategic measures to enhance students' academic achievements in mathematics.

This study provides valuable insights that can serve as a foundation for more effective educational interventions. By acknowledging and addressing the factors identified by mathematics teachers, governments, schools, and parents can collaboratively develop strategies focused on improving student mathematics achievement. This approach will not only potentially increase future PISA scores but will also generally enhance the quality of mathematics education in Indonesia. The study also underscores the importance of listening to the voices of teachers who interact directly with students in the learning context, thus offering rich and practical perspectives for formulating educational policies.

Although this research provides new knowledge and several practical recommendations for improving student mathematics achievement, it also possesses several limitations that warrant attention. Firstly, the study is based on interviews with 36 mathematics teachers in Indonesia, which may not adequately represent the diverse teaching experiences and perspectives across different regions of the country. This limitation restricts the generalizability of the findings to all Indonesian mathematics teachers or to those in other countries. Future studies should consider including a larger and more diverse sample of mathematics teachers from various regions of Indonesia. This expansion would enhance the representativeness and generalizability of the findings. Additionally, involving teachers from different countries participating in PISA would offer a more global perspective.

Lastly, while the study provides valuable insights from teachers, it does not include the perspectives of other stakeholders such as students, parents, policymakers, and educational administrators. These additional viewpoints could offer a more comprehensive understanding of the factors influencing mathematics scores. Including the viewpoints of students, parents, educational administrators, and policymakers in future research would provide a more holistic understanding of the factors influencing mathematics performance. This multi-perspective approach would aid in identifying systemic issues and in formulating comprehensive strategies for improvement.

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