

Shifts in students' perspectives on mathematics and its learning during the transition to remote learning

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Abstract

This study examines high-school students' perspectives on mathematics learning and teaching during remote learning. Twenty-four Israeli 11th grade advanced mathematics students were interviewed about their experiences transitioning from classroom to remote learning during the COVID-19 pandemic. Drawing on Di Martino and Zan's three-dimensional model in 2010 for mathematical attitudes—vision of mathematics, perceived competence, and emotional disposition—we analyzed reflections from before and during the pandemic. Ten central themes emerged, revealing varying stability and change across cognitive, emotional, and behavioral domains. While students' fundamental views on the importance of mathematics remained stable, significant shifts occurred in learning experiences. Some reported enhanced autonomy, responsibility, and self-reliance, while others described reduced engagement, concentration difficulties, and limited teacher interaction. Three perspective profiles were identified: positive (greater engagement and resilience), mixed (gains and setbacks), and negative (decline in motivation and competence). The results highlight the complexity of students' responses to remote mathematics instruction, with implications for designing resilient and inclusive approaches to remote and hybrid learning.

Keywords: students' perspectives, remote learning, vision of mathematics, mathematics learning and teaching, perceived competence, emotional disposition, COVID-19

INTRODUCTION

Remote learning has become an integral part of global education systems, both in regular hybrid teaching models and in emergency contexts such as wars, natural disasters, or health crises. The large-scale transition during the COVID-19 pandemic accelerated the adoption of online mathematics instruction and exposed both opportunities and challenges (Moore et al., 2022). Research highlights a dual reality: remote learning can foster digital literacy, autonomy, and self-regulated learning (He et al., 2022; Ibad & Saelaemae, 2024), yet, in mathematics—where interaction, immediate feedback, and hands-on practice are critical—learning outcomes often fall short compared to face-to-face teaching (Jin, 2023).

Students' perspectives on remote learning have been investigated through diverse methodologies. Large-scale surveys have mapped achievement gaps,

especially among disadvantaged groups (Reich et al., 2020). Other studies examined teachers' practices and experiences with synchronous and asynchronous formats (Drijvers et al., 2021) or explored young learners' engagement in specific contexts (Kalogeropoulos et al., 2021). Qualitative studies, though fewer, provided in-depth insights into students' engagement, emotions, and autonomy (Treacy & Leavy, 2021). These findings underscore the importance of student voices: while some learners report growth in independence and digital competence, others experience reduced motivation, concentration difficulties, and limited interaction with teachers.

Despite this expanding literature, several gaps remain. First, most research has focused on teachers' practices or higher education contexts, leaving the secondary school students underrepresented (Källberg & Roos, 2025; Raes et al., 2020). Second, large-scale surveys offer trends but overlook how students describe

Contribution to the literature

- This study contributes to the literature by systematically examining high-school students' perspectives on mathematics learning during emergency remote instruction, an area underexplored in secondary education. Applying Di Martino and Zan's (2010) three-dimensional model of mathematical attitudes, the study reveals how remote learning can foster autonomy and self-reliance, even among students with initially low motivation.
- Methodologically, the research introduces a structured profiling approach for analyzing diverse student experiences, offering a framework that can be adapted in future studies.
- Practically, the findings inform the design of more resilient and inclusive mathematics education, emphasizing the need for accessible digital resources and differentiated support strategies to enhance student engagement and autonomy during crises and in everyday practice.

their competence, emotions, and vision of mathematics. Third, little is known about how high-achieving secondary students in advanced mathematics programs interpret their experiences of remote learning—a group whose sustained engagement makes their reflections especially valuable. Finally, relatively few studies have systematically applied a robust theoretical framework to analyze such perspectives.

Accordingly, there is a need for studies that systematically examine the interplay between students' cognitive, emotional, and dispositional perspectives on mathematics when shifting to remote learning. Such perspectives are not only relevant to the temporary pandemic response but also to ongoing hybrid and emergency education models. Understanding students' voices is essential for assessing how mathematics education can remain resilient and inclusive. Insights from such research can inform emergency preparedness in contexts like Israel—where sudden school closures are not rare—and contribute to the broader design of hybrid and flexible learning models worldwide (Aristovnik et al., 2020; Jiang et al., 2023).

Our study addresses this issue by examining Israeli 11th grade advanced mathematics students' perspectives on mathematics learning and teaching before and during the pandemic-driven shift to remote learning. Guided by Di Martino and Zan's (2010) three-dimensional model—vision of mathematics, perceived competence, and emotional disposition—we analyze how students' multidimensional perspectives evolved. Although schools have since returned to in-person instruction, the study highlights the initial abrupt transition to remote learning, offering insights relevant for future emergency preparedness and for the design of resilient and inclusive approaches to mathematics education.

THEORETICAL BACKGROUND

The literature review comprises two key sections, each exploring an essential aspect related to teaching and learning mathematics in the broader context of remote learning, including but not limited to the COVID-19 pandemic. The first focuses on remote mathematics learning and the use of this concept in

research. The second section explores students' perspectives on mathematics, its learning, and its teaching.

Remote Mathematics Learning

Remote mathematics learning, defined as instruction delivered entirely through online platforms, has increasingly attracted attention in educational research, particularly during and beyond the COVID-19 pandemic (Bozkurt & Sharma, 2020). Studies using large-scale surveys, teacher reports, and cross-country comparisons (Drijvers et al., 2021; Kalogeropoulos et al., 2021; Reich et al., 2020) have underscored both opportunities and challenges. Benefits include improved accessibility to materials, flexibility, and the development of innovative digital teaching strategies. Yet persistent difficulties involve reduced teacher-student interaction, declining engagement, and constraints on fostering deep conceptual understanding without immediate feedback. These challenges often pushed teachers to adopt more interactive practices, refine communication about goals and assessments, and expand synchronous learning opportunities.

Much of this research, however, has concentrated on teachers' practices, with students' voices remaining underrepresented. A few recent studies (e.g., Abdulah et al., 2025; Julaihi et al., 2022; Källberg & Roos, 2025) have begun to examine students' experiences, but systematic investigations of high-school students' perspectives—particularly during abrupt transitions such as pandemic-related remote education—remain scarce. The present study therefore contributes to this evolving literature by applying a multidimensional framework (Di Martino & Zan, 2010) to capture changes in secondary students' perceptions, competence, and emotions during remote mathematics learning.

Students' Perspectives Regarding Mathematics, Its Learning, and Its Teaching

In mathematics education research, students' voices have often been underrepresented, with greater attention given to teachers' practices or students' learning outcomes (Källberg & Roos, 2025). Yet students'

perspectives provide essential insights into how they perceive, experience, and make sense of mathematics and its learning and teaching. Here, *perspective* refers to a multifaceted configuration of beliefs, perceived competence, and emotional responses. While earlier studies described attitudes in unidimensional terms such as positive/negative disposition (Haladyna et al., 1983), recent studies recent research emphasizes that students' views are complex, context-dependent, and shaped by affective, cognitive, and sociocultural factors (Källberg & Roos, 2025).

Understanding students' perspectives is crucial. They shape how students engage with mathematical content, respond to instructional practices, and envision mathematics' relevance to their lives (Källberg & Roos, 2025). Positive perspectives are associated with greater motivation, higher achievement, and continued participation in advanced mathematics courses, whereas negative perspectives may lead to avoidance, anxiety, and exclusion from mathematics-related careers (Shakya & Maharjan, 2023).

To conceptualize and investigate students' perspectives in this study, we draw on the three-dimensional model proposed by Di Martino and Zan (2010). This model was developed through a large-scale empirical study with students and teachers across all school levels and characterizes student attitudes along three interrelated dimensions:

1. **Vision of mathematics:** This dimension refers to the students' perceptions regarding the nature of mathematics and its learning and teaching processes. Students' perceptions may range from viewing mathematics as a rigid system of formulas and procedures to recognizing it as a more dynamic field that involves reasoning and understanding (Di Martino & Zan, 2010). Additionally, students' perceptions of how mathematics is learned and taught encompass aspects such as the role of effort, the importance of active participation, the role of the teacher, and the integration of real-world connections (Artigue et al., 2020). Studies show that such students' perceptions of mathematics can potentially shape the extent of their engagement and achievements (Kurepa et al., 2019).
2. **Perceived competence in mathematics:** This dimension refers to students' self-perceived competence in mathematics, the individual's subjective perception of their ability or skill to understand and perform a specific mathematical task in a specific mathematical context (Rodríguez et al., 2021; Samuelsson, 2023). Studies have shown that students' perceptions of their competence affect their willingness to tackle mathematical tasks, the effort they invest, their persistence, and ultimately their performance (Lennon-Maslin et al., 2024). Moreover, perceived competence has been shown to impact students' decisions to pursue advanced mathematics courses and their engagement with the subject (Shin & Shim, 2021). In this sense, perceived competence does not merely reflect past performance but also functions as a powerful predictor of students' future engagement and persistence in mathematics.
3. **Emotional disposition towards mathematics:** This dimension refers to students' emotional responses to mathematics and to various instances of learning and teaching mathematics. Mathematics evokes varied emotions among students, including feelings of joy, excitement, a desire for a stress-free environment, hate, anxiety and fear (Gur et al., 2023). Recent studies emphasize that these emotions are complex and situational, shaped by individual, social, and instructional factors within the learning environment (Schoenherr et al., 2025).

These emotions, particularly for students with low perceived competence, can significantly affect their motivation and engagement (Longos & Regidor, 2022; Nyman & Sumpter, 2019). Mathematics is known to elicit a wide spectrum of emotions, ranging from joy, excitement, and curiosity to frustration, anxiety, and even fear (Berlin & Cohen, 2020).

These three dimensions—vision, competence, and emotions—remain understudied in the context of remote mathematics learning, especially among high-school students. Di Martino and Zan's (2010) model provides a theoretically grounded and empirically robust framework that goes beyond binary distinctions such as "likes/dislikes" or "good/bad at math" and captures both stability and change in students' perspectives. It is particularly relevant for analyzing the abrupt transition from in-person to remote learning during the COVID-19 pandemic, which altered the structure and pace of lessons as well as student-teacher dynamics.

By bringing together the two strands reviewed above—research on remote mathematics learning and on students' perspectives—the present study applies Di Martino and Zan's (2010) three-dimensional model to examine how advanced secondary students' vision of mathematics, perceived competence, and emotional disposition shifted during the transition to remote learning. In doing so, it extends the application of this model to an underexplored context and positions students' reflections as a critical lens for designing inclusive and resilient approaches to mathematics education in both emergency situations and evolving hybrid environments.

MATERIALS AND METHODS

Research Context and Participants

The study involved 24 11th grade students (16 females, 8 males) enrolled in advanced-level mathematics (5 study units) in Israel. These students experienced both traditional in-person classroom learning before the COVID-19 pandemic and remote mathematics teaching during the pandemic. The interviews were conducted during the pandemic period, focusing on students' reflections comparing their experiences of remote learning during the pandemic with their prior experiences of in-person classroom learning.

Participants were recruited with the assistance of seven mathematics teachers from different high schools representing both Jewish and Arab communities. These teachers were randomly selected by the research team from a nationwide database of schools offering advanced mathematics programs and were asked to recommend 3-4 students who could offer meaningful reflections on their experiences with mathematics. The teachers themselves did not take part in the study beyond this role.

To ensure variation in students' mathematical proficiency, the teachers categorized their recommended students into three performance groups based on academic records: high-performing (grades above 85), moderate-performing (grades between 60 and 85), and low-performing (students who struggled to pass). These groupings were based on the teachers' professional judgment, informed by students' previous and current performance in mathematics.

The decision to focus on students enrolled in 5-unit mathematics was based on the first author's prior experience as a mathematics instructor and on field reports indicating that these students had maintained high attendance rates in online math lessons during the COVID-19 pandemic. Therefore, this group was considered likely to provide particularly rich, illuminating, and coherent insights into the experience of remote mathematics learning.

All data were collected during the early stages of the COVID-19 pandemic, when nationwide school closures in Israel necessitated a full and immediate transition to online instruction, primarily via Zoom. During this period, students received no in-person instruction whatsoever. Prior to the pandemic, mathematics instruction was delivered in-person in traditional classroom settings, characterized by direct student-teacher interaction. The sudden shift to remote learning marked a substantial change in the structure, delivery, and nature of students' educational experiences. This context is crucial for interpreting students' reflections, as it shaped both the learning environment they

encountered and the perspectives they communicated during their one-on-one interviews.

Data Collection

The data collection was conducted through semi-structured individual interviews, designed in accordance with Di Martino and Zan's (2010) three-dimensional model of student perspectives. The interview questions were adapted from this model and underwent a pilot with several students not included in the main study, to ensure clarity, relevance, and alignment with the study's aims. Revisions were made based on the pilot feedback to refine and improve the appropriateness of the questions.

The interviews focused on three key dimensions:

- (1) students' perspectives on mathematics, its learning and teaching,
- (2) their perceived competence in mathematics, and
- (3) their emotional disposition toward the subject.

The main interview topics included students' descriptions of mathematics lessons in both traditional (pre-pandemic) classroom settings and during the COVID-19 period; the perceived importance of learning mathematics; their conceptualizations of mathematics as a school subject; their views on how mathematics lessons could be improved if they were in the teacher's place; their perceptions of success in mathematics; their approaches to dealing with difficulties; their enjoyment of mathematics; and their typical patterns of participation in math classes. For each topic, students were asked to reflect on and compare their experiences in traditional (pre-pandemic) classroom settings with those during remote learning. They were encouraged to elaborate and provide concrete examples from their personal experience.

All interviews were conducted remotely via Zoom during the COVID-19 period and lasted ~90 minutes each. With participants' informed consent, all interviews were audio-recorded and transcribed verbatim for analysis. While qualitative interviews do not rely on traditional measures of validity and reliability, the use of a theoretically grounded interview framework, along with pilot testing, reinforced the veracity and credibility of the data. The full interview protocol is provided in the **Appendix A**.

Data Analysis

The data analysis of the interviews combined direct analysis and inductive content analysis (Patton, 2002). The unit of analysis in this study was defined as a student's statement, which could be a single sentence, part of a sentence, or a sequence of several sentences expressing a coherent thought related to students' perspectives on mathematics. This choice allowed for a

precise and detailed examination of students' experiences and interpretations.

In the direct analysis, statements were categorized according to the three dimensions of Di Martino and Zan's (2010) model. Statements categorized under the *vision of mathematics* dimension reflected students' perspectives of mathematics, including their views on learning and the teaching processes. Statements categorized under *perceived competence in mathematics* captured students' perceptions of their mathematical ability, including their perceived strengths and weaknesses, their capacity to handle challenges, and their participation in various learning settings, such as peer discussions or independent study. Lastly, statements categorized under *emotional tendencies towards mathematics* represented students' expressed emotions regarding the subject and their reactions to learning experiences of different kinds.

Next, an inductive content analysis was conducted to identify emerging themes within each dimension. This process involved iterative data sorting and continual comparisons, both within and across developing categories, to construct a nuanced understanding of students' perspectives. Interpretations were discussed collaboratively between the two authors, with coding refined through repeated cycles of check-coding to ensure consistency (Miles & Huberman, 1994). Through this process, twelve themes were identified. Within the *vision of mathematics* dimension, ten themes emerged, addressing different aspects of students' experiences: Two themes pertained to mathematics as a discipline, focusing on the importance and relevance of mathematics, and students' perceptions of its nature. Two additional themes related to the teaching of mathematics, highlighting the role of dynamics and accuracy in instruction and the importance of receiving teacher feedback. The remaining six themes addressed aspects of mathematics learning, including students' perceptions of accessibility and availability of materials; the significance of effort and investment in their own learning; their sense of responsibility for their own learning; their sense of self-reliance in learning; their ability to concentrate; and their level of engagement during lessons. Within the *perceived competence* dimension, a single theme emerged related to students' experiences with challenges and how they coped with them. In the *emotional tendencies* dimension, one theme emerged, reflecting the extent of students' connectedness/ to mathematics.

Once themes were established, a comparative assessment was conducted to analyze variations in students' perspectives before and during remote learning. To examine these shifts, we distinguished between statements referring to mathematics learning prior to the COVID-19 pandemic and those referring to remote learning during the pandemic. Based on these comparisons, shifts in perspective were categorized as

follows: A *positive shift* was noted when a student's statements indicated a more favorable view of mathematics, improved perceived competence, and/or more positive emotional responses during remote learning. Conversely, a *negative shift* was identified when statements reflected a decline in positive perspectives of mathematics, decreased perceived competence, or more negative emotional tendencies in the remote learning context. If students' responses showed no significant difference between the two learning environments, their perspectives were considered *unchanged*.

Following this analysis, patterns of change in students' perspectives were examined. The themes which reflected a positive shift varied significantly across students, with individuals exhibiting between 2-9 of the 10 identified themes. In contrast, themes reflecting no change in perspective were less common, appearing in up to six themes per student. Notably, themes suggesting a negative shift were the least frequent, with students displaying between 0-5 negatively associated themes.

To synthesize these findings, students were grouped into three perspective profiles based on the extent of negative change observed in their statements. The *positive profile* included students who did not exhibit any increase in negative perspectives. The *mixed profile* comprised students who displayed one or two themes associated with a negative shift. Lastly, the *negative profile* consisted of students who exhibited three to five themes reflecting a decline in the positivity of their perspectives toward mathematics during remote learning. This classification enabled a more nuanced understanding of how students navigated the transition to remote mathematics instruction. By analyzing shifts across emotional, cognitive, and motivational dimensions, the profiles offer insights into the diversity of students' experiences and the ways in which remote learning environments shaped their engagement and relationship with mathematics.

RESULTS

This section presents the findings related to students' perspectives regarding the three dimensions of Di Martino and Zan's (2010) model. The findings are presented thematically for each dimension, with a focus on the central shifts and stable aspects in students' experiences as they adapted from in-person to remote mathematics learning. Profiles summarizing patterns of adaptation are subsequently described.

Themes Identified for Each of the Three Dimensions

Dimension 1. Perceptions of mathematics, its learning, and its teaching

The first dimension includes students' perceptions of mathematics, its learning and teaching processes, the

nature of mathematical activities, and the organization of learning. Perceptions were analyzed comparatively—contrasting students' views before and during remote learning—to identify key shifts resulting from the change in learning modality. The analysis identified 10 themes: two about mathematics as a discipline, two about mathematics teaching, and six about mathematics learning. Below are summaries of each theme, highlighting key changes and consistencies in students' perspectives.

The importance and relevance of mathematics: This theme appeared consistently in all interviews and highlights students' perceptions of the importance and relevance of mathematics. While all students acknowledged the value of mathematics there were variations in enthusiasm and perceived practical application.

Most students regarded mathematics as essential for cognitive development and future success, emphasizing its role in problem-solving and as a basis for scientific and technological advancement. For example, Janan expressed this belief succinctly:

Those who study mathematics, especially at a high level, will develop higher-order thinking skills.

Similarly, Rafael illustrated the broad applications of mathematics in different contexts:

Mathematics is an important tool that encompasses many topics at the most basic level, whether it is shopping, planning the trajectory of an Iron Dome missile, or designing chess software.

While most students appreciated mathematics' cognitive benefits, some questioned its direct relevance to daily life. Although they recognized its significance for academic career advancement, they struggled to see the practical application of certain mathematical topics. This skepticism highlights a dual perspective—an acknowledgment of mathematics' role in developing thinking skills, coupled with doubts about the real-world utility of specific concepts. Moshe articulated this tension:

Truthfully, I even asked my parents when I was little why we learn it. After all, we don't use equations, we don't use variables in real life... But I understand it's an important subject that helps develop our thinking skills and problem-solving abilities!

These varied perspectives demonstrate that, while students generally acknowledge the importance of mathematics, their interpretations of its relevance differ. Some perceive it as a universal tool for cognitive development and problem-solving, while others view it

primarily as an academic requirement with limited everyday applications. Notably, these views remained consistent throughout the transition to remote learning, suggesting that students' core beliefs about the importance of mathematics are deeply ingrained and not easily influenced by changes in the learning environment.

The nature of mathematics: Students expressed a range of perspectives on the nature of mathematics, recognizing both its complexity and interconnectedness. Many emphasize how seemingly distinct mathematical topics are ultimately part of a unified system, underscoring the relationships between algebra, geometry, trigonometry, and other mathematical domains. Naomi captured this idea by describing mathematics as a puzzle, where initially separate pieces gradually form a cohesive whole:

Mathematics is like a huge puzzle with many pieces. At first, each topic seems like a separate piece—algebra, geometry, trigonometry. But as you learn more, you start to see how all the pieces fit together. For example, when I solved a problem in trigonometry, I suddenly realized that I was using geometric theorems. Or when I worked on word problems, I saw how it relates to algebraic techniques. It's amazing to discover how all these topics, which seem so different at first, are actually connected and complement each other.

Other students perceived mathematics as a field with an inner logic and structured organization, recognizing that—despite its initial complexity—there is an underlying order made up of patterns, rules, and coherent relationships. Galit illustrated this view through an analogy, comparing mathematics to sushi, where initial disorder gives way to an underlying structure:

Mathematics is like sushi. It might look messy from the outside, but inside there's order and organization. Each piece has its place.

For some students, mathematics was also seen as a flexible and adaptive discipline, requiring different strategies for different problems. This perspective underscored the importance of adjusting one's thinking and applying a variety of approaches to problem-solving. Dalia expressed this adaptability by likening mathematics to a chameleon, highlighting its dynamic nature:

Mathematics is like a chameleon. Each question requires a different approach, and you need to adapt your thinking, just like a chameleon changes its colors.

Conversely, some students viewed mathematics as rigid detached, describing it in ways that emphasized difficulty, inflexibility, and a lack of personal connection.

This perspective reflects a view of mathematics as a fixed system of rules and procedures, with little room for interpretation or flexibility. Maya encapsulated this feeling with a stark metaphor:

Mathematics is like a rock—hard, unchanging, and difficult to grasp or relate to. It's just there, solid and unyielding.

Across all perspectives, students' conceptualizations of the nature of mathematics remained stable before and during remote learning, underscoring the durability of disciplinary beliefs against changes in instructional formats.

Dynamics and accuracy in mathematics: This theme, which emerged in 16 of the 24 student interviews, reflects students' perceptions of the dynamism and precision in mathematics learning, particularly when comparing face-to-face classroom settings to the remote learning environment during the COVID-19 pandemic. Students discussed how technological tools and digital resources influenced both the accuracy of mathematical representations and the interactive nature of learning, particularly in areas such as graphing, transformations, and geometric visualization.

Many students noted that during remote learning, mathematical concepts were presented with greater precision and dynamism than in face-to-face lessons. They observed that graphs, which were traditionally drawn by hand on the blackboard, were now rendered using technological tools, providing more accurate and visually refined representations. Similarly, geometric drawings were more precise when created digitally, which facilitated a clearer understanding of geometric relationships. This enhanced visual accuracy was particularly beneficial for topics such as function analysis and geometry, where detailed, error-free diagrams played a critical role in comprehension.

Beyond precision, students emphasized the dynamic aspects of mathematics learning, particularly in relation to functions and transformations. They described how digital tools allowed them to observe real-time transformations of graphs, making abstract concepts such as translations, stretching, and shrinking of functions more tangible and interactive. For instance, they noted that in remote learning, teachers could demonstrate the rise and fall of functions dynamically, relying on static board drawings. This interactivity, they argued, made mathematical principles more engaging and easier to grasp.

Many students attributed these improvements to the increased accessibility and ease of use of technological tools in remote learning. They felt that teachers were more inclined to integrate digital applications in remote lessons, as these tools were often simpler to operate and required less effort compared to manually drawing on a board. This shift led to a teaching format that moved

beyond the traditional board-based method, incorporating more computer-based learning activities. Janan, reflecting on her experience during the pandemic, articulated this shift clearly:

We now see the functions on the computer **moving** rather than 'sitting on the board' ... It's much more than before the pandemic. Now, the teacher incorporates these tools in classroom lessons more than before the pandemic: functions, quadrilaterals, and triangles in geometry; she **moves the elements** to show us how the functions and geometric shapes work with such **movement**, unlike static drawings on the board ... Everything is **accurate**! The charts of the functions of trigonometry, the circles. This aspect has intensified during this period ... With the integration of technological tools, we now **understand how things derive** ... It's not just about sketching a function in a notebook and seeing it, and that's it! The teacher now has more time and opportunity to show us simulations and illustrations for all the parameters of functions... stretching, contraction ... shifts, etc. Since everything is on the computer, which she uses in the remote lesson, she doesn't need to exert **effort** to connect things like in a regular classroom lesson (emphasis added).

Janan's account underscores how remote learning encouraged teachers to adopt digital tools more frequently, ultimately transforming the way mathematical concepts were visualized and taught. These perspectives demonstrate that for many students, remote learning greatly improved the clarity and interactivity of mathematical representations, making abstract concepts more accessible through real-time visual demonstrations.

While students' core beliefs about the importance and nature of mathematics remained stable, their perceptions of its accuracy and dynamism shifted positively during remote learning. The increased use of digital tools led many to view mathematical representations as more precise, interactive, and engaging than before.

Receiving feedback: This theme, emerging in 19 of the 24 student interviews, focuses on how students experienced teacher feedback before and during the COVID-19 pandemic. It highlights shifts in feedback practices and students' perceptions of these changes, particularly in relation to homework review, digital submission processes, and the effectiveness of different types of feedback.

Seventeen students reported that during remote learning, they received more frequent and higher-quality feedback compared to pre-pandemic times. This improvement was largely attributed to the shift in

homework submission methods. During remote learning, students were required to scan and upload their solutions through Google Classroom, a practice that was not common before the pandemic. This digital submission enabled teachers to review students' work more thoroughly and provide personalized feedback. In contrast, prior to COVID-19, many students noted that teachers rarely checked their homework assignments, leaving them uncertain about their mistakes and learning progress. Yohanna illustrated this shift:

In class, the teacher cannot **review all our homework**, but from remote learning, he checks all the tasks, and then we **know our mistakes** and **learn** from them.

The increase in feedback was particularly evident in computerized mathematical tasks, which provided immediate automated feedback on students' performance. Additionally, teachers actively reviewed these digital submissions and provided personalized comments, a practice that differed from traditional in-class homework checks. Maya described this difference:

During the regular school period, they [teachers] didn't give assignments for submission. Usually, they give homework that you either prepare or you don't! Like, in a way, it's your problem. On Zoom, there's the issue of assignments for submission ... you get comments on what you did each time ... where the teacher checks and gives comments, not like it was before corona.

For a minority, digital feedback was perceived as less helpful, emphasizing final answers over solution processes. Rami highlighted this concern:

From the book! Because the method is much simpler. In the computerized tasks, they ask you to write only the final answer, but with book tasks, you work on a tangible page, and you write down the whole process for yourself. There [online], it feels like what matters is only the final answer... whether you succeeded or not!

Overall, these findings indicate that for most students, perceptions of teacher feedback shifted positively during remote learning, as they recognized its greater availability and personalization. However, for some, the shift toward digital feedback raised concerns about its depth and its focus on final answers rather than mathematical reasoning.

Degree of accessibility and availability of the material: This theme, which emerged in 11 of the 24 students' interviews, explores how the shift to online learning impacted students' access to mathematical content and resources. The increased availability of digital course materials and recorded lessons provided students with greater flexibility in accessing and

revisiting concepts outside of traditional classroom hours. This flexibility helped address some of the challenges associated with remote learning while offering new opportunities for students to engage in mathematical content.

Students identified several challenges in remote learning, including internet connectivity issues, reduced concentration (which will be discussed further in theme 9), and various distractions in the home environment. Additionally, they noted difficulties such as the lack of immediate face-to-face interaction with teachers, technical issues with online platforms, and the need to adapt to digital tools for learning mathematics. However, they also emphasized that the availability of digital resources and recorded lessons helped mitigate these difficulties by allowing them to review missed content, study at their own pace, and revisit complex concepts.

One of the primary advantages students noted was the ability to access recorded lessons and summarized class materials after each session. Additionally, the option to share screens during lessons, which is not possible in traditional classrooms, allowed for more personalized interactions with teachers. Students explained that if they missed a class or struggled with certain material, they could easily review both the lesson and accompanying resources at their own pace. In contrast, in a face-to-face setting, students would typically need to ask their teacher or classmates for help or seek external tutoring. Elham highlighted the benefits of recorded lessons and digital resources:

The teacher immediately sends us the **summary** after we finish the Zoom lesson. It makes it easier for us to keep up with each sub-topic, rather than waiting until the end to review everything [...] Learning this way made me like mathematics more and feel that it was more understandable on zoom [...] I always felt that there was **another explanation available, another resource to return to**, and **constant repetition** by the teacher ...

Similarly, when asked whether any aspects of remote learning were preferable to traditional classrooms, Liza pointed out the advantages of screen sharing for collaborative problem-solving:

Yes, sometimes you can **share your screen**, and if there is a solution to a question, the class teacher can show it to the whole class. In a physical classroom, the teacher can't show my notebook to everyone, but with screen sharing, it's possible. You could show it on the board, but it's not the same.

Overall, students' perceptions of the availability of learning materials shifted positively during remote learning. Many came to appreciate the convenience of

digital access and the ability to review content at their own pace, which, for some, fostered greater confidence and engagement in mathematics.

The importance of investment in learning mathematics: This theme, which emerged in all student interviews, highlights the significance of dedicating time and effort to studying mathematics. Students consistently emphasized that mathematics is a demanding subject, requiring constant devotion to learning to achieve success.

When comparing their perspectives before and during the pandemic, the interviewees reported placing greater importance on mathematics and dedicating a greater effort to learning it during remote learning. This contrasted with their views before the pandemic. Dalya reflected on this shift, explaining how the extra effort became even more essential during remote learning:

I still see mathematics as equally important, and even more so, because we must make more of an effort or study harder to fully understand the material well [...] In **remote classes**, we have to make a **greater effort** to ensure we **don't miss anything**. It's different from in-person classes, where the effort required would be less.

Students' perceptions of the effort required to learn mathematics shifted positively during remote learning. Many recognized the need for greater self-discipline and independent study, which deepened their appreciation of the efforts required to succeed in mathematics.

Responsibility for learning: This theme, which emerged in 21 of the 24 students' interviews, explores students' evolving sense of responsibility for their own mathematics learning, while comparing their experiences in traditional classroom settings and remote learning. Two key factors shaped this shift: the accessibility of learning materials and the increased necessity for independent study.

The interviews revealed a notable awakening of responsibility among students during remote learning. Many attributed this change to the greater availability of learning materials, such as recorded lessons and uploaded resources, which were not previously accessible. This increased access empowered students to take more initiative in their studies. Others emphasized that remote learning required them to actively seek out and engage with material rather than relying on in-class explanations. In particular, students stated that they could no longer depend on immediate teacher assistance, which compelled them to complete missed content or review materials uploaded to digital platforms on their own. Saker described how this shift in responsibility changed his learning habits:

Before the COVID-19 period, when I had difficulty with something, I would wait until the next day to

go to school and ask the teacher [...] Now, in remote learning, if I struggle with a specific question, I **don't wait** for the next lesson. I check the **material** and the **summaries** the teacher uploaded [...] Even if I lose focus during the lesson, I can return later to read the teacher's summary.

Similarly, Yohanna reflected:

Suppose the teacher solves something and I don't understand it. In that case, I have to review the **recorded material** on my own to understand it [...] During the COVID-19 period, **my responsibility** for my own learning increased.

Some students reported that remote learning fostered a more consistent, daily sense of responsibility. They attributed this heightened sense of accountability to the unique challenges posed by remote classes, including increased distractions and the physical absence of the teacher. These factors often resulted in missed content, requiring them to develop adaptive strategies to compensate for these gaps. Shlomo reflected on this change in his approach:

I have difficulty concentrating in a remote class, but after the lesson, **devote more** effort than I used to when we were in school [...] I think this remote method **made me learn more**. Before, I could have done it too, but I didn't, because I think I didn't feel the need to as much as I do now.

These perspectives indicate a positive shift in students' sense of responsibility for their own learning during remote education. While many initially relied on in-class instruction for understanding mathematical concepts, remote learning required them to take greater initiative in reviewing materials, seeking clarification, and managing their own learning progress. This transition fostered stronger independent learning habits and a greater awareness of the effort needed to succeed in mathematics—changes that many students viewed as beneficial and that may continue to influence their learning beyond the remote learning period.

Self-reliance in learning: This theme, which emerged in all 24 student interviews, explores students' sense of independence in tackling mathematical challenges during remote learning compared to their disposition to seek help in traditional classroom settings. It sheds light on changes in teacher-student interactions, the availability of peer support, and students' problem-solving strategies across both learning environments.

A significant portion of the students (19 out of 24) reported that before the pandemic, they typically relied on their teacher when encountering complex mathematical material or difficulties in solving problems. Many felt comfortable waiting for the next

lesson, knowing they could ask their teacher for clarification in person. Students described a notable shift toward self-reliance during remote learning, with many attempting to solve problems on their own before seeking help from teachers, peers, or family members. Nurit expressed this change in her approach to problem-solving:

I sit down to solve an exercise and do not immediately turn to **get help** [...] Before COVID-19, I would work on it for **five minutes**, and if I couldn't solve it, I'd ask for help or read the solution. Now, I'm willing to sit with a question for **three hours**!

The other five students reported that their level of self-reliance remained unchanged across both learning periods. This consistency was attributed to the presence of academic support at home. These students had immediate access to family members, such as parents or siblings, who were either mathematics teachers or highly proficient in the subject, providing a constant source of assistance. As a result, they did not experience an increased need to work independently before seeking help. Shlomo described this experience:

First of all, my sister is an excellent solver. Whenever I encountered something, I would immediately turn to her or to the teacher in class. Now it's the same thing!

Overall, students' perceptions of their self-reliance in mathematics shifted positively during remote learning. While many previously depended on teachers for immediate guidance, the constraints of remote learning encouraged them to engage more persistently with mathematical problems before seeking external help. This greater independence contributed to a deeper sense of perseverance and problem-solving resilience, skills that may extend beyond the remote learning period.

Concentrating on learning: This theme, which emerged in 21 of the 24 student interviews, examines the differences in students' ability to focus and maintain attention in traditional classroom learning compared to remote learning. It considers various factors influencing concentration, including the learning environment, distractions, and the nature of student-teacher interactions in different educational settings.

A majority of students (13 out of 24) reported experiencing greater difficulty concentrating during remote classes due to various distractions at home, such as phones, computers, food, and household noise. Some noted that while physical classrooms could also be noisy, they still found it easier to focus due to direct eye contact with the teacher and the structured nature of in-person lessons. Simply turning on their cameras during remote lessons, they explained, did not resolve these challenges. Tehila described her experience:

The **distractions** I have at home [...] I always have **the phone** [...] **the computer** [...] all kinds of **distractions** [...] keep pulling my attention away. [...] There is also **noise** from the house [...] In class, even though it's noisy, I can concentrate better than a Zoom lesson. At home, because I **can't see the teacher**, I get distracted more easily.

Similarly, Dalya emphasized the importance of visual teacher presence in maintaining focus:

I'm the type of person who needs to **see the teacher** in front of my eyes ... his **body language** ... use of hands, facial expressions ... if **my mind wanders**, I can see **the teacher looking at me**, and that brings me back to focus. But in remote learning, if I'm not concentrating, who's there to bring me back? Even if we turn on our cameras, I don't think it would help.

Interestingly, six students reported improved concentration during remote learning. These students explained that managing distractions at home required extra effort, which motivated them to focus more. The need to actively control their learning environment made them more aware of their concentration levels and pushed them to develop stronger focus strategies. Galit described how this heightened awareness influenced her concentration:

You need to be **much more focused** on Zoom because it's like, you **can't lose** your train of **thought** or stop listening to the teacher for a moment. Because you have many **distractions** around you—you have your phone, you're in your room, all sorts of things. You need to **maintain twice** as much **attention** compared to the classroom.

Overall, students' perceptions of their ability to concentrate shifted negatively for most, as they found it harder to maintain attention during remote learning due to increased distractions and the absence of direct teacher-student interactions. However, for a smaller group of students, the challenge of managing distractions led to a positive shift, as they developed greater self-awareness and focus strategies that enhanced their ability to concentrate.

Involvement in learning: This theme, which emerged in all 24 interviews, explores student participation in classroom activities before and during the COVID-19 pandemic. It includes various forms of engagement, such as answering the teacher's questions; seeking clarification; contributing to class discussions; completing tasks and exercises during the lessons; participating in group or pair work; demonstrating solutions on the board (or screen in remote learning); explaining concepts to classmates; and asking for assistance when facing difficulties.

Students expressed diverse experiences regarding their involvement in learning during remote education. Eight students reported an increase in participation during the pandemic, stating that the shift to online platforms provided a more comfortable environment for engagement. These students felt that participating in Zoom lessons was less intimidating than speaking in a physical classroom, allowing them to express themselves more freely. Mary described how remote learning enhanced her willingness to engage:

I felt more comfortable speaking on Zoom because no one could **see me**, therefore I could **express myself** better [...] In class, the teacher goes by turn, and it takes **time before it's my turn** to solve a problem [...] On Zoom, I have more opportunities to speak and participate, as not all students are as active, giving me a greater **chance to contribute** [...] I also think that **understanding** the material better on Zoom **motivates** me to cooperate more.

While some students found remote learning to be a more inclusive space for participation, 10 students reported reduced participation compared to in-person classes, citing concentration difficulties and less time to think before responding, which lowered their confidence. Shlomo explained illustrated this shift in engagement:

Now I **participate much less** ... Before COVID-19, I used to participate a lot more. When I was in the classroom, I would ask questions and show interest ... Now I participate much less ... I don't get to participate as much ... Because many times when I'm **not so focused** on the lesson, it's difficult for me to participate; it's hard to answer the teacher's questions or even to ask questions.

Overall, students' perceptions of their involvement in learning shifted in different directions during remote education. While some found online platforms to be a more accessible and less intimidating space for participation, others struggled with maintaining focus and confidence, leading to lower levels of engagement. This divergence suggests that students' participation was significantly influenced by their ability to adapt to the remote learning platform and their personal learning preferences.

Summary of students' perceptions of mathematics, its learning, and its teaching: The first 10 themes examined students' perceptions of mathematics, its learning, and its teaching, before and during the COVID-19 pandemic. While students' views on the importance and nature of mathematics remained consistent, their learning experiences shifted in both positive and negative ways. On the positive side, students reported greater access to learning materials, increased responsibility, and stronger self-reliance. However, on

the negative side, many faced challenges with concentration and engagement, particularly due to distractions and reduced teacher-student interaction.

The next section examines the second dimension of Di Martino and Zan's (2010) model—perceived competence in mathematics—to examine how students' confidence in their mathematical abilities evolved during remote learning.

Dimension 2. Perceived competence in mathematics

The second dimension examines students' perceptions of their mathematical abilities, including their strengths, weaknesses, and capacity to overcome challenges before and during the pandemic. The analysis highlights changes in students' self-perception of competence in mathematics. Unlike the first dimension, which revealed multiple themes, this dimension centers around a single key theme: "Challenges and coping with challenges." This theme captures the variations in students' mathematical confidence, reflecting how the transition from traditional classroom to remote learning impacted their sense of competence and resilience in learning mathematics.

Challenges and coping with challenges: This theme, which emerged in all 24 student interviews, explores how the challenges of remote learning during the COVID-19 pandemic impacted students' perceived mathematical competence. Prior to the pandemic, students' confidence in their mathematical abilities varied, with many relying on traditional face-to-face instruction for support. However, the abrupt shift to remote learning required students to adapt quickly, take greater responsibility for their learning, and develop independent study strategies. For many, the process of overcoming difficulties boosted their sense of mathematical perceived competence, as they discovered their ability to learn independently and solve problems without immediate teacher support.

Students described how successfully navigating the transition to online learning bolstered their confidence in their mathematical abilities. Eighteen out of 24 students reported that as they adjusted to remote learning, they gained a stronger sense of self-efficacy, realizing they were more capable in mathematics than they had previously believed. Hiba reflected on this realization:

At the beginning of the COVID period, I missed some math materials and wanted to ask the teacher for **individual lessons**, but I kept postponing it ... In the end, I **had to understand** the material on **my own** without the teacher's help! **Then I saw** that I **can** indeed do math, that I have a **good ability** ... I didn't know this before.

While many students experienced a positive shift in perceived competence, six students reported that the challenges of remote learning had the opposite effect,

leading to a decline in their confidence in mathematics. These students struggled particularly with concentration difficulties, which hindered their ability to engage effectively with mathematical content. Shlomo described how distractions in the remote learning environment negatively impacted his learning experience:

It's really quite difficult because it's hard to understand what the teacher is explaining and what's going on during the lesson through the computer screen ... It's much harder than in the classroom... There are all kinds of distractions on the side that can interfere and various other things as well ..." ... "No, not at all! Sometimes I would completely lose it and feel like I had become bad at mathematics. I would get failing grades (60s) and all sorts of scores like that.

Overall, students' perceptions of their mathematical competence shifted in different directions during remote learning. For most, the experience of overcoming challenges and adapting to independent learning strengthened their confidence in mathematics. However, for a smaller group, difficulties with focus and engagement led to a decline in their perceived competence. These differences show how the effectiveness of remote learning varies depending on students' ability to manage distractions and maintain self-discipline.

Dimension 3. Emotional disposition towards mathematics

The third dimension explores students' emotional expressions toward mathematics, as a subject as well as in specific learning and teaching contexts. By comparing their experiences before and during the pandemic, this analysis explores the evolution of students' emotional relationship to mathematics in response to the transition to remote learning. The analysis identified one central theme: The depth of the connection to mathematics. This theme reflects students' general perspectives on the subject and captures their affective responses to learning situations in both traditional and remote environments. This exploration provides insight into how students' emotional engagement with mathematics may have shifted during the pandemic.

The depth of relationship to mathematics: This theme emerged across all 24 student interviews, revealing nuanced emotional tendencies toward mathematics before and during COVID-19. Most students (17 out of 24) emphasized that their feelings about mathematics remained stable, regardless of the shift from face-to-face to remote learning. For them, the emotional connection to mathematics was not dependent on the teaching format but rather on their intrinsic perspectives on the subject.

Hiba captured this perspective when asked whether her feelings toward mathematics had changed during the COVID-19 period:

No ... Even though I had some setbacks and didn't get satisfactory grades on all the tests ... I never thought that because of this I would hate mathematics. I remained the same ...

A small subset of students experienced shifts in their mathematical affect: five students reported an increased affinity for mathematics during remote learning, while two students expressed a decreased enjoyment of the subject. This variation in emotional responses to remote learning is exemplified by contrasting student experiences. For instance, Saker expressed a positive shift in his perspective on mathematics:

It [my attitude] improved because of the digital tools and computerized learning that I connected with very much, which gives me a feeling of learning through games ... That's why I loved mathematics more because of these tools during the COVID period, to the extent that when the teacher gives us computerized homework assignments, I am very happy.

Conversely, Keren reported a negative impact on her enjoyment of mathematics:

The truth is that now, because of Zoom, it has caused me to like mathematics a little less!

These contrasting experiences highlight the diverse ways in which remote learning affected students' emotional connections to mathematics, with some finding new enthusiasm through digital tools while others struggled with the virtual format. These findings suggest that while students' learning experiences were affected by the transition to remote education, the core emotional attachment of most students to mathematics—whether positive or negative—remained predominantly unchanged.

Summary of findings on students' perspectives concerning mathematics: The findings reveal a complex interplay between stability and change in students' perspectives during the transition to remote learning. While students' core perspectives on mathematics as a discipline remained stable, their experiences of learning and teaching underwent notable shifts. Many students reported greater accessibility to learning materials, increased responsibility, and enhanced self-reliance, which contributed to a stronger sense of competence in mathematics. Successfully adapting to remote learning helped them develop independent learning strategies, thus reinforcing their confidence in their mathematical abilities. However, others struggled with concentration, engagement, and the lack of direct teacher interaction, which in some cases led to a decline in their perceived

Table 1. Distribution of students across perspective profiles and shift variations in their perspectives on mathematics

Profile name	Positive	Mixed	Negative
Number of students in each profile	9	11	4
Range of themes in green (out of ten themes, indicating increased positivity in students' perspectives during the pandemic compared to beforehand)	4-9	3-6	2-5
Range of themes in yellow (out of ten themes, indicating no change in students' perspectives during the pandemic compared to beforehand)	0-6	1-5	2-3
Range of themes in red (out of ten themes, indicating increased negativity of students' perspectives during the pandemic compared to beforehand)	0-0	1-2	3-5

competence. Despite these varied experiences, students' emotional connection to mathematics remained unchanged—those who enjoyed the subject continued to do so, while those who felt disconnected from mathematics did not report shifts in their attitudes due to remote learning.

Overall, the findings highlight how students' engagement with mathematics appears to be shaped more by the learning environment than by their fundamental views of the subject.

The next section explores three distinct student profiles—positive, mixed, and negative—which illustrate the different ways in which students navigated the challenges and opportunities of remote mathematics learning.

Profiles of Students: Comparing Perspectives on Mathematics Before and During Remote Learning

To further analyze the variations in students' perspectives, participants were categorized into three perspective profiles as reflected in their statements: positive, mixed, and negative. These profiles offer insight into the extent to which students adapted to the transition to remote mathematics learning, capturing both the challenges and opportunities they experienced.

Students were assigned to profiles based on their responses across twelve key themes, which were coded to indicate positive shifts (green), no change (yellow), or negative shifts (red) in their perspectives on mathematics.

1. **Positive profile:** Students who exhibited no negative shifts (no red-coded themes).
2. **Mixed profile:** Students who demonstrated a balanced response, with one to two red-coded themes alongside positive (green-coded) and stable (yellow-coded) perspectives.
3. **Negative profile:** Students who exhibited 3-5 red-coded themes, reflecting a significant decline in their perspectives during remote learning.

Table 1 summarizes the distribution of students across these three perspective profiles and presents the number of themes in which each student showed a positive, no change, or a negative shift.

This classification framework highlights the diversity of students' experiences, capturing both their

engagement and emotional responses, as well as changes in their perceived competence and attitudes toward mathematics throughout remote learning.

In addition to these perspective shifts, students' general perspectives on the importance and nature of mathematics are visually represented using shades of gray, ranging from dark gray (high importance and strong appreciation for mathematics) to light gray (lower perceived importance and greater challenges with mathematics).

To illustrate these profiles in greater depth, three representative student cases are presented: Mary (positive profile), Hiba (mixed profile), and Keren (negative profile). These cases exemplify the dominant trends within each category, offering concrete insights into how individual learners navigated the transition to remote mathematics learning during the COVID-19 pandemic in Israel.

Before delving into each case, **Figure 1** presents a comparative, color-coded summary of their perspective shifts across the ten themes, providing a quick reference for how their perspectives evolved before and during remote learning.

Profile 1. The positive profile

This profile includes students whose perspectives on mathematics either improved or remained stable during remote learning. Nine out of 24 participants fell into this category, representing a mix of strong and average performers, as assessed by their teachers.

Example. Mary's story: Mary exemplifies the positive profile. Her perceptions across the study's three dimensions are outlined below, supported by illustrative quotes. **Figure 1** presents a framework for characterizing the perspectives of Mary as part of the positive profile.

Dimension 1. Perspectives on mathematics, its learning and teaching

Perceptions of mathematics: Mary views mathematics as dynamic, logical, and deeply relevant. She describes it as a "complex puzzle" that challenges creativity and problem-solving skills:

Mathematics is like a complex puzzle with many interconnected pieces. At first glance, it may seem overwhelming, but as you delve deeper, you discover an elegant structure and logic. What I

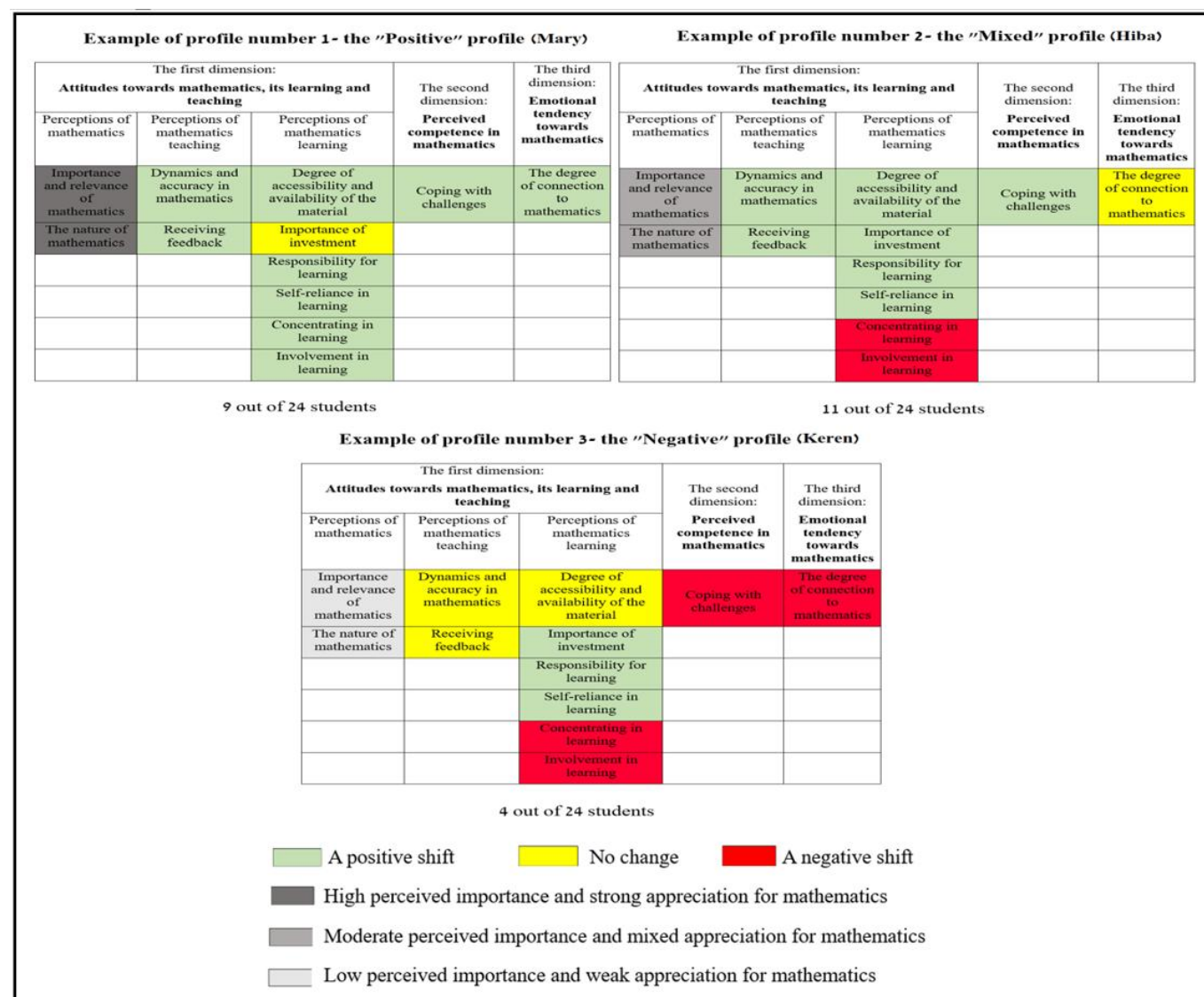


Figure 1. Representative student profiles: changes in perspectives on mathematics during remote learning (Source: Authors' own elaboration)

love most about math is how it challenges you to think creatively and approach problems from different angles. It's not just about memorizing formulas; it's about understanding the underlying principles and applying them in diverse situations.

She also emphasizes the importance of mathematics for cognitive development and future opportunities:

It contributes to elevating one's thinking ... In the future, it's important to have mathematics at the 5-unit level for academia or various fields of work.

Perceptions of mathematics teaching: Mary highlighted how the integration of digital tools in remote learning enhanced both the precision of mathematical representations and her understanding of dynamic concepts. She particularly appreciated the use of GeoGebra and Desmos software, which helped her

visualize transformations and analyze functions more effectively:

Now I understand mathematics better; for example, I understand dynamic drawings more than on the board in geometry. I understand the graphs better in the analysis due to the GeoGebra and Desmos applications and how the function behaves more than the drawing on the board.

Beyond visualization, Mary also emphasized the substantial improvement in the quality and frequency of teacher feedback during remote learning, particularly due to the use of computerized tasks:

Computerized tasks provide immediate and detailed feedback on my performance, helping me understand mistakes and improve my understanding. They allow me to check my answers before submitting them, which is not typically possible in regular classes.

Perceptions of mathematics learning: Mary highlighted the increased availability of recorded lessons and teacher-provided summaries during remote learning significantly improved her ability to review and reinforce mathematical concepts:

When the Zoom lesson is finished, the teacher immediately sends us the summary. This way, I can review each sub-topic without waiting until the end of the unit.

Mary emphasized that mathematics has always required effort and dedication, and her commitment to investing time in the subject remained unchanged during remote learning:

For me, the importance of mathematics remained the same.

However, she noted that the remote setting increased her sense of responsibility for learning, as she had to take greater initiative to review material and bridge gaps independently:

On Zoom, the teacher would summarize all the material and send it to us, but it was my responsibility to go back to the materials and study on my own if I missed something or didn't concentrate during the lesson. Remote learning made me realize I needed to take greater initiative to ensure I fully understood the material.

Mary also highlighted how remote learning reinforced her ability to work independently and solve problems on her own, rather than relying on immediate teacher assistance:

Before COVID-19, if I had difficulty with something, I would wait until the next day to ask the teacher. Now, I use the summaries and materials the teacher sent us and figure it out myself.

Mary found that her concentration improved during remote learning due to the structured environment and the availability of resources:

The fact that all the material was organized and accessible to me on Zoom allowed me to concentrate better during the lesson, because I knew that if I missed something, I could go back to it later, and that reduced my stress and gave me peace of mind to learn.

Finally, Mary reported that her engagement in class discussions and participation increased in the online format. She found Zoom lessons less intimidating, which made her more willing to contribute:

I felt more comfortable speaking on Zoom because no one could see me; therefore, I could speak and express myself in a better way ... I also had more opportunities to participate because fewer students were active. It may also be because I understand the material better in Zoom classes, and it motivates me to cooperate more.

Dimension 2. Perceived competence in mathematics

Mary reported a positive shift in perceived competence, attributing it to available resources and independent study:

There was always material I could return to or review, which helped me feel more confident in my understanding. When we returned to school, we took an exam covering everything we had learned through Zoom, and it wasn't difficult for me. In fact, most of the class, including myself, achieved high marks, which made me realize how much I had improved.

Dimension 3. Emotional tendency towards mathematics

Mary's emotional connection to mathematics strengthened during remote learning:

This period increased my love for mathematics. Mathematics became more enjoyable in Zoom lessons, more than it was in school ... Contrary to what I had expected, remote learning turned out to be better for understanding the material.

Summary of Mary's experience

Overall, Mary's experiences exemplify the positive profile, as she consistently demonstrated a shift toward higher perceived competence, a stronger emotional connection to mathematics, and greater appreciation for the advantages of remote learning. Like Mary, other students in this category experienced increased engagement, a growing sense of self-reliance, and a more positive outlook on mathematics, highlighting how remote learning reinforced their confidence and deepened their engagement in the subject.

Profile 2. The mixed profile

The mixed profile includes students whose perspectives on mathematics exhibited both positive and negative shifts during remote learning. While certain aspects of their perceptions improved, others either remained stable or declined.

Of the 24 participants, 11 fell into this profile. These students represented a range of achievement levels, including strong and average performers, as well as two students who struggled with mathematics, as assessed by their teachers. Their experiences reflect the nuanced and varied impact of remote learning, highlighting both the opportunities and the challenges it presented.

Example: Hiba's story: Hiba is a representative of the mixed profile, Displaying both positive and negative shifts in her perspectives on mathematics during remote learning. Her views are outlined below across the three study dimensions, supported by illustrative quotes. **Figure 1** summarizes her profile.

Hiba is student with moderate achievement in mathematics; her experience captures the complexity of the mixed profile. While she developed a stronger sense of self-reliance and responsibility, she also faced difficulties in concentration and engagement. The following analysis explores her perspectives across the three dimensions of the study.

Dimension 1. Perspectives on mathematics, its learning and teaching

Perceptions of mathematics: Hiba views mathematics as a challenging subject that requires perseverance and daily effort:

In mathematics, if you don't practice and persist, even during breaks, you forget the material or get confused. That's why you need to practice mathematics every day.

She also recognizes its universal significance:

Mathematics is the most important subject that we can't live without. It's a global subject with practical relevance in all aspects of life.

Her perception of the importance of mathematics remained stable, as she continued to see it as a valuable and necessary discipline both before and during remote learning.

Perceptions of mathematics teaching: Hiba found that remote lessons enhanced certain aspects of mathematics instruction, particularly the use of dynamic tools such as GeoGebra and Desmos, which helped her understand functions and transformations more effectively:

The teacher presents a function and shows us through GeoGebra how its graph looks and behaves dynamically, which makes it easier to understand. This helps us grasp the material more deeply.

However, her preference for learning tasks was mixed. She appreciated immediate feedback from digital tasks, but still preferred traditional paper-based tasks for exam preparation:

I liked the digital tasks because they were shorter and gave feedback, but the notebook tasks were more useful for preparing for exams.

This contrast highlights how remote learning introduced new tools that improved understanding but also presented limitations in preparing for assessments.

Perceptions of mathematics learning: During remote learning, recorded lessons and written summaries became essential tools for Hiba, allowing her to review difficult content at her own pace:

The teacher sent us videos and explanations. This helped me a lot because when I didn't understand something, I could go back and repeat the videos.

Remote learning also increased her awareness of the need to invest more time in mathematics:

Before COVID-19, I didn't repeat the material much, but during this period, I realized how important it was to practice consistently.

Hiba developed a greater sense of responsibility for her learning, as she could no longer rely on immediate teacher guidance and needed to take more initiative:

I feel that during the COVID-19 period, my personal responsibility for learning increased, which wasn't the case before ... During the COVID-19 period, a person undergoes changes because they feel alone and need to understand things on their own.

Similarly, she became more independent in problem-solving, recognizing that she had to attempt solutions before seeking help:

It was not like this before. I had to take the initiative and solve things myself, and that made me realize I could handle more than I thought.

However, despite these positive shifts, Hiba faced significant challenges with concentration during remote learning. The absence of face-to-face teacher interaction made it difficult for her to stay engaged:

It's not easy to sit in front of a screen for two hours and concentrate. In class, the teacher sees us and knows if we understand, but on Zoom, it's harder to stay focused and ask questions.

Additionally, she participated less in remote lessons because the pace of instruction was too fast, making it difficult to take notes and engage actively:

In class, the teacher gives us time to copy and understand before asking questions. On Zoom, it's harder because the teacher assumes we'll take screenshots, but it takes time to process everything before answering.

Hiba noted that during the remote-learning period, the absence of the teacher's daily physical presence pushed her to rely more on herself when learning mathematics. Unlike before the pandemic, when she could easily ask for clarification in class, remote learning required her to independently review materials and

attempt solutions before seeking help. This shift strengthened her self-reliance:

Before COVID-19, it was easier for me to go directly to the teacher and understand the material with her help. During this period, I learned to rely on myself more, which also made me more responsible in learning mathematics.

This further reinforced the duality of her experience: while remote learning enhanced her independence and problem-solving skills, it also challenged her ability to stay engaged and participate actively.

Dimension 2. Perceived competence in mathematics

Hiba's perceived competence in mathematics increased during remote learning as she navigated challenges independently and gained confidence in her ability to solve problems without immediate teacher support. While she initially struggled with adapting to the new learning environment, she discovered her ability to learn on her own:

At first, I struggled with some topics and wanted to ask the teacher for individual lessons, but I ended up figuring it out on my own. That's when I realized I actually have good ability in math.

This shift illustrates how overcoming obstacles during remote learning reinforced her faith in her own mathematical abilities, even in the absence of traditional classroom support.

Dimension 3. Emotional disposition towards mathematics

Hiba's emotional connection to mathematics remained stable despite challenges she faced with concentration and engagement, during remote learning:

Even though I struggled with some tests and didn't always get high grades during remote learning, I never felt like I hated math because of it—I still liked it just as much.

Summary of Hiba's experience: Overall, Hiba's experience exemplifies the mixed profile, reflecting both positive and negative shifts in response to remote learning. She became more responsible and independent in learning mathematics but struggled with concentration and active participation. Her case illustrates the complexity of the mixed profile, where students recognized both the benefits and limitations of remote learning, ultimately shaping a nuanced perspective on mathematics education.

Profile 3. The negative profile

This profile includes students whose perspectives on mathematics became less positive during remote learning compared to the pre-pandemic period. Students in this profile exhibited a decline in multiple themes,

with a relatively less positive perspectives overall. Four students belong to this profile, consisting of two strong performers and two average performers in mathematics, as assessed by their teachers.

Example: Keren's story: Keren exemplifies the negative profile, highlighting the challenges she encountered during remote learning. Her perspectives are summarized in [Figure 1](#), as part of the negative profile.

Dimension 1. perspectives on mathematics, its learning and teaching

Perceptions of mathematics: Keren's fundamental perception of mathematics as a stable and structured subject remained unchanged:

It's still mathematics, it's the same thing, it doesn't change; that's what's cool about it.

She continued to view mathematics as essential for academic and career success, but questioned its broader relevance to everyday life:

To succeed in the future and get a good profession, yes, but for life itself, I don't think it will really help.

Perceptions of mathematics teaching: For Keren, remote learning did not introduce significant changes in the way mathematical content was taught, as her teacher had already been incorporating GeoGebra and Desmos software before the pandemic:

Even before the pandemic, the teacher used programs like GeoGebra and Desmos to illustrate mathematical concepts, making them dynamic and accurate. This approach continued unchanged during remote learning on Zoom, using the same methods.

Similarly, her experience of receiving feedback remained stable, as her teacher provided consistent assessments both before and during remote learning. Keren noted that while the assessment format changed—shifting from regular paper-based evaluations to digital tasks—the frequency and impact of the feedback she received remained the same:

Before the pandemic, the teacher also assessed three papers a week ... now there are the computerized tasks ... it's the same thing.

Perceptions of mathematics learning: Keren did not perceive a substantial change in the availability of learning materials, as her teacher had regularly provided resources and summaries before the transition to remote learning:

Even before the coronavirus, the teacher would explain everything and give us the material we

needed. It was always available to us, so on Zoom, nothing really changed in this respect.

However, remote learning significantly disrupted her concentration, making it difficult for her to remain engaged:

While you are on Zoom, you can be busy with many other things, so it is very difficult to concentrate, and it really sucks.

Her difficulty in concentrating negatively impacted on her participation in class, as she struggled to comprehend the material:

Because it is hard for me to concentrate, I cannot understand the material, so how can I participate in the lesson? How can I answer the teacher's questions?

Due to these struggles, Keren admitted that remote learning required her to invest more effort in her studies to compensate for missed material:

The importance of learning and investing in mathematics has, of course, increased because we need to invest more in it now because of the coronavirus.

With the teacher less accessible for immediate support, Keren had to take greater responsibility for reviewing and reinforcing her understanding:

It is really quite difficult because it's hard to understand what the teacher is explaining and what is going on during the lesson through the computer and the screen ... there are all kinds of distractions that can get in the way. Yes, you have to constantly study math, repeat it as much as possible.

Although she found this process challenging, she acknowledged that it made her more proactive in her learning:

I think the remote learning made me learn more. Before that, I might have been able to do it too, but I didn't, because I didn't feel the need to as much as I do now.

Similarly, she developed greater self-reliance, as she could no longer rely on the teacher's immediate guidance:

I try to solve [problems] by myself more, there is no teacher now. I think remote learning pushed me to rely on myself more than before.

Dimension 2. Perceived competence in mathematics

Despite previously feeling confident in mathematics, Keren's struggles with concentration and understanding

during remote learning led to a decline in her perceived competence:

I've always considered myself good at math, but with these Zoom lessons, it's been harder to focus, and that's made me feel like I'm not performing as well as I used to.

Dimension 3. Emotional tendency towards mathematics

Keren reported that remote learning negatively impacted her emotional connection to mathematics, making her feel less engaged with the subject:

The truth is that now, because of the Zoom lessons, I like math less!

Summary of Keren's experience: Keren's experience exemplifies the negative profile, as her perspectives on mathematics became less positive during remote learning. Her difficulty in concentrating during online lessons not only made learning more frustrating but also led to decreased participation and involvement in class activities. As a result, she struggled to understand the material, which further reduced her engagement and sense of competence in mathematics. While Keren developed greater responsibility and self-reliance, these shifts were largely out of necessity rather than preference. Although she acknowledged certain benefits, such as increased independence, these were accompanied by a notable decline in her enjoyment of mathematics and her perceived connection to the subject. Like other students in this profile, Keren experienced significant challenges in adapting to remote learning, with fewer benefits compared to students in the other profiles.

DISCUSSION AND CONCLUSIONS

This study examines the perspectives of 24 11th grade students enrolled in advanced-level mathematics in Israel, comparing their reflections on remote learning during the COVID-19 school closures with their prior experiences in face-to-face instruction. While the data were collected in the context of the pandemic, the focus of this research is remote mathematics learning as an educational disruption with continuing relevance for hybrid and emergency contexts. Guided by Di Martino and Zan's (2010) three-dimensions model-vision of mathematics, perceived competence, and emotional disposition—we analyzed how students described changes in their perspectives when transitioning to remote learning. The following discussion highlights the key findings and their implications.

By analyzing student profiles, we identified distinct patterns in students' perspectives on mathematics during remote learning compared to pre-pandemic conditions. These profiles illuminate how students adapt

to major educational transitions—a recurring challenge in systems increasingly adopting digital learning formats.

The *positive profile*, exemplified by students like Mary, reflects a group that maintained or even strengthened their positive perspectives on mathematics during remote learning. These students, typically high achievers with strong perceived self-efficacy, demonstrate resilience and adaptability, leveraging the digital learning environment to enhance their engagement with mathematics. Their ability to navigate the transition successfully suggests that remote learning, when supported with appropriate resources and instructional strategies, can reinforce mathematical confidence and self-reliance. The implications for mathematics education are significant, as understanding the characteristics of these students can inform targeted strategies to foster positive mathematical perspectives in broader student populations, particularly in digital or hybrid learning contexts.

The *mixed profile*, represented by students like Hiba, illustrates a more complex and variable response to remote learning. Students in this profile reported both positive and negative shifts across different themes, highlighting the multifaceted nature of learning mathematics remotely. While increased self-reliance and responsibility were perceived as benefits, these students also faced concentration and engagement challenges due to home-based distractions. The mixed profile emphasizes that students' responses are not uniform but shaped by the interaction between learning habits, instructional methods, and the challenges of the remote format. These findings suggest that adaptive teaching approaches, which accommodate both strengths and areas for improvement, are particularly relevant for this group.

The *negative profile*, exemplified by students like Keren, highlights the most significant struggles in adapting to remote mathematics learning. Despite sometimes having high perceived competence, these students experienced a decline in positive perspectives across multiple themes. Their experiences point to the critical importance of face-to-face interaction and direct teacher support in fostering mathematical engagement. The challenges described by students in this profile raise concerns about the long-term implications of extended remote learning for students who struggle with motivation and self-discipline in digital environments. This profile emphasizes the urgent need for strategies that mitigate the negative effects of reduced teacher presence, such as structured interventions, more interactive digital tools, and increased opportunities for real-time feedback and student-teacher interaction.

A key distinction among the profiles lies in students' perceptions of the nature and relevance of mathematics. Students in the positive profile tended to describe mathematics as dynamic, logical, and broadly

applicable, reinforcing their intrinsic motivation to engage with the subject (Hu & Ma, 2022). In contrast, those in the negative profile often viewed mathematics as static and primarily valuable for future academic or career purposes only, a belief associated with lower engagement and motivation (Broda et al., 2023; Hossein-Mohand & Hossein-Mohand, 2023). The challenges of remote learning—particularly the reduction of face-to-face teacher presence and direct interaction—further compounded these negative perspectives (Abdulah et al., 2025). Together, these findings suggest that students' core beliefs about mathematics, in interaction with contextual factors such as teacher presence and opportunities for dialogue, may influence their ability to adapt to changes in instructional format. This highlights the need for further exploration of how mathematical perspectives shape learning experiences across diverse educational contexts.

While the study revealed various perspectives across different student profiles, certain challenges associated with remote learning were particularly pronounced among students in the mixed and negative profiles. These students more frequently reported decreased engagement and struggles with concentration during remote mathematics lessons, attributing these struggles to the lack of physical teacher presence, eye contact, and non-verbal cues. These findings differ from Attard and Holmes' (2022) study, which suggested that remote learning improved teacher-student communication; yet it aligns with recent research by Abdulah et al. (2025), who emphasize the critical role of teacher presence and meaningful student interactions in fostering engagement and overcoming challenges in online mathematics education.

Notably, the decrease in engagement was not solely linked to mathematical ability or pre-existing perspectives on the subject, but also by environmental and technological factors inherent to remote learning. Many students from the mixed and negative profiles described feeling hesitant to unmute their microphones due to background noise and reduced confidence in participating due to missed material or lack of clarity. These examples illustrate how contextual barriers limited active engagement. Such findings align with Abdulah et al. (2025), who emphasize that deficits in social interaction, unequal access to resources, and limitations in digital design strongly influence student engagement and motivation in online mathematics education. Together, these results underscore the complexity of remote learning: digital platforms alone cannot guarantee engagement. Effective strategies must ensure not only technological access but also foster interpersonal interaction and address the specific conditions of learners' environments.

Despite these challenges, the study also revealed positive developments across all three profiles. Most notably, the accessibility of digital resources—such as

recorded lessons and structured resources available on digital platforms- supported independent review, better time management, and more informed decision-making. Students repeatedly emphasized that these resources enhanced their sense of ownership over learning. These findings resonate with Çağırğan and Soytürk (2021), who identify autonomy and resource access as critical to academic success in mathematics, and with Ambarsari and Wahyuni (2022), who underscore the role of online environments in promoting discipline and self-regulation. Our study extends these insights by demonstrating how structured digital resources not only facilitates self-directed learning but actively enhances students' sense of ownership and responsibility in mathematics.

Another key theme that emerged was the intensification of self-reliance in mathematics learning among students during remote learning. Many reported that the absence of daily face-to-face teacher interactions motivated them to exert greater effort independently. They shifted from seeking immediate help to persisting with problem-solving autonomously before soliciting assistance, a change attributed to the nature of remote learning where teacher support was less immediately accessible. This shift facilitated the development of stronger problem-solving strategies and greater perseverance in tackling complex mathematical tasks, aligning with Wang et al. (2024) definition of self-reliant learners; i.e., those who engage in metacognitive monitoring and self-directed learning. They also corroborate Wege et al.'s (2022) research, which found that many students demonstrated higher levels of independence in online learning. Our study contributes by specifying how remote learning conditions in mathematics can foster this self-reliance.

A particularly striking finding was that 18 out of 24 students reported an increase in their perceived mathematical competence during remote learning, crediting their growth to intensified effort and responsibility. Despite initial concentration difficulties during online lessons, many students invested additional time in independent problem-solving, leading to academic growth and enhanced confidence. Such self-reported improvements affirm Julaihi et al. (2022), who found that moderate to high levels of perceived competence, linked to increased autonomy and self-regulation during remote learning environments.

Lastly, regarding emotional disposition toward mathematics, the findings indicate that most students did not experience a shift in their feelings toward the subject due to remote learning. In their interviews, students emphasized that their enjoyment of mathematics remained stable, independent of the instructional format. This emotional continuity aligns with Doz et al. (2024), who emphasize the durability of positive emotional tendencies and resilience in

mathematics learning amid instructional changes. These findings indicate that while learning conditions can shape students' engagement and perceived competence, deep-rooted emotional tendencies toward mathematics are more predictable over time, even when transitioning between different educational environments.

Overall, this study provides a nuanced understanding of high-school students' perspectives on remote learning in mathematics. The three profiles- positive, mixed, and negative-illustrate the diverse ways in which students navigated the transition from classroom to remote learning. While some adapted effectively, demonstrating increased self-reliance and responsibility, others struggled with concentration, engagement, and motivation in the absence of face-to-face support. Across profiles, students reported an increased sense of responsibility for their learning and greater self-reliance in problem-solving, largely attributed to accessible recorded lessons and digital resources that enabled flexible, self-paced review. However, many students also shed light on difficulties with maintaining concentration, reduced participation due to the absence of direct teacher-student interactions, and challenges stemming from the digital nature of learning, such as a lack of immediate feedback on their problem-solving processes, their failures, and successes. These insights reinforce the complexity inherent of remote mathematics education and point to the urgent need for instructional designs that balance technological accessibility with sustained interpersonal interaction and timely, meaningful feedback. Importantly, they also emphasize that students differ in how they adapt, underscoring the necessity of differentiated strategies that can support a range of learner needs in digital and hybrid settings.

From a theoretical perspective, this study builds upon Di Martino and Zan's (2010) framework by applying it to a remote mathematics learning context. The findings highlight the interplay between students' vision of mathematics, their perceived competence, and their emotional disposition, and show that prior perspectives strongly shaped students' ability to adapt. Those with higher perceived competence maintained or even strengthened their perspectives, while those with lower perceived competence experienced greater challenges-underscoring the central role of self-efficacy in adapting to new instructional formats (Zakariya, 2022).

A particularly novel contribution is that students, regardless of initial perspectives, reported increased self-reliance and responsibility. This challenges the assumption that autonomy is linked only to positive dispositions (Longos & Regidor, 2022) and suggest that the remote learning itself acts as a catalyst for greater independence, even among students who experienced difficulties.

Another theoretical contribution concerns teacher presence. Contrary to claims that remote settings enhance communication (Attard & Holmes, 2022), our findings indicate that the absence of non-verbal cues and reduced immediacy undermined engagement. This points to the need for a more refined theoretical conceptualization of teacher presence in digital mathematics education—one that emphasizes the *quality* of interaction, including feedback and embodied cues, rather than frequency alone (Abdulah et al., 2025).

More broadly, the study highlights the critical role of learning environments in shaping both students' perspectives and their learning behaviors, emphasizing the need for instructional designs—whether remote or in-person—that foster engagement and autonomy. Such designs are essential to ensure that students not only remain actively involved in the learning process but also develop the self-management skills necessary to take ownership of their learning. In this way, the findings contribute to current theoretical and practical dialogues on how to design mathematics education that is both adaptable and inclusive.

Methodologically, the study employs a qualitative approach that provides a rich and nuanced exploration of students' perspectives during remote learning. By categorizing students into distinct perspective profiles and analyzing their experiences across three dimensions, the study offers a structured yet flexible framework for examining student perspectives in various learning environments. This profiling approach not only illuminates variation within the sample but also provides a potential model for future research on how students navigate educational transitions. Emphasizing students' own narratives underscores the importance of student-centered qualitative methodologies, which reveal insights that large-scale surveys might overlook. More broadly, this framework can be adapted to study student perspectives in both remote and in-person contexts, preserving the richness and complexity of individual experiences while supporting comparative analyses across settings.

From a practical standpoint, these findings offer several implications for mathematics education, particularly in designing learning environments that support student engagement and autonomy. First, the study suggests that remote learning environments can encourage greater responsibility and self-reliance, informing curriculum development by incorporating structured opportunities for independent learning. Ensuring that digital materials are well organized and consistently accessible is therefore essential. Such availability enables students to review, plan, and regulate their learning, and should be prioritized in both remote and hybrid curriculum design.

Second, the study underscores the need for flexible support systems that address diverse student profiles.

While some students benefited from the increased independence, others struggled with concentration and engagement in the absence of face-to-face interaction. Teacher training programs should therefore focus on strategies that balance fostering student independence with maintaining strong instructional presence, even in digital environments.

Third, the study highlights the importance of recognizing students' prior perspectives on mathematics. A one-size-fits-all approach is insufficient; differentiated strategies are needed to support learners with varying levels of confidence and motivation. This insight offers clear guidance for policymakers and educators aiming to design resilient and inclusive mathematics education that equips students not only with mathematical competence, but also with the skills to manage their own learning across diverse contexts.

This study has several limitations. The sample included only high-level mathematics students, potentially limiting generalizability. Future research should expand to include students across different performance levels, educational settings—including middle and high schools—and diverse ethnic and geographic backgrounds. Additionally, our reliance on self-reported data and the cross-sectional nature of the study limit conclusions about long-term effects. A longitudinal design could reveal whether the self-reported increases in a sense of responsibility and competence persist over time.

Although situated in Israel, the findings have broad global significance. Education systems worldwide may need to shift rapidly between in-person and remote learning in times of crises, making it crucial to understand students' experiences in cognitively demanding subjects like mathematics for both emergency preparedness and instructional design innovation.

Further studies should expand to include students across different performance levels, educational settings, and diverse ethnic and geographic backgrounds. Future work might also compare student reflections with teacher perspectives on engagement, providing a more comprehensive understanding of digital learning dynamics in mathematics education.

In summary, this study sheds light on the complex and diverse ways in which students experience mathematics learning in remote contexts. By outlining student profiles and identifying key perspective shifts, it demonstrates how Di Martino and Zan's (2010) model can be applied to an underexplored context and highlights the dual role of remote learning as both a challenge and an opportunity. The findings provide theoretical and practical insights for designing mathematics education that is more adaptive, inclusive, and resilient in a post-pandemic world.

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APPENDIX A: THE INTERVIEW WITH THE STUDENTS

The interview is a semi-structured personal one that focuses on the students' perspectives on:

- (1) mathematics, its learning and teaching,
- (2) their perceived competence in relation to mathematics, and
- (3) their emotional disposition towards mathematics.

The interview focuses on eight categories, each relating to a specific topic and including several questions on that topic. For convenience, each category was referred to as a "question card" (i.e., a set of questions on a particular theme). The categories (i.e., the topics of the question cards) are detailed below:

What characterizes math lessons during the COVID-19 period?

- (1) Does the student like math?
- (2) How does the student perceive the importance of learning mathematics?
- (3) How does the student perceive mathematics?
- (4) What would the student change in the math lessons if s/he were in the teacher's place?
- (5) Does the student think s/he is successful in learning mathematics?
- (6) What does the student do when s/he has difficulty?
- (7) What characterizes the student's participation in math classes?

In categories 1, 3, 4, 5, and 8 the students' answers were sorted according to the first dimension (mathematics, its learning and teaching). Categories 6 and 7 were sorted according to the second dimension (perceived competence in relation to mathematics) while category 2 was sorted by the students' answers according to the third dimension (the emotional disposition of the students towards mathematics).

Below are the interview questions:

Hello,

My name is Suha, and I want to ask you some questions about mathematics and your math lessons ... I want to learn from you today to improve myself (smile) ... I want to ask you some questions, and I would be very happy if you cooperate with me ...

Thank you for taking the time to answer my questions.

- How are you during this period of time?
- Tell me, why did you choose to study math at the 5-unit [highest] level?
- Was there something specific (or someone or an event) that made you want to study math at the 5-unit level?

Since you were in the first grade and up until mid-March of 2020, when COVID-19 broke out, you studied at school, in a physical classroom. however, from mid-March you had to switch to remote learning.

I would like to learn about your experience throughout this special period of time. We teachers would like to hear about your learning experience, so we can improve our teaching methods. I will ask you some questions, and I would be happy if you would help me and answer the questions in detail and tell me everything you know.

Question Card Number 1

- Tell me about your recent math class routine ... If a student came from another world where there is no COVID-19 and asked you how math is taught here now, what would you tell him?
- How many math lessons per week are there via "Zoom"/in-person lessons in the classroom/ asynchronously (e.g., through Google Classroom)?
- What do you usually do in "Zoom" lessons? What do you do in class? What do you do asynchronously? Please elaborate and give examples.
- What tasks do you get in math? computerized? from the book? Are the assignments more interesting to you than they were before the COVID-19 pandemic, in normal learning? Please elaborate and give examples.
- What do you write in the chat in the "Zoom" classes? What activities are usually done in remote classes? Discussions? Breakout rooms? Activities? Do you receive research problems in math?
- Are technological tools used? How is it different from before?
- In your opinion, is there something special that you're experiencing now in mathematics? Please elaborate and give examples.

Question Card Number 2

- Let's not think specifically about the COVID-19 pandemic ... in general, do you like mathematics?
[if answered "yes"]
- What do you like about mathematics? Please elaborate and give examples.
- Can you recall a specific event that made you like mathematics?
[if answered "no"]
- What do you think needs to change so that you can enjoy mathematics?
- Can you recall a specific event that made you dislike mathematics?
- Can you point to something that has changed in terms of your attitude to mathematics following the COVID-19 pandemic?
- If mathematics were food, what kind of food would it be? Why? Has it changed from what it was before?
- If mathematics were an animal, what animal would it be? Why?

Question Card Number 3

- Do you think learning math is important?
- [If so ...] In what way is it important? Please elaborate and give examples.
- [If not ...] In what way is it not important? Please elaborate and give examples.
- (If answered in general terms, I will direct the student to answer about himself personally, and vice versa.)
- Do you think that because of this change, learning mathematics remains at the same level of importance for you?

Question Card Number 4

- I have asked many high-school students and adults, and it made me realize that they view mathematics in different ways. How do you view mathematics?
- Is there anything now, following this period, that has changed in your perception of mathematics, or regarding certain mathematical topics, such as geometry, algebra, calculus?
- Do you regard mathematics in this period as a different way than before? how? Please elaborate and give examples.

Question Card Number 5

- If you were a teacher, what would you do differently, and why?
- What would you ask your math teacher to do so that you do well in math classes?
- Let's say COVID-19 passed from the world, would you like to stay in this kind of remote learning? What would you change? What teaching method, and why?
[If I concluded that it does not relate to the current teaching method]
- How do you deal with the current teaching method in mathematics?
- If we now went back to normal in-person learning, how would you feel?
- When we return to normal learning soon, what would you like to preserve and continue from the remote-learning method? What would you like to stop?
- Suppose it were possible to go back in time, to the beginning of the 10th grade, and suppose you knew then that learning would be like it is now (remote learning), would you still choose to study math at the 5-unit level? Why or why not?

Question Card Number 6

- Do you think you are good at math?
[If the student answered that he is doing well in math]
- Have you always been good at math since you were little?
If not, what happened that made you feel that you are doing well in math? Was there a particular experience?

- Can you tell me about a time you remember not being good at math? When was it? Why do you think you didn't do well in math then? How do you explain that it didn't affect your being good at math now?

[If the student answered that he is not doing well in math]

- Have you not done well in math all the time since you were little?
- If not, what happened that made you feel that you are not doing well in math? Was there a particular experience?
- Can you tell me about a time you remember when you were good at math? When was it? Why do you think you did well in math at the time?

Guiding questions:

- Do you think you are good/bad at math related to how much you invest in math? Perhaps your teachers? Support from home? Something else?
- Is it perhaps related to the teaching method? Please elaborate and give examples
- Do you think this period affected how you do in math? Please elaborate and give examples.

Question Card Number 7

- What do you do when you have trouble with math?
- Do you get help from the teacher? From friends? From the books? From websites? Or from another source?
- In what cases/situations do you seek outside help?
- Please tell me about getting help in math in this period and also in the period before COVID-19
- Is there a change in your actions/behavior in this matter? If so, please elaborate and give examples.

Question Card Number 8

- How do you regard your participation in the lessons? On Zoom (participation during live online lessons; e.g., asking and answering questions, taking part in discussions)? In tasks (participation in completing assignments or exercises given by the teacher)? In the math activities (participation in any special math-related activities, such as projects, games, or competitions organized as part of the lessons)? In a group (participation in group work or collaborative activities with classmates, either online or in person)?
- Is it different than it used to be? Please elaborate and give examples.
- Has your opportunity to participate in lessons, discussions, activities changed from what it was before? On Zoom? Working in groups with/without the teacher? In whole-class work? Please elaborate and give examples.
- In which of the above are you more active? Please elaborate and give examples.
- If math class was a party, where would you sit? Would you participate? Dancing? What would you do? And why?

Is there anything else you would like to tell me?

Thank you very much for your cooperation. I learned a lot from you.

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