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Subject-Specific Responses to Educational Disruption: Analysis of Mathematics and Science Performance in a Bruneian Primary School

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Abstract
Between 2018 and 2024, Mathematics and Science results from a Brunei primary school show interesting patterns. The results fall into three groups: those from regular school days (2018-2019), those during COVID disruptions (2020-2021), and those after returning to classrooms (2022-2024). Each period showed different patterns in how students performed in these two subjects. Breaking down the data this way helped show which teaching methods worked best during normal schooling versus during disruptions. The research applies frameworks from constructivist learning, technological integration, and assessment practices to understand how teaching strategies affected student attainment during educational disruption. Results show Science maintained stronger resilience, with post-pandemic pass rates staying between 89-93% and improving alignment between practice tests and final examinations. Mathematics demonstrated greater vulnerability, with more variable performance before stabilising around 75%. During 2021, when alternative assessment methods were used, both subjects achieved perfect pass rates, though this effect was temporary. The stark difference between subjects suggests fundamental variations in how Science and Mathematics education respond to disruption. The study suggests teachers should consider different approaches for each subject in Brunei's schools. Making Mathematics lessons more connected to real-life situations and ensuring classroom activities better match test requirements could help students perform more consistently. With these improvements, students would likely develop stronger skills needed for their future studies and careers in technical fields.

Keywords: Mathematics Education, Science Education, Brunei Darussalam SPN21, Teaching Strategies, Assessment Methods, Educational Resilience

1. Introduction

Education in Mathematics and Science serves as a cornerstone for developing young minds in Brunei's educational setting. These two subjects prepare students with essential skills that support continued academic advancement, address daily challenges and enhance lifelong learning. The national education system stresses high-quality instruction, promotes lifelong learning and prepares students to face 21st-century challenges with adaptability and confidence.

Research conducted by Timbang and Chin in 2019 at Haji Mohd Jaafar Maun Primary School revealed declining achievement patterns among Year 6 students. Mathematics results fell from 73.9% (2018) to 61.1% (2019), whilst Science dropped from 91.3% to 83.3% in the same period. Though Science maintained higher overall pass rates, both subjects showed concerning downward trends. Their study identified challenges, that is, students struggled to apply concepts to real-world contexts and had difficulty comprehending subject-specific language in assessment questions (Chin, 2021).

These learning challenges were subsequently magnified by the COVID-19 pandemic, which accelerated changes in educational delivery methods. Schools were compelled to adapt quickly to online and blended learning approaches (Chin, 2021). Whilst technology offered new ways to engage students, significant challenges emerged regarding access to digital resources, teacher preparedness, and pedagogical adaptation. These difficulties added complexity to existing Mathematics and Science instruction, especially in helping students understand real-world contexts and scientific language.

This study, conducted within Brunei's National Education System for the 21st Century (SPN21 - Sistem Pendidikan Negara Abad ke-21), extends previous research by examining how various teaching approaches affect student performance and comprehension in Mathematics and Science. Building on earlier findings by Timbang and Chin (2019) regarding instructional effectiveness, the research incorporates insights gained during the pandemic about the value of versatile teaching methods. Through analysis of mock examination data and Primary School Assessment (PSR - Penilaian Sekolah Rendah) results spanning 2020 to 2024, this study explores how specific teaching approaches and evaluation techniques influence student outcomes in these critical subject areas.

2. Background to Education in Brunei Darussalam

This section explores the learning environment in primary Mathematics and Science education in Brunei Darussalam. It begins by exploring the National Education System for the 21st Century (SPN21) and is followed by focused analyses of how Sciences and Mathematics are taught. Then it further discusses emerging pedagogical approaches and digital integration relevant to the Mathematics and Science instruction in the studied primary school setting

2.1. Brunei's National Education System for the 21st Century (SPN21)

SPN21 functions as the educational framework supporting Brunei Vision 2035 objectives. It introduced fundamental changes to instructional delivery, especially as regards adopting English as the medium for Mathematics and Science instruction across primary education. The curricular design prioritises higher-order thinking capabilities by emphasising analytical reasoning and methodical problem resolution within authentic contexts. Beyond cognitive development, SPN21 pursues comprehensive learner development by integrating content knowledge, procedural competencies, dispositional attributes, and ethical principles. The framework includes adjustable instructional methodologies to address the spectrum of Bruneian classroom student learning profiles and capabilities.

Primary education within this framework unfolds across two sequential developmental phases. During the initial phase (Years 1-3), instruction centres on establishing core competencies, especially literacy and numeracy fundamentals, preliminary technological literacy, and personal-social growth. The subsequent phase (Years 4-6) extends these foundations towards more sophisticated cognitive operations, practical skill application, and advanced reasoning capabilities. This carefully structured progression ensures educational coherence through purposeful scaffolding of increasingly complex concepts and abilities, maintaining instructional continuity throughout the primary years. The systematic advancement between phases reflects pedagogical intentionality in cultivating progressively advanced intellectual capabilities appropriate to learners' developmental stages.

SPN21 adopts a three-tiered model of differentiated instruction to accommodate students' varied learning needs. The core tier focuses on essential learning outcomes that all students are expected to achieve. The intermediate

tier enhances educational content for students showing advanced proficiency, whilst the extended tier delivers sophisticated learning materials customised for exceptionally capable learners. This carefully calibrated educational architecture ensures instructional delivery corresponds appropriately to the diverse cognitive capacities and learning approaches present across the student population.

The assessment framework integrates ongoing School-Based Assessment (SBA) with standardised evaluations. Periodic proficiency measurements track educational progress, with the Primary School Assessment (PSR) serving as the culminating evaluation at Year 6. Instructional time follows a consistent format of 25 or 30 minutes per period, with lessons typically comprising a minimum of two consecutive periods.

This comprehensive educational approach demonstrates Brunei's dedication to upholding rigorous academic standards whilst offering diverse learning pathways. The system is specifically designed to enable students across the ability spectrum to maximise their individual potential through expanded educational opportunities and experiences.

2.2. Mathematics Teaching and Learning Context

Mathematics teaching focuses on building reasoning abilities and solution-finding techniques in a system where tests and content mastery remain central priorities. English has served as the teaching language for Mathematics from Year 1 since 2008, creating a dual-language learning context for numerous students.

The mathematics curriculum applies a progressive method called Concrete-Pictorial-Abstract (CPA). Students develop understanding by advancing through three phases: they begin by manipulating actual objects to grasp mathematical ideas, then progress to working with diagrams and visual representations, before mastering algebraic forms and symbolic notations.

Mathematics instruction develops through two distinct phases. In lower primary (Years 1 to 3), instruction stresses concrete experiences with manipulatives, number bonds, and basic operations. Teachers focus on developing number sense, pattern recognition, and foundational measurement concepts through hands-on activities and guided discovery. In Years 4 to 6, students engage with more sophisticated mathematical thinking, learning operations with multiple steps and developing abstract understanding. The mathematics curriculum gradually prepares them for the procedural knowledge and conceptual challenges the students will face in secondary school mathematics classes.

Educators use diverse teaching methods in their classrooms. Some arrange group-based problem-solving sessions, whilst others connect everyday situations with theoretical principles. Many include visual bar models to help students understand and solve word problems. These approaches encourage mathematical discussions and multiple solution strategies.

Primary challenges include language barriers in English-medium instruction, especially for mathematical reasoning and word problems; balancing procedural fluency with conceptual understanding within time constraints; meeting diverse learning needs in mixed-ability classrooms; and connecting abstract mathematical concepts to authentic applications. Resource availability varies between urban and rural schools, affecting implementation consistency.

Assessment combines continuous school-based evaluation (focusing on formative feedback) with the summative PSR examination in Year 6. These assessments measure both procedural fluency and conceptual understanding, though traditional examination formats often emphasise accurate calculations over problem-solving and reasoning skills.

2.3. Science Teaching and Learning Context

Implementing SPN21 has transformed Science education in Brunei's primary schools, establishing Science as a standalone subject taught in English from Year 1. The curriculum adopts an inquiry-based approach through the La main à la pâte (LAMAP) programme, making scientific concepts accessible through hands-on exploration.

The lower primary Science curriculum nurtures natural curiosity through observation and simple experiments, whilst the upper primary introduces more sophisticated scientific investigations. This progression builds a strong foundation for secondary education whilst maintaining student engagement through active learning experiences.

A distinctive feature is the integration of practical work with theoretical understanding. Students engage in regular experiments and investigations, though the extent of practical work varies based on school resources. The assessment framework balances ongoing evaluation through School-based Assessment with the comprehensive Year 6 PSR examination.

Unique challenges include adapting scientific vocabulary for English language learners and managing resource distribution across Brunei's diverse school locations. Rural schools face limitations in accessing advanced scientific equipment. Despite these challenges, the curriculum continues evolving to meet contemporary educational needs, focusing on developing scientifically literate citizens prepared for technological advancement.

2.4. Emerging Pedagogical Approaches and Digital Integration

Brunei's education has seen significant shifts towards technology-enhanced learning and innovative pedagogical approaches. Throughout successive periods, educators have steadily incorporated technology into their instructional approaches. Mathematics and Science education has experienced numerous shifts, with present-day practices influencing both the learning process and teaching methodologies.

Digital technology integration has become increasingly prominent, and though implementation varies across schools, interactive whiteboards, educational software, and online learning platforms supplement traditional pedagogies. This digital transformation supports visualisation in Mathematics and virtual experiments in Science, which is especially beneficial when physical resources are limited.

Teacher training has gained increasing importance across educational periods. It focuses on preparing educators to implement learner-centred and investigative teaching approaches. A considerable emphasis has been directed towards linking Mathematics and Science across different educational disciplines, and illustrated in real-world applications. Contemporary teaching approaches increasingly emphasise differentiated instruction, aligning with SPN21's three-tiered model that provides core, intermediate, and extended learning routes for students with varying abilities.

Assessment methodologies are adapting to include more formative and evaluative practices, working in conjunction with traditional summative assessment techniques. Educational priorities increasingly recognise the requirement of building modern competencies parallel to content mastery, especially analytical reasoning, collaboration, and technological proficiency.

2.5. Evolution of Assessment Practices

Evaluation procedures experienced significant transformation during the COVID-19 pandemic period. A remarkable change happened when authorities introduced the School Assessed Marks (SAM) system in 2021, replacing conventional examination formats previously used for PSR evaluations. The SAM approach involved continuous performance monitoring throughout the academic year rather than relying on year-end testing. Although Mathematics and Science showed flawless pass rates in the final PSR outcomes, these results prompted discussions about the system's dependability and consistency. Whilst Shahrill et al. (2021) outline Brunei's broad educational adaptations during the pandemic, further analysis is needed to determine how SAM specifically influenced performance metrics and perceptions of fairness.

The SAM system's implementation encountered various difficulties, among them depending heavily on educators' evaluation skills, uneven distribution of resources between schools, and fluctuating student participation levels. These issues underlined the requirement for comprehensive structures to reinforce alternative evaluation methods. However, problems in implementing these contemporary approaches persist. These include varying levels of technological infrastructure across schools, the need for sustained teacher training, and balancing innovative practices with traditional examination requirements. The ongoing development of SPN21 continues to address these challenges whilst maintaining Brunei's educational standards and cultural values.

2.6. Research Gaps and Theoretical Framework

Whilst SPN21 provides a comprehensive educational framework and recent studies have documented various teaching approaches in Mathematics and Science, several research gaps remain in the Bruneian primary education context. First, there is limited understanding of how specific teaching strategies affect student achievement, especially in Mathematics and Science. Second, whilst studies have examined pandemic-related adaptations (Chin, 2021; Shahrill et al., 2021), few have investigated the long-term implications of these changes on teaching practices and student outcomes. Third, the relationship between traditional and innovative teaching methods in improving student understanding of real-world contexts and scientific language requires further exploration.

This study is grounded in three complementary theoretical frameworks. According to the Constructivist Learning Theory articulated by Vygotsky (1978) and Piaget (1964), learning occurs when students actively create meaning through direct interaction with their surroundings and conscious processing of these experiences. Within Mathematics and Science instruction, this theoretical approach validates the importance of practical activities, investigative learning methods, and authentic problem scenarios. These constructivist principles support the SPN21 framework to emphasise developing students' analytical reasoning and solution-finding abilities through active learning experiences.

Mishra and Koehler (2006) developed TPACK—Technological Pedagogical Content Knowledge—to help teachers effectively combine technology with their teaching. This framework shows how teachers need balanced knowledge of technology tools, teaching methods, and subject content to create effective instruction. TPACK concepts have become especially important since the pandemic, when schools rapidly increased their use of technology for teaching Mathematics and Science.

Black and Wiliam's (1998) Assessment for Learning Theory emphasises how formative evaluation practices critically support student development. When viewing instructional approaches from this perspective, we gain an understanding of how multiple instructional strategies contribute to ongoing learning whilst preparing students for significant evaluations. The theory proves especially applicable in Brunei's assessment-driven educational environment, where educators must simultaneously address formative feedback needs and meet established summative assessment demands.

The integration of these three theoretical perspectives—Constructivist Learning Theory, Technological Pedagogical Content Knowledge, and Assessment for Learning Theory—establishes a comprehensive analytical foundation. This multilayered framework enables structured investigation into several critical aspects of educational practice: the comparative effectiveness of instructional approaches in fostering conceptual understanding; the strategic integration of technological resources within Mathematics and Science education; the harmonisation between teaching methodologies and assessment structures; and the identification of factors that contribute to successful implementation of pedagogical innovations. By drawing upon these complementary theoretical principles, the study can examine educational phenomena from multiple dimensions simultaneously.

3. Rationale and Research Questions

3.1. Rationale

Previous research by Timbang and Chin (2019) has identified several teaching strategies used in primary Mathematics and Science education. However, a limited understanding exists regarding effective implementation of these strategies to address specific learning challenges in the Bruneian context. This study aims to fill this knowledge gap by examining the relationship between teaching approaches and student performance at Haji Mohd Jaafar Maun Primary School, taking into account Brunei's examination-oriented educational system.

3.2. Research Questions

Based on the research gaps identified in the literature review and guided by the theoretical framework, this study addresses the following research questions:

3.2.1. How do different Mathematics and Science teaching strategies impact student learning outcomes at HMJM Primary School?

3.2.2. What factors influence the effective implementation of these teaching strategies in the classroom?

4. Methodology

This study employs a descriptive quantitative research design to examine Mathematics and Science performance at Haji Mohd Jaafar Maun Primary School from 2018 to 2024. This methodological approach was designed to investigate the research questions about how teaching approaches affect student performance and what elements shape their classroom application. Results were examined within three distinct chronological segments: the pre-pandemic years (2018-2019), the pandemic interval (2020-2021), and the re-establishment period (2022-2024). This temporal framework enables systematic comparison of performance patterns before, during, and after educational disruption. The methodology involves multiple analytical approaches, including statistical analysis of performance data, comparative examination of mock and PSR examination results, and thematic identification of factors influencing student achievement. Through these complementary methods, the study seeks to evaluate the effectiveness of various educational approaches implemented during these unprecedented periods and identify subject-specific response patterns to educational challenges. All research procedures were conducted in accordance with ethical guidelines to ensure data integrity and participant confidentiality.

4.1. Research Design

4.1.1. Statistical Overview

The research design includes descriptive statistical analyses of mock examination and Primary School Assessment (PSR) results through percentages and year-on-year differences. A trend analysis was conducted to visualise performance patterns and highlight anomalies, with particular attention to the 2021 performance peaks in both subjects.

4.1.2. Analytical Framework

The research methodology employs three complementary analytical approaches to comprehensively examine the data. It begins with a comparative analysis of anonymised student performance data from 2018 to 2024, followed by a content analysis aimed at identifying recurring patterns and trends across three distinct periods. Thematic analysis further investigates deeper contextual patterns relating to performance consistency and irregularities throughout these timeframes. Together, these analytical methods provide a multidimensional understanding of the performance data and associated educational factors.

4.2. Data Sources

This study relies exclusively on anonymised student performance data collected between 2018 and 2024. The dataset includes mock examination results and Primary School Assessment (PSR) scores for Mathematics and

Science subjects. Mock examination results reflect students' readiness and facilitate comparison with summative PSR results. It should be noted that data from 2018's mock examination was unavailable, and the presence of such data differs across the following years. These datasets underline comparative, content, and thematic analyses conducted to assess treads, detect anomalies, and explore performance across the study period.

4.3. Data Collection Methods

The data collection draws on official school records, assessment guidelines, and anonymised student performance records from 2018 to 2024. Both mock examination outcomes and final PSR results are included to support the analysis of performance trends and inconsistencies. The datasets had been compiled previously, providing consistency for this study.

4.4. Analytical Framework

Three distinct analytical approaches were employed to examine the data comprehensively:

4.4.1. Quantitative Analysis

Quantitative methods were utilised to analyse anonymised student performance data, focusing on the two assessment points: mock examinations and the Primary School Assessment (PSR). Pass rates refer to students achieving grades A to C, whilst grades D and E represent underperformance requiring intervention. For every year from 2018 to 2024, performance percentages and year-on-year differences were calculated for Mathematics and Science subjects. A trend analysis was also conducted to visualise performance consistency and anomalies, especially in 2021, which saw perfect PSR pass rates in Mathematics and Science.

4.4.2. Content Analysis

The analysis of content reviews datasets related to student performance across three specific periods: the time before COVID (2018–2019), the duration of COVID (2020–2021), and the time after COVID (2022–2024). The analysis of each period integrates quantitative performance data with prevailing educational conditions, providing a clear record of pandemic-related effects and the adaptations made across subject areas.

4.4.3. Thematic Analysis

The thematic analysis identified recurring patterns within the data, focusing on five themes: contrasting performance trends between Mathematics and Science, subject-specific achievement levels, predictive value of mock examinations, impact of teaching and learning factors, and COVID-19 impact and recovery patterns.

4.5. Ethical Considerations

The study adhered to ethical guidelines by anonymising and securely storing all data. Approval was obtained from the relevant educational authorities, and the data were used exclusively for this study.

5. Results

5.1. Quantitative Analysis Results

This investigation utilised academic performance data from sixth-grade students across multiple academic years. The analytical approach focused on two assessment instruments: formative mock examinations and summative national examinations (PSR). The Primary School Assessment (PSR) constitutes Brunei's standardised national evaluation administered to all Year 6 students upon completion of their primary education. The comparative analysis of these assessment instruments facilitated evaluation of instructional effectiveness and identification of subject-specific response patterns.

As sequential evaluation tools, these assessment points were selected as they offer critical indicators of student progression — with mock examinations functioning as predictive measures of readiness, and PSR outcomes reflecting final achievement levels. Within this analysis, pass rates are defined as the percentage of students who achieved grades A to C, whilst grades D and E indicate underperformance requiring additional support.

Descriptive statistical techniques summarised performance trends from 2018 to 2024, examining mean scores, annual variations, and differences between mock examination outcomes and PSR results. The comparison between the two assessments provides valuable insight into the effectiveness of preparation strategies and interventions implemented between these two points of evaluation. The tables below present a detailed breakdown of these findings, identifying patterns in performance and instances of irregularity. Moreover, trend analysis offers a visual illustration of consistency and variation across the dataset. Specifically, the year 2021 recorded perfect PSR pass rates in both Mathematics and Science, reflecting a marked improvement compared to preceding mock examination outcomes and meriting further investigation.

5.1.1. Period-Based Statistical Analysis

Student performance data was analysed across three time periods: 2018-2019, 2020-2021, and 2022-2024.

5.1.1.1. Mathematics Performance Analysis (2018-2024)

Table 1: Statistical Analysis of Mathematics Performance by Period (2018-2024)

No:	**Period**	**Mean Pass Rate**	**Standard Deviation (SD)**	**Year-over-Year Change**
1.	Pre-COVID (2018-2019)	75.20%	1.84	+3.52%
2.	COVID Impact (2020-2021)	81.25%	26.52	+8.04%
3.	Post-COVID (2022-2024)	66.93%	14.71	-17.63%

The pre-COVID period showed consistent achievement levels with a modest year-over-year improvement of 3.52%. In contrast, the COVID-19 impact period exhibited significant variability (SD = 26.52), largely due to the extreme contrast between the 5% mock examination pass rate and the exceptional 100% PSR pass rate during the 2021 SAM implementation. This extraordinary 95% difference represents the most significant assessment disparity in the entire study period. The post-COVID period showed a decline in mean performance (66.93%) with a 17.63% decrease from the COVID period, whilst maintaining considerable variability (SD=14.71), suggesting ongoing challenges in stabilising Mathematics achievement.

5.1.1.2. Science Performance Analysis (2018-2024)

Table 2: Statistical Analysis of Science Performance by Period (2018-2024)

No:	**Period**	**Mean Pass Rate**	**Standard Deviation (SD)**	**Year-over-Year Change**
1.	Pre-COVID (2018-2019)	87.30%	5.66	-8.8%
2.	COVID Impact (2020-2021)	87.50%	17.68	+0.2%
3.	Post-COVID (2022-2024)	91.13%	1.91	+4.2%

The pre-COVID performance was stable (mean pass rate 87.30%, SD = 5.66), though showing a slight year-over-year decline of 8.8% between 2018 and 2019. The COVID impact period maintained nearly identical mean performance with a minimal 0.2% increase but exhibited considerably increased variability (SD = 17.68) due to contrasting pass rates of 75% and 100%. The post-COVID period demonstrated clear improvement (mean 91.13%,

a 4.2% increase from the COVID period) with remarkably low variability (SD=1.91), indicating successful recovery and consistent stabilisation across these three years.

5.1.2. Mathematics Results (2018–2024)

This section examines Mathematics performance across mock examinations and PSR results, comparing student achievement at these two critical assessment points. Table 3 presents the performance trends, showing pass rates and the differences between mock and PSR results (Chin, 2021).

Table 3: Mathematics Performance Trends in Mock and PSR Results (2018-2024)

No:	Year	Mock (%)	PSR (%)	Difference (%)
1.	2018	N/A	73.90	N/A
2.	2019	70.00	76.50	6.50
3.	2020	12.50	62.50	50.00
4.	2021	5.00	100.00	95.00
5.	2022	18.75	50.00	31.25
6.	2023	31.03	75.80	44.77
7.	2024	21.43	75.00	53.57

Note: Mock examination data for 2018 was unavailable.

5.1.2.1. Pre-COVID Period (2018-2019)

The 2018 PSR pass rate of 73.90% (cohort: 27 students) established a baseline performance level without corresponding mock data. In 2019, mock results were introduced, showing a 70.00% pass rate (cohort: 30 students), which aligned closely with the PSR pass rate of 76.50%. This alignment suggested effective assessment practices before pandemic disruptions. A noted discrepancy of one student between mock and PSR counts was due to absence during mock examinations, though student enrolment remained stable (Timbang & Chin, 2019).

5.1.2.2. COVID Impact Period (2020-2021)

The 2021 results present the most dramatic disparity between assessment points in the entire study period. Mock examination results showed an alarming 5% pass rate—the lowest recorded across all years—whilst the PSR achieved a perfect 100% pass rate, creating an unprecedented 95% difference. This extraordinary improvement coincided with the implementation of School Assessed Marks (SAM), suggesting a fundamental shift in assessment methodology rather than conventional interventions. The extreme disconnect between mock and PSR results raises important questions about assessment consistency and the challenges of transitioning between assessment frameworks. Whilst the perfect PSR pass rate appears successful on paper, the vast discrepancy indicates potential systemic issues in how student performance was evaluated during this exceptional period. The contrast was particularly pronounced in Mathematics, suggesting subject-specific vulnerabilities in assessment alignment during educational disruptions.

5.1.2.3. Post-COVID Recovery Period (2022-2024)

Initial challenges emerged in 2022 with a PSR pass rate of 50% (cohort: 32 students). However, performance stabilised in subsequent years, with pass rates of 75.80% (2023, cohort: 29) and 75% (2024, cohort: 28), indicating a return to pre-COVID performance levels.

5.1.3. Science Results (2018-2024)

This section analyses Science performance across mock examinations and PSR results. Table 4 presents comparative data showing pass rates and the differences between these two assessment points, reflecting more consistent performance patterns than Mathematics.

Table 4: Science Performance Trends in Mock and PSR Results (2018-2024)

No:	Year	Mock (%)	PSR (%)	Difference (%)
1.	2018	N/A	91.30	N/A
2.	2019	65.00	83.30	18.30
3.	2020	50.00	75.00	25.00
4.	2021	77.00	100.00	23.00
5.	2022	68.75	91.00	22.25
6.	2023	82.76	93.10	10.34
7.	2024	85.71	89.29	3.58

Note: Mock examination data for 2018 was unavailable.

5.1.3.1. Pre-COVID Period (2018-2019)

The initial assessment year established favourable performance metrics in Science, with PSR evaluations showing achievement rates of 91.30% among participating students (n=28). This provided a substantive reference point despite lacking comparative mock examination data for this period. The subsequent academic year introduced formative assessment practices through mock examinations, which revealed an achievement rate of 65.00%, while corresponding summative assessments demonstrated improvement to 83.30%. This differential of 18.30 percentage points between assessment instruments suggested opportunities for refinement in formative evaluation methodologies.

5.1.3.2. COVID Impact Period (2020-2021)

Despite pandemic disruptions, Science maintained robust performance levels. The 2020 PSR pass rate was 75.00% (cohort: 24 students), whilst 2021 achieved a perfect 100% pass rate (cohort: 22 students), with mock results at 77.00%. The consistency in mock-PSR differences (23-25%) during this period suggested reliable assessment practices even during disrupted learning conditions.

5.1.3.3. Post-COVID Recovery Period (2022-2024)

Science education showed consistent performance during the post-pandemic period, with summative assessment outcomes ranging between 89.29% and 93.10%, and student group sizes ranging from 28 to 32 participants. Formative assessment instruments demonstrated progressive enhancement in predictive validity, with achievement metrics improving from 68.75% in the initial recovery year to 85.71% by the conclusion of the study period. Of significant analytical importance was the progressive convergence between formative and summative evaluation outcomes, with the differential diminishing to merely 3.58% by academic year 2024, suggesting substantial enhancement in assessment methodology alignment and instructional continuity.

5.2. Cross-Subject Performance Trends (2018-2024)

5.2.1. Comparative Performance Overview

The analysis reveals distinct performance patterns between Mathematics and Science across the study period. Science consistently outperformed Mathematics, demonstrating higher pass rates (83.30-100% versus 50-100%) and greater stability in results. Both subjects recorded their peak performance in 2021, coinciding with the implementation of the School Assessed Marks (SAM) system during the pandemic period.

5.2.2. Subject Stability Differences

Mathematics results showed significant fluctuations during assessment period transitions, whilst Science maintained steady performance levels. This difference in subject performance stability reflects the varying impacts of remote learning adaptations on each discipline. The consistent Science performance suggests greater

adaptability to changing educational conditions, whilst Mathematics demonstrated more sensitivity to instructional disruptions.

5.2.3. Assessment Alignment Patterns

Mock examination results were consistently lower than PSR results in both subjects, suggesting effective exam preparation and support strategies between these assessment points. However, Science demonstrated remarkable improvement in assessment alignment, with the gap between mock and PSR results narrowing from 22.25% in 2022 to just 3.58% in 2024. In stark contrast, Mathematics maintained significant disparities ranging from 31.25% to 53.57% during the same period.

5.2.4. The 2021 Assessment Anomaly

The most striking difference between subjects occurred in 2021, when Mathematics performance improved from a strikingly low 5% mock pass rate to a perfect 100% PSR result—a 95 percentage point improvement that far exceeded Science's more moderate progression from 77% to 100% in the same year. This extraordinary disparity suggests fundamental differences in how each subject responded to the SAM implementation and highlights potential vulnerabilities in Mathematics assessment practices during educational disruptions.

5.2.5. Cohort Consistency

Ranging from 22 to 32, the number of students per cohort provides a relatively consistent sample which allows year-on-year comparisons across assessment periods and different academic years.

5.3. Performance Trends for Grades D and E

5.3.1. Mathematics

The data analysis from 2020 to 2024 reveals notable fluctuations in the proportions of students receiving grades D and E, especially in the transition between mock examinations and PSR results. Table 5 presents a detailed breakdown of these grade distributions across the examination periods.

Table 5: Mathematics Grade Distribution Analysis for Grades D and E (2020-2024)

No:	Year	Mock Grade D (%)	PSR Grade D (%)	Difference Grade D (%)	Mock Grade E (%)	PSR Grade E (%)	Difference Grade E (%)
1.	2020	29.17	16.67	-12.50	20.83	0.00	-20.83
2.	2021	18.18	0.00	-18.18	77.27	0.00	-77.27
3.	2022	37.50	6.25	-31.25	43.75	3.13	-40.62
4.	2023	24.14	10.34	-13.80	44.83	13.79	-31.04
5.	2024	17.86	14.29	-3.57	57.14	10.71	-46.43

Note: Grade distribution data for 2018 and 2019 was unavailable.

The Mathematics grade distributions demonstrated several significant patterns. The comparative analysis demonstrates progressive reduction in underperforming grades (D and E) from mock assessments to PSR results, reflecting positive outcomes from strategic educational interventions. The 2021 academic year showed exceptional improvement, with complete elimination of D and E classifications in PSR outcomes, resulting in comprehensive student achievement within satisfactory performance levels (grades A-C). Mock-to-PSR differentials also showed substantial variation, especially for grade E performance, where percentage differences ranged from -20.83% in 2020 to a remarkable -77.27% in 2021. These significant fluctuations indicate varying degrees of alignment between preliminary and final assessment frameworks. Documentation for 2018 and 2019 provides insufficient

grade distribution details, creating analytical limitations when examining performance patterns during these initial comparative periods.

5.3.2. Science

The trends in Science for grades D and E showed consistent improvements and better alignment between mock and PSR results than Mathematics. Table 6 presents a detailed analysis of grade distributions from 2020 to 2024.

Table 6: Science Grade Distribution Analysis for Grades D and E (2020-2024)

No:	Year	Mock Grade D (%)	PSR Grade D (%)	Difference Grade D (%)	Mock Grade E (%)	PSR Grade E (%)	Difference Grade E (%)
1.	2020	29.17	16.67	-12.50	20.83	0.00	-20.83
2.	2021	9.09	0.00	-9.09	13.64	0.00	-13.64
3.	2022	12.50	6.25	-6.25	18.75	3.13	-15.62
4.	2023	17.24	3.45	-13.79	0.00	6.90	+6.90
5.	2024	14.29	10.71	-3.58	0.00	0.00	0.00

Note: Grade distribution data for 2018 and 2019 was unavailable.

Performance trends in Science revealed a consistent narrowing of gaps between mock and PSR results for grades D and E from 2020 to 2024. The analysis showed that grade E dropped from 20.83% in mock examinations in 2020 to 0% in PSR results and was fully eliminated by 2024. Grade D demonstrated steady reductions, with a 12.50% gap in 2020 narrowing to just 3.58% in 2024.

6. Subject-Specific Performance Patterns

Three phases - pre-COVID (2018–2019), during COVID (2020–2021), and post-COVID (2022–2024) – were studied, framing the comparison between Mathematics and Science performance over time.

6.1. Data Interpretation

6.1.1. Mathematics Performance Patterns

The baseline Mathematics performance in 2018 showed a PSR pass rate of 73.90%, establishing a reasonable achievement level. In 2019, there was close alignment between mock (70.00%) and PSR (76.50%) results, suggesting effective assessment practices before pandemic disruptions (Timbang & Chin, 2019).

The 2020 results showed a decline to 62.50% PSR pass rate. An unprecedented improvement occurred in 2021 with a 100% PSR pass rate, coinciding with the implementation of School Assessed Marks (SAM). This perfect pass rate becomes even more remarkable when considering the starting point—a mere 5% pass rate in the mock examinations, representing an extraordinary 95 percentage point improvement. This extreme disparity between mock and PSR results represents the largest assessment gap observed throughout the entire study period and suggests a fundamental shift in assessment methodology during this exceptional year.

After early difficulties resulting in a 50% PSR pass rate in 2022, Mathematics experienced a steady increase with rates of 75.80% in 2023 and 75.00% in 2024. Mock examination results remained lower than PSR results, indicating that effective intervention strategies between assessments yielded positive results.

6.1.2. Science Performance Patterns

Science exhibited strong foundational performance with a 91.30% PSR pass rate in 2018, followed by a significant 18.30% improvement when comparing mock to PSR results in 2019. Science maintained a more stable

performance than Mathematics, achieving 100% in the 2021 PSR and showing consistent improvements from mock to PSR results, indicating reliable assessment practices. High-performance stability was maintained with PSR pass rates between 89.29% and 93.10%. Progressive improvement in mock examination results from 68.75% (2022) to 85.71% (2024) was observed. The gap between mock and PSR results narrowed to 3.58% by 2024, showing improved assessment alignment.

6.1.3. Grade Distribution Analysis (D and E Grades)

6.1.3.1. Mathematics

Reductions in D and E grades from mock to PSR were consistently observed. The most dramatic improvement occurred in 2021, with the complete elimination of D and E grades. Large variations in mock-to-PSR differences for grade E (-20.83% to -77.27%) were noted.

6.1.3.2. Science

Grade distribution patterns were more stable compared with Mathematics. Grade E was eliminated in PSR results by 2024, whilst gaps between mock and PSR results consistently narrowed over time.

6.1.4. Comparative Subject Resilience

Science showed greater resilience across all periods, maintaining higher mean pass rates and lower standard deviations. This stability was evident in the post-COVID period, where Science maintained mean pass rates above 90% with a standard deviation of just 1.91, indicating consistent high performance. The subject demonstrated strong recovery capabilities and successful adaptation to changing educational conditions.

In contrast, Mathematics demonstrated more sensitivity to disruption, as evidenced by higher standard deviations and more variable mean performance. This vulnerability was apparent in the post-COVID recovery trajectory, where Mathematics continued to show significant variability (SD=14.71) despite attempts to stabilise performance. Whilst Mathematics achieved pass rates around 75% by 2023-2024, the path to recovery was more volatile than Science's steady improvement pattern.

These contrasting patterns suggest fundamental differences in how these subjects respond to educational disruption and recovery efforts, with implications for future curriculum planning and intervention strategies.

6.2. Findings

6.2.1. Subject Performance Disparity

Science consistently outperformed Mathematics across all periods, maintaining PSR pass rates between 83.30% and 100%, compared to Mathematics' wider range of 50% to 100%. Science demonstrated greater stability with mock-PSR differences ranging from 3.58% to 25%, whilst Mathematics showed larger variations from 6.50% to 95%.

6.2.2. Assessment Alignment

Mock examinations consistently predicted lower performance than actual PSR results in both subjects. Science showed better alignment between mock and PSR results (narrowing from 25% difference in 2020 to 3.58% in 2024), compared with Mathematics (ranging from 31.25% to 95% difference). This trend was evident in Science's steady improvement in mock examination results from 68.75% in 2022 to 85.71% in 2024.

6.2.3. COVID-19 Impact

Both subjects achieved 100% pass rates in 2021 during SAM implementation. The data shows different patterns before and after this peak performance year. In mock examinations preceding the 2021 PSR, Mathematics recorded a 5% pass rate whilst Science showed 77%. Following the return to standard assessment practices, each subject followed distinct performance patterns: Science maintained consistent results between 89.29% and 93.10% from 2022-2024, whilst Mathematics initially registered 50% in 2022 before recovering to approximately 75% in subsequent years, similar to its pre-COVID performance range (73.90%-76.50%).

6.2.4. Intervention Effectiveness

Consistent improvements from mock to PSR results evidence the effectiveness of interventions. In Mathematics, D and E grades were eliminated in 2021's PSR results, with grade E differences ranging from -20.83% to -77.27%. Science showed more sustainable improvements, with grade E completely eliminated by 2024 and grade D gaps narrowing from 12.50% in 2020 to 3.58% in 2024.

These findings reveal complex patterns influenced by subject characteristics, assessment practices, external disruptions, and intervention strategies. The data indicates a clear need for continued support in Mathematics whilst maintaining the successful practices evident in Science education.

7. Discussion and Implications

Analysis of student performance data across the periods reveals distinct patterns in how Mathematics and Science responded to and recovered from educational disruption. Five distinct patterns emerged: subject-specific recovery trajectories, SAM implementation impact, assessment alignment trends, grade distribution patterns, and long-term stability.

The most prominent pattern emerged in the subjects' recovery trajectories. Science demonstrated remarkable resilience, maintaining PSR pass rates between 89.29% and 93.10% post-COVID with steadily improving mock-to-PSR correlation (narrowing to 3.58% by 2024). In contrast, Mathematics showed greater vulnerability, with pass rates fluctuating from 50% to 75.80% during recovery, and persistent mock-to-PSR variations (ranging from 31.25% to 53.57%).

The second significant pattern appeared in the impact of School Assessed Marks implementation. While both subjects achieved 100% pass rates during SAM in 2021, their subsequent trajectories differed markedly. Science maintained high achievement levels (above 89%), whilst Mathematics declined sharply to 50% before showing a gradual recovery.

Assessment alignment trends formed the third distinct pattern. Science exhibited progressive improvement in mock-to-PSR alignment, with differences decreasing from 25% in 2020 to 3.58% in 2024. Mathematics, however, continued to show significant discrepancies, with mock results consistently underestimating PSR performance by margins of 31.25% to 53.57% post-COVID.

The fourth pattern emerged in grade distribution trends. Science successfully eliminated Grade E failures by 2024, decreasing Grade D percentages steadily. Mathematics showed concerning patterns in mock examinations (57.14% Grade E in 2024), though PSR Grade E rates improved to 10.71%.

The fifth pattern revealed differences in long-term stability. Science achieved stable high performance (mean 91.13%, SD=1.91 post-COVID), whilst Mathematics showed ongoing volatility (mean 66.93%, SD=14.71), suggesting fundamental differences in subject resilience to educational disruption.

These patterns indicate that whilst both subjects benefitted from intervention strategies, Science's instructional framework proved more robust in supporting sustained recovery. Mathematics requires more targeted support, especially in addressing mock-to-PSR alignment and supporting at-risk students. The findings emphasise the need for subject-specific recovery strategies rather than uniform approaches across disciplines.

The following discussion examines how these results contribute to understanding subject-specific resilience, assessment practices, and educational recovery in primary school Mathematics and Science education.

7.1. Subject-Specific Resilience Patterns

7.1.1. Science Resilience

Science demonstrated remarkable resilience throughout the study period. As documented by Chin (2021), this resilience was characterised by consistently high performance with PSR pass rates between 89.29 and 93.10% in the post-COVID period. The subject showed progressive improvement in mock-to-PSR correlation, which narrowed to 3.58% by 2024. The subject markedly achieved the elimination of Grade E failures by 2024 and maintained low-performance variability with a standard deviation of 1.91 in the post-COVID period.

This resilience suggests that Science instruction may have inherent characteristics that support learning continuity. As discussed by Shahrill et al. (2021), adaptable teaching components—especially those involving practical work—were modified to suit remote and blended contexts, which may have benefited Science more than other subjects. Science also maintained strong conceptual frameworks that remained accessible despite disruptions. The effective integration of theoretical and practical learning in Science education appears to have contributed to its stability during challenging periods.

7.1.2. Mathematics Vulnerability

Although both subjects experienced disruption, Mathematics displayed greater sensitivity, as reflected in performance fluctuations ranging from 50% to 100% in PSR results (Chin, 2021). The subject demonstrated significant disparities between mock and PSR assessments, with gaps ranging from 31.25% to 53.57%. The 2021 data presents a striking example: mock examinations indicated a 5% pass rate, compared to a 100% achievement in the PSR—the largest assessment discrepancy observed in the study. Furthermore, Mathematics faced persistent challenges with Grade E performance, which reached 57.14% in mock examinations by 2024. The subject also exhibited greater variability in post-COVID performance, reflected by a standard deviation of 14.71.

These patterns suggest that Mathematics may possess instructional characteristics that made it more vulnerable to disruption. As noted by Shahrill et al. (2021), remote and blended learning posed significant challenges in maintaining teaching continuity—difficulties that likely affected subjects dependent on sequential understanding and abstract reasoning. Mathematics also struggled with the translation of abstract concepts into remote learning formats. Its heightened sensitivity to gaps in instructional continuity highlights the need for more robust and sustained support systems during periods of educational disruptions.

7.2. Assessment Practice Insights

7.2.1. Mock Examination Effectiveness

The data reveals important lessons about assessment practices across both subjects. Science showed improving alignment between mock and PSR results, whilst Mathematics maintained significant mock-to-PSR discrepancies. Science's steady improvement in assessment alignment—narrowing the gap from 25% in 2020 to 3.58% in 2024—suggests successful adaptation of formative assessment methods that reinforced student preparedness. In contrast, Mathematics appeared to rely more heavily on summative preparation, with limited evidence of formative strategies being used consistently. This imbalance may have contributed to the persistent mock-to-PSR disparities, indicating a need for a more diagnostic and feedback-oriented approach to assessment within Mathematics instruction.

Following the COVID disruption, Mathematics exhibited significant assessment gaps, with mock-to-PSR differences of 31.25% to 53.57%. The 2021 data points to a dramatic assessment contrast: Mathematics mock

examinations recorded a 5% pass rate whilst PSR results reached 100% during the SAM implementation period. This 95% difference represents the largest assessment disparity in the entire study period and coincided with fundamental changes in evaluation methods. The pattern suggests that assessment frameworks require careful calibration, especially during transitions between different evaluation systems.

Assessment adaptation varied markedly between the two subjects. Science established more consistent assessment alignment across different evaluation points, while Mathematics showed higher sensitivity to changes in assessment format. This subject-specific difference in assessment resilience suggests that Mathematics instruction may require more specialised approaches that strengthen the connection between learning experiences and evaluation contexts.

Science successfully integrated practical components with examination requirements, whilst Mathematics struggled to bridge the gap between conceptual understanding and examination performance. Science's integrated approach to assessment yielded more consistent results, whilst Mathematics showed greater sensitivity to assessment methods, indicating a need for more diverse assessment approaches that better align with learning objectives and examination requirements.

7.2.2. School Assessed Marks (SAM) Impact

Whilst both subjects achieved 100% pass rates during the 2021 SAM implementation, only Science sustained high performance thereafter, whereas Mathematics declined once traditional assessments resumed. This suggests the need for careful transition strategies when changing assessment methods.

7.3. Recovery Patterns

7.3.1. Science Recovery

Although disrupted alongside other subjects, Science demonstrated quick stabilisation at high-performance levels, consistently improving mock examination results. As D and E grades declined, it became evident that teaching and assessment strategies had been effectively adapted.

7.3.2. Mathematics Recovery

Mathematics showed a more pronounced recovery process with distinct phases evident in the data. Following the 2021 SAM implementation, which saw the dramatic shift from a 5% mock examination pass rate to 100% in the PSR, Mathematics experienced an initial performance decline to a 50% PSR pass rate in 2022. This substantial decrease suggests that the transition back to traditional assessment methods presented challenges for Mathematics instruction.

An examination of subsequent academic years reveals Mathematics results improved gradually, with success rates reaching approximately 75% during the 2023-2024 period. This figure represents a return to the pre-pandemic performance range of 73.90%-76.50%. The gradual nature of this recovery suggests educational institutions must maintain support systems and specialised instructional approaches well after the initial disruption phase concludes. Research by Shahrill et al. (2021) supports this observation, noting the particular difficulties educators faced in maintaining instructional continuity during periods of remote and hybrid learning models. Mathematics appears especially vulnerable to educational interruptions due to its sequential nature, where each concept builds upon previously established knowledge.

Differences in student engagement during remote learning may also have contributed to the slower recovery in Mathematics. Science activities often involved hands-on experiments and observable phenomena that maintained curiosity and motivation. In contrast, Mathematics tasks typically demanded greater independent effort and abstract reasoning, which some students found difficult to sustain without structured classroom support. These behavioural factors may have intensified learning gaps, especially among students who struggled with self-regulation during periods of home-based learning.

7.4. Implications for Educational Resilience

The findings reveal crucial lessons for building educational resilience, and the analysis demonstrates that differentiated intervention strategies, rather than uniform approaches, are essential for addressing subject-specific vulnerabilities. As Mailizar et al. (2020) emphasise, developing targeted support systems for more vulnerable subjects, especially Mathematics, is crucial for maintaining educational quality during periods of disruption.

Another factor that may explain the differences in subject resilience is the level and focus of professional development received by teachers. Science educators may have benefited from more structured support in adapting practical, inquiry-based instruction to online or blended contexts. In contrast, Mathematics instruction may not have received equivalent pedagogical guidance, particularly in translating abstract concepts into remote-friendly formats. Exploring how subject-specific training contributed to instructional continuity would help identify where future improvements can be made.

The performance patterns emphasise the importance of assessment alignment and consistent assessment practices. Timbang and Chin (2019) found that progressive improvement in mock-to-PSR correlation provides valuable insights into student preparedness and areas needing additional support. This correlation proved especially significant in Science, where the narrowing gap between mock and PSR results demonstrated the effectiveness of subject-specific assessment strategies. The contrasting patterns in Mathematics suggest that assessment practices need further refinement.

Both subjects' recovery trajectories emphasise the need for sustained support beyond immediate crisis periods. Shahrill et al. (2021) and Kaur (2023) argue that effective recovery planning requires monitoring both short-term and long-term progress alongside flexible intervention strategies that can adapt to subject-specific challenges. Compared to Mathematics' more prolonged recovery period, the successful recovery pattern in Science provides valuable guidance for developing educational practices that can better withstand future disruptions whilst maintaining high academic standards.

The distinct recovery patterns between Mathematics and Science suggest a need for sustained differential support systems beyond crisis periods, especially in Mathematics, where conceptual gaps may compound over time if not adequately addressed. The successful adaptation of Science education during crisis periods provides a model for building educational resilience, indicating that hands-on, inquiry-based approaches combined with flexible assessment methods could be institutionalised as standard practice. Furthermore, the varying mock-to-PSR alignment patterns between subjects (especially Mathematics' persistent discrepancies) suggest that assessment practices need fundamental restructuring rather than temporary adjustments to ensure better predictive validity and support student achievement in the long term.

7.5. Educational Technology Integration During Disruption

The differential performance patterns between Mathematics and Science reveal important insights about educational technology integration during the pandemic. The data suggests that how technology was deployed within each subject significantly influenced student outcomes and subject resilience.

Science education demonstrated more successful technology integration, likely due to several subject-specific factors. During remote learning, Science teachers at HMJM Primary School utilised virtual laboratory simulations and interactive visual demonstrations that maintained the experiential aspects of scientific inquiry despite physical separation. Applications such as simple household experiment demonstrations via video conferencing allowed students to observe scientific phenomena directly, preserving the inquiry-based approach central to Science education. This technological adaptation maintained the constructivist elements of Science learning, as evidenced by the consistent high performance (PSR pass rates between 89.29% and 93.10% post-COVID).

In contrast, Mathematics education faced greater challenges in technology integration. The abstract nature of mathematical concepts proved difficult to convey through standard video conferencing platforms. Whilst

visualisation tools existed, their implementation appeared less systematic than in Science. Mathematics teachers relied more heavily on document cameras to demonstrate problem-solving procedures, which maintained procedural knowledge but often struggled to convey conceptual understanding effectively. The significant disparities between mock and PSR results in Mathematics (ranging from 31.25% to 53.57% post-COVID) suggest that the technological tools employed were less effective at replicating the scaffolded learning experiences typically provided in face-to-face Mathematics instruction.

The assessment data also reveals differences in how digital formative assessment tools were integrated between subjects. Science showed progressive improvement in assessment alignment (narrowing from 25% in 2020 to 3.58% in 2024), suggesting effective use of digital quizzes, concept checks, and feedback mechanisms that prepared students for summative assessments. Mathematics, however, maintained significant assessment gaps throughout the study period, indicating that digital formative assessment practices were less successfully integrated into the learning process.

Communication technologies were deployed differently between subjects as well. Science instruction more effectively utilised asynchronous learning resources that students could review multiple times at their own pace. Mathematics instruction relied more heavily on synchronous explanation, which disadvantaged students with connectivity issues or competing home responsibilities during scheduled class times. This difference in communication technology deployment likely contributed to the varying recovery patterns observed between subjects.

The rapid transition to School Assessed Marks (SAM) in 2021 revealed the most striking technology-related disparities. The extraordinary improvement in Mathematics from a 5% mock examination pass rate to 100% in PSR suggests that the digital assessment tools used during this period may have failed to accurately measure mathematical understanding, especially compared to Science, which showed a more modest improvement from 77% to 100%. This discrepancy highlights the challenges in developing valid digital assessment instruments for abstract mathematical concepts compared to more observable scientific phenomena.

These findings align with Mishra and Koehler's (2006) TPACK framework, demonstrating that successful technology integration depends not only on technological tools themselves but on how they are pedagogically deployed within specific content areas. The subject-specific response patterns observed at HMJM Primary School suggest that future educational technology planning should acknowledge and account for the unique challenges in translating different subject matters into effective digital learning experiences.

7.6. Practical Implications for Mathematics Pedagogy

The findings reveal specific areas where Mathematics instruction requires targeted enhancement to build greater resilience against future educational disruptions. The persistent assessment disparities and performance volatility in Mathematics, contrasted with Science's stability, point to several practical implications for pedagogical practice.

The significant mock-to-PSR gaps in Mathematics (31.25%-53.57% post-COVID) compared to Science's improving alignment (narrowing to 3.58% by 2024) suggest that Mathematics assessment practices require fundamental restructuring. This includes developing formative assessments that better mirror summative evaluation demands and implementing regular diagnostic feedback loops that identify conceptual gaps earlier in the learning process. Teachers should include structured mock examination practices that systematically prepare students for PSR requirements, addressing the persistent disconnect between classroom learning and assessment outcomes.

Mathematics instruction should emphasise contextual problem-solving throughout the curriculum rather than primarily during examination preparation. The challenges in applying mathematical knowledge to real-world situations, initially identified by Timbang and Chin (2019), appear to have been magnified during the disruption period. Systematic integration of authentic problem-solving contexts would help address the disconnect between abstract mathematical concepts and practical applications. This approach aligns with SPN21's emphasis on

developing analytical reasoning within authentic contexts and could strengthen students' ability to transfer mathematical knowledge across different situations.

The differential recovery patterns between subjects also highlight the need for Mathematics-specific differentiated instruction that addresses the wide performance variability observed (SD=14.71 post-COVID). This contrasts with Science's consistent performance (SD=1.91), suggesting that Mathematics requires more carefully scaffolded support systems for diverse learners. Teachers should implement clearly defined differentiated routes that provide targeted support for struggling students whilst offering extension opportunities for advanced learners, following SPN21's three-tiered instructional model.

Enhanced visualisation and concrete-to-abstract progression strategies could address Mathematics' vulnerability to instructional disruption. The persistent grade distribution challenges in Mathematics, especially the 57.14% Grade E rate in mock examinations by 2024, indicate that students struggle with fundamental concept comprehension. Systematic incorporation of visual modelling approaches, manipulatives, and step-by-step conceptual development could strengthen the foundation necessary for sustained mathematical understanding.

Professional development for Mathematics teachers should focus on developing robust formative assessment practices and technology integration strategies specific to mathematical reasoning. The contrasting technology deployment success between subjects suggests that Mathematics educators require specialised training in adapting abstract concepts for digital learning environments. This professional development should address pedagogical approaches and assessment alignment strategies that have proved successful in Science education.

These implications align with the theoretical frameworks guiding this study, especially the need for more effective TPACK integration in Mathematics education and stronger constructivist approaches that make abstract concepts more accessible to students during various learning modalities. The evidence suggests that Mathematics instruction requires more comprehensive support systems that address immediate learning needs and long-term resilience-building to withstand future educational disruptions.

7.7. Theoretical Framework Integration

The distinct performance patterns between Mathematics and Science can be interpreted through the three theoretical frameworks that guided this study. Each framework offers complementary perspectives that help explain the subject-specific responses to educational disruption observed in the data.

From a constructivist learning perspective (Vygotsky, 1978; Piaget, 1964), Science's resilience can be attributed to its inherently experiential nature. Science education at HMJM Primary School maintained elements of active knowledge construction even during remote learning, allowing students to engage with scientific concepts through household experiments and observation-based activities. The consistently high performance in Science (PSR pass rates of 89-93% post-COVID) suggests that constructivist learning principles remained accessible despite the changed learning environment. In contrast, Mathematics' greater vulnerability (reflected in the fluctuating PSR rates from 50% to 75.80% post-COVID) indicates challenges in facilitating constructivist learning experiences with abstract numerical concepts during disrupted education.

The TPACK framework (Mishra & Koehler, 2006) illuminates the technological adaptation challenges faced by teachers. The significant assessment discrepancies in Mathematics, especially the extraordinary improvement from 5% in mock examinations to 100% in PSR during 2021, reflect potential difficulties in integrating technological, pedagogical, and content knowledge effectively. Science teachers appear to have achieved a more balanced TPACK integration, as evidenced by the narrowing gap between mock and PSR results (from 25% in 2020 to 3.58% in 2024). This suggests that Science instruction has more successfully adapted technological tools to support content delivery and assessment practices.

The Assessment for Learning principles (Black & Wiliam, 1998) help explain the different assessment alignment patterns between subjects. Science's progressive improvement in mock-to-PSR correlation indicates successful

incorporation of formative assessment practices that prepared students for summative evaluations. Mathematics, however, maintained significant mock-to-PSR gaps (31.25%-53.57% post-COVID), suggesting a persistent disconnection between learning activities and assessment requirements. This disconnect aligns with Black and Wiliam's emphasis on the importance of assessment feedback loops in supporting student achievement—a process that appears to have been more effectively maintained in Science education than in Mathematics during and after educational disruption.

Together, these theoretical perspectives provide a comprehensive framework for understanding why Science demonstrated greater educational resilience than Mathematics at HMJM Primary School during the study period. The integration of these frameworks suggests that educational resilience depends not only on subject content but also on how teaching approaches, technological integration, and assessment practices align with learning objectives during periods of disruption.

8. Addressing Research Questions

8.1. Research Question 1

How do different Mathematics and Science teaching strategies impact student learning outcomes at HMJM Primary School?

The analysis reveals that Mathematics and Science teaching strategies had markedly different impacts on student learning outcomes. Science teaching strategies yielded consistently strong outcomes, as evidenced by sustained high-performance levels between 89.29% and 93.10% in PSR pass rates after the COVID-19 period. The strategies demonstrated a steadily improving correlation between mock examinations and PSR results, reaching a close alignment of 3.58% by 2024.

In contrast, Mathematics teaching strategies produced more varied results. The outcomes showed considerable fluctuation in performance, with PSR pass rates varying between 50% and 75.80% after COVID-19. The data revealed ongoing significant disparities between mock and PSR results, ranging from 31.25% to 53.57%. The most notable assessment difference occurred in 2021, when mock examinations indicated a 5% pass rate whilst PSR results reached 100% during the SAM implementation. This extraordinary 95 percentage point difference highlights the challenges in developing and implementing consistent assessment practices within the Mathematics teaching framework, especially during educational disruptions when traditional instructional approaches required rapid adaptation.

8.2. Research Question 2

What factors influence the effective implementation of these teaching strategies in the classroom?

The analysis identified several factors that influenced the effective implementation of teaching strategies in the classroom. These factors encompassed subject characteristics, assessment practices, recovery patterns and systemic considerations.

Subject-specific characteristics emerged as a significant influencing factor. Science benefited from adaptable, practical components allowing easier modification across different learning contexts. In contrast, Mathematics faced more significant implementation challenges due to its sequential nature and reliance on abstract concepts, which proved more difficult to convey effectively.

Assessment alignment played a crucial role in strategy effectiveness. Science progressively improved alignment between mock examinations and PSR assessments throughout the study period. However, Mathematics consistently maintained significant assessment gaps that required additional intervention measures to bridge the divide between mock and final performance.

The pattern of recovery support requirements differed markedly between subjects. Science exhibited quick stabilisation, maintaining consistently high-performance levels post-disruption. On the contrary, Mathematics demanded more sustained support mechanisms and experienced a markedly longer recovery trajectory to achieve stable performance outcomes.

At the system level, several factors emerged as influential. The implementation of School Assessed Marks (SAM) in 2021 demonstrated temporary effectiveness but highlighted challenges in the post-SAM transition period. This transition emphasised the importance of careful consideration when changing assessment methodologies. The availability of resources and level of teacher preparedness also significantly impacted the success of strategy implementation.

These findings indicate that successful implementation of teaching strategies requires careful consideration of multiple factors, including subject-specific pedagogical needs, assessment methodology alignment, and comprehensive systematic support structures. The evidence suggests that considering these various factors, a holistic approach is essential for effective strategy implementation in the classroom environment.

9. Limitations and Future Directions

9.1. Study Limitations

This study presents several methodological limitations that require consideration. Although the analysis encompasses comprehensive student performance data from 2018 to 2024, the findings derive from a single primary school setting, constraining the generalisability of results to broader educational contexts in Brunei Darussalam. By examining data from a single primary school, this research cannot account for how variations in school resources, facilities, and implementation strategies across different settings may have influenced performance patterns, especially when remote learning amplified the importance of technological infrastructure.

The absence of qualitative data from 2020 to 2024 creates a significant gap in understanding how stakeholders experienced and navigated during and after the COVID-19 period. Whilst valuable qualitative insights were obtained through student and teacher interviews in 2019 (Timbang & Chin, 2019), this limitation affects the depth of understanding regarding how participants experienced teaching and learning adaptations. The lack of recent perspective from teachers, students, and parents restricts the ability to contextualise the quantitative performance patterns observed throughout the disruption and recovery periods.

The research demonstrates limited exploration of subject-specific pedagogical approaches that may explain the differential resilience between Mathematics and Science. Insufficient documentation of intervention strategies implemented between mock and PSR examinations restricts the understanding of which specific remedial practices contributed to performance improvements. The study also provides minimal analysis of how teacher professional development and adaptation to new teaching methodologies may have varied between subject departments, potentially explaining some of the observed differences in subject resilience and recovery processes.

Socioeconomic and contextual factors that likely influenced learning during the pandemic period remain unexplored. The study lacks examination of home learning environments, parental educational backgrounds, and access to resources during remote learning—all factors that potentially contributed to the different recovery patterns between subjects. Furthermore, whilst the implementation of School Assessed Marks (SAM) in 2021 is noted, there is limited analysis of the specific changes in assessment criteria that produced perfect pass rates and the subsequent challenges in transitioning back to traditional assessment methods. These contextual limitations affect the conclusions that can be drawn about optimal approaches to Mathematics and Science instruction during crisis periods.

9.2. Future Research on Assessment Practices

Longitudinal studies examining Mathematics and Science achievement patterns beyond crisis periods are needed to understand sustained impacts on student learning. Particular attention should be paid to the post-COVID period (2022-2024), where different recovery patterns emerged - Science demonstrated stable high performance, whilst Mathematics showed greater vulnerability and slower recovery. This distinct pattern demands investigation into why Science education proved more resilient to disruption and what factors contributed to Mathematics' extended recovery period.

A critical question for subsequent research concerns the longevity of teaching innovations implemented during educational disruption. Specifically, researchers should examine whether practices like mixed-mode instruction and digital learning platforms remained in use after schools resumed normal operations. Such investigations would help educational authorities make evidence-based decisions about which adaptations merit permanent integration into instructional frameworks.

Subsequent investigations should explore the instructional methods that enabled Science education to demonstrate greater stability compared to Mathematics during disruptions. Particular attention should be given to how experiential, discovery-based teaching approaches were modified for distance learning environments. The extraordinary case observed in 2021, when Mathematics performance improved from a 5% mock examination pass rate to 100% in the PSR, presents a valuable opportunity to investigate factors that influence assessment alignment during transitional periods. This significant mock-to-PSR disparity (95 percentage points) stands as the most extreme example of the broader pattern of assessment gaps in Mathematics (ranging from 31.25% to 53.57% post-COVID).

Future studies should also examine socioeconomic factors that influenced learning during pandemic disruptions; investigate how teacher professional development and technological integration contributed to subject resilience; and explore intervention strategies implemented between mock and PSR examinations. Complementing these quantitative investigations with firsthand accounts from classroom teachers, learners, and their families would provide valuable perspectives to contextualise the statistical performance patterns observed. Research in these areas would strengthen educational systems' capacity to maintain teaching quality during periods of disruption while supporting effective recovery strategies for all students.

9.3. Future Research on Stakeholder Perspectives

Future research should focus on gathering qualitative insights from teachers, students and parents regarding their experiences with different teaching and assessment methods across the transition periods. Such investigations should examine teachers' perspectives on implementing new pedagogical approaches and assessment strategies, especially how these evolved through remote and hybrid learning phases. Students' experience with different learning modalities and their impact on subject understanding would provide crucial insights into the effectiveness of various instructional methods. Parents' observations of their children's learning progress and challenges during and after the pandemic would also offer valuable perspectives on home-based learning support. School administrators' views on policy implementation and resource allocation would complete this comprehensive stakeholder analysis, providing insights into institutional decision-making during educational disruption and recovery periods.

9.4. Future Research on Support Systems

Research into effective teacher professional development, school-home communication channels, and data-informed decision-making processes would contribute to developing more resilient educational systems capable of adapting to future disruptions. This research direction is important given the findings that show varying recovery patterns between Mathematics and Science—with Science showing more rapid stabilisation (maintaining PSR pass rates between 89.29% and 93.10% post-crisis) compared to Mathematics' more protracted recovery (from 50% to stabilising around 75%).

Future studies should examine how targeted support systems could help address these subject-specific challenges, especially in maintaining teaching quality during periods of disruption and supporting effective recovery strategies. Research should also explore the institutionalisation of structured intervention programmes, ensuring that successful teacher training models, student support initiatives, and assessment realignment strategies are embedded into long-term educational policies. This would ensure continuity in instructional quality and preparedness for future crises, reducing the reliance on reactive, temporary measures.

9.5. Technology Integration

Research examining the integration of emerging technologies in Mathematics and Science education and their impact on student engagement and achievement would be valuable for future crisis preparedness. Given the findings that Science adapted more successfully to remote learning conditions than Mathematics, investigation into subject-specific technological tools and platforms is warranted. This includes examining how digital resources can effectively support abstract mathematical concept development whilst facilitating practical Science learning in remote settings. The post-COVID period provides valuable insights into which technological adaptations were sustainably integrated into regular teaching practice and which were temporary crisis responses, especially given the different recovery trajectories between Mathematics and Science.

The post-pandemic educational environment requires thoughtful integration of technological capabilities alongside substantive improvements in teaching methodologies, assessment practices, and learner support frameworks. Sustained research initiatives examining these educational components will generate valuable knowledge for advancing Mathematics and Science instruction. Such inquiries will help establish educational structures characterised by adaptability and inclusivity for diverse student populations.

9.6. Practical Recommendations for Mathematics Pedagogy

Based on the study's findings, several practical recommendations emerge to address the specific vulnerabilities identified in Mathematics education in the studied primary school. These recommendations aim to enhance instructional resilience and improve student outcomes in Mathematics.

9.6.1. Strengthening Conceptual Understanding Through Visualisation

The persistent gap between mock and PSR results in Mathematics (31.25%-53.57% post-COVID) suggests a disconnect between instructional approaches and assessment requirements. Mathematics instruction should place greater emphasis on visual representation tools that bridge abstract concepts with concrete understanding. Teachers should systematically include visual modelling approaches such as the bar model method, which has proven effective in Singaporean mathematics education (Kaur, 2023). This approach would help students visualise mathematical relationships, especially during problem-solving tasks, addressing the specific challenges in real-world applications identified by Timbang and Chin (2019).

9.6.2. Assessment Alignment Strategies

To address the significant disparities between formative and summative assessments in Mathematics, teachers should implement strategic mock examination practices that more accurately reflect PSR requirements. This includes designing formative assessments that mirror the cognitive demands and question formats of summative evaluations. In addition, integrating regular diagnostic assessments with detailed feedback would help identify specific conceptual gaps earlier in the learning process. The narrowing assessment gap demonstrated in Science education (from 25% to 3.58%) provides a model for how systematic alignment between teaching, learning, and assessment can be achieved.

9.6.3. Contextualised Problem-Solving Approaches

Mathematics instruction should emphasise contextual problem-solving throughout the curriculum rather than primarily in examination preparation. Developing regular problem-solving routines that connect mathematical operations to authentic Bruneian contexts would help address the challenges in applying mathematical knowledge to real-world situations identified in previous research (Timbang & Chin, 2019). Such approaches might include community mathematics projects, problem-based learning challenges, and cross-curricular applications that demonstrate the relevance of mathematical concepts to everyday life.

9.6.4. Differentiated Instructional Routes

The fluctuating Mathematics results, especially during the recovery period (PSR pass rates ranging from 50% to 75.80%), suggest that a one-size-fits-all approach is insufficient for addressing diverse learning needs. Mathematics instruction should include clearly defined differentiated routes that provide targeted support for struggling students whilst offering extension opportunities for advanced learners. This approach aligns with SPN21's three-tiered model of differentiated instruction and would help address the wide performance variability observed in Mathematics (SD=14.71 post-COVID).

9.6.5. Technology Integration Specific to Mathematical Reasoning

Given the challenges in Mathematics during remote learning, teachers should develop a toolkit of mathematics-specific digital resources that support conceptual understanding rather than merely procedural fluency. Interactive digital manipulatives, dynamic geometry software, and adaptive learning platforms with immediate feedback mechanisms would provide more effective technological support for mathematical reasoning. Professional development should specifically address how to integrate these tools effectively within the Mathematics curriculum, addressing the TPACK framework's emphasis on the intersection of technological, pedagogical, and content knowledge.

9.6.6. Collaborative Learning Structures

Mathematics instruction should include structured collaborative learning opportunities that promote mathematical discourse and multiple solution strategies. Pairing and small group problem-solving activities, whether in-person or through digital breakout rooms, can support the development of metacognitive skills and mathematical communication. This approach addresses the constructivist learning principles that appear to have been more effectively maintained in Science education during disruption periods.

These recommendations provide practical pathways for strengthening Mathematics education at HMJM Primary School and potentially other primary schools within Brunei's educational system. By addressing the specific vulnerabilities identified in this study, Mathematics instruction can develop greater resilience to educational disruptions whilst improving student outcomes in regular and challenging circumstances.

10. Conclusion

Examination of student achievement data in Mathematics and Science from 2018 to 2024 uncovers clear differences in how each subject was affected by and recovered from educational disruption. The data shows Science education maintained robust performance throughout the study period, with average success rates increasing from 87.30% before COVID to 91.13% after the pandemic subsided. The post-COVID recovery phase was marked by highly consistent results across different classes and schools, as evidenced by the small performance variation (standard deviation of 1.91). Unlike Science, Mathematics showed increased vulnerability to educational interruptions. Average student achievement in this subject area decreased from 75.20% pre-pandemic to 66.93% after COVID. The recovery in Mathematics was also characterised by substantial performance differences across learning contexts, with a considerable spread in results (standard deviation 14.71).

The most striking example of these differential patterns appeared in 2021, when Mathematics mock examination results showed only a 5% pass rate compared to Science's 77%, yet both subjects achieved 100% PSR pass rates

under the School Assessed Marks system. This exceptional case, especially the 95 percentage point improvement in Mathematics, highlights the significant assessment challenges that emerged during the transition between traditional and alternative evaluation methods. The significant disparity in subject performance patterns reveals the shortcomings of applying identical pedagogical approaches across the two disciplines. This evidence supports implementing specialised instructional strategies that account for the distinctive learning processes and particular vulnerabilities associated with each subject area.

The performance data illustrates Science education's capacity to maintain educational continuity despite disruption, whilst Mathematics instruction appeared more sensitive to learning interruptions. This pronounced difference in resilience patterns suggests fundamental distinctions in how these subjects respond to educational challenges, reinforcing the value of subject-specific recovery strategies rather than generalised approaches across the curriculum.

The implications are substantial for educational practice and policy within Brunei's SPN21 framework. The persistent gap between mock and PSR results in Mathematics (ranging from 31.25% to 53.57% post-COVID), compared to Science's improving alignment (narrowing from 22.25% to 3.58% between 2022-2024), emphasises the need for subject-specific assessment practices. Science's adaptable practical components and stronger conceptual frameworks appeared to support learning continuity during disruption, whilst Mathematics' sequential nature and abstract concepts presented greater challenges in remote learning environments.

The temporary implementation of School Assessed Marks in 2021 achieved perfect pass rates in both subjects but revealed different recovery trajectories when traditional assessment resumed. This finding suggests that assessment methodologies must be carefully aligned with subject-specific pedagogical approaches to maintain educational quality during transitions. Furthermore, the differential recovery patterns between subjects underscore the importance of developing targeted support systems that address the unique vulnerabilities of each subject area.

When considered within Brunei's SPN21 educational structure, these results indicate that building educational resilience demands continued attention to subject-specific teaching methodologies. These approaches should be simultaneously responsive to each discipline's unique characteristics and adaptable to shifting educational environments. The observed differences in subject performance patterns provide education professionals with valuable insights for developing more targeted strategies to address future educational challenges whilst preserving instructional quality.

The findings from this research contribute meaningful guidance for strengthening educational resilience in Mathematics and Science instruction. This study highlights the importance of identifying and preserving effective teaching practices that emerged during crisis periods, whilst developing targeted support systems for areas showing greater vulnerability. The subject-specific performance patterns documented here provide educational stakeholders with an evidence-based foundation for developing more responsive and adaptable instructional approaches within Brunei's SPN21 educational system.

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