Performance Assessments in Mathematics Education

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Contents

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Abstract

This qualitative case study explores elementary teachers' perceptions and practices regarding performance assessments in mathematics education. Grounded in a social constructivist framework, the research investigates how teachers believe performance tasks impact students' understanding of mathematical concepts and the characteristics of these assessments as implemented in classrooms. The study aims to provide an in-depth understanding of how performance assessments are used to foster meaningful learning and problem-solving skills, addressing the gap in literature about practical applications of these tools in real-world settings.

Three elementary teachers, selected through purposive sampling, participated in semi-structured virtual interviews. Data collection involved detailed interviews to capture teachers' experiences, thoughts, and strategies for using performance assessments. The data were analyzed through open coding, thematic analysis, and the use of NVivo software to identify recurring themes and insights.

Findings highlight the value of performance assessments in promoting student-centered learning, critical thinking, and collaborative problem-solving. Teachers reported challenges in transitioning from traditional paper-pencil tests to authentic assessments, emphasizing the need for professional development and support. This research contributes to understanding how performance assessments can enhance teaching practices, align with curriculum goals, and foster deeper student engagement in mathematics education.

Chapter 1: Introduction

Personal Introduction

In 2021, I graduated with a Primary-Junior specialization (Grades Kindergarten–6) from the Bachelor of Education (BEd) program at Lakehead University in Ontario. During my two years of study, I encountered a new approach to learning mathematics that differed significantly from the traditional methods I experienced as a student. Throughout my school years, mathematics instruction often focused on rote memorization of procedures and step-by-step instructions. For example, I vividly recall memorizing the multiplication table in Grade 4, a task I found challenging and prone to forgetting. My teachers frequently emphasized that repeated practice was the key to mastering the multiplication table. Following their advice, my mother and I spent fifteen minutes daily, even during summer breaks, reviewing the multiplication table. My mother, like my teachers, believed that memorization and additional practice were essential.

Looking back, I recognize that those fifteen minutes could have been more effectively used to solve real-world problems relevant to daily life, such as calculating the cost of gasoline for our car trips. Alternatively, we could have engaged in interactive math games to develop a deeper understanding of mathematical concepts. At that time, however, the goal of mathematics education was primarily to practice problems and master traditional algorithms. Teachers often said, “The more you practice, the easier math becomes.”

A few years ago, I came across a Facebook post featuring a mathematics student workbook that was once my math textbook. The person who shared it referred to the workbook as a “nightmare,” and many commenters echoed the sentiment. Their shared experiences highlighted the widespread challenges associated with traditional math instruction. My own experience as a student, coupled with my peers’ shared disdain for mathematics during my BEd

program, underscores the long-term impact of these instructional methods. When many of my cohort struggled to pass the Grade 6 level mathematics competency exam, a graduation requirement at Lakehead University, it became evident that the problem lay in how we were taught math during our formative years. We were taught procedures without understanding their origins or relevance, leaving us ill-prepared to apply these concepts.

As I progressed in my education, I began to recognize the ubiquity of mathematics in everyday life. Real-world examples demonstrated how math is interwoven with daily activities. For instance, math is present in retail prices, sales discounts, and grocery shopping. If a pound of apples costs $2.99, how much would three pounds cost? These examples illustrate the practical applications of math. As a teacher, I have observed students questioning the purpose and relevance of learning math. When I began to understand the importance and applicability of math in real-life situations, my enthusiasm for the subject grew. I realized that math is a critical skill that permeates daily life, and this realization motivated me to approach learning and teaching math with a new perspective. For students to succeed, they must connect mathematics to their lived experiences, making the learning process meaningful and relevant. Providing authentic learning opportunities can positively influence students' attitudes toward math.

This realization inspired me to explore current teaching practices and instructional methods in mathematics. I began observing how teachers approach math instruction and sought to understand their pedagogical perceptions and practices. The literature reveals that teachers' beliefs, efficacy, and knowledge significantly influence their teaching methods, particularly in mathematics (Bandura, 1997; Ball et al., 2008; Kajander, 2010; Koh & Chapman, 2019; Lee, 2017). In the context of this study, teacher efficacy refers to educators' beliefs in their own capacity to effectively teach mathematics and positively impact student learning outcomes

(Bandura, 1997). This concept is operationalized by examining how teachers perceive their ability to implement performance-based assessments, design rich learning experiences, and support diverse learners in understanding mathematical concepts. Teachers with high self-efficacy often employ student-centered and problem-based approaches to mathematics instruction (Bruce & Flynn, 2013), which aligns closely with the performance-based strategies explored in this study.

Furthermore, research indicates that teachers with strong efficacy beliefs contribute to improved student achievement (Bruce et al., 2010; Moore & Esselman, 1994; Muijs & Reynolds, 2001; Ross, 1992). Their confidence and enthusiasm in teaching mathematics can be contagious, positively shaping students' attitudes and engagement. By investigating teachers' perceptions and instructional choices, this study sheds light on how efficacy beliefs influence the integration of performance assessments in mathematics education.

Assessment and learning are intrinsically linked, and assessments play a vital role in the educational process. Assessments provide teachers with valuable insights into students' progress, allowing them to identify gaps in understanding and adapt their instruction accordingly. For students, assessments offer opportunities for self-reflection, enabling them to track their progress against success criteria and ensure their work meets task requirements (Black & Wiliam, 2010; Dixson & Worrell, 2016; Sadler, 1989). As Gulikers et al. (2004) suggest, "Assessment and learning are two faces of the same coin" (p. 28). Consequently, incorporating assessments into daily teaching practices is essential.

The Ontario Ministry of Education (2010), in its Growing Success document, emphasizes that "the primary purpose of assessment is to improve student learning" (p. 28). Assessments should provide accurate information about students' achievement of curriculum expectations.

My interest lies in understanding how teachers integrate assessments into their daily practices, particularly in mathematics. I aim to explore whether teachers use assessments in ways that actively support student learning and whether they incorporate performance tasks, projects, tests, and assignments to create engaging and meaningful assessment experiences in mathematics.

Context of the Study

Assessment plays a critical role in education by identifying students' progress, helping teachers plan subsequent lessons, and uncovering students' understanding and misconceptions (Black & Wiliam, 2010; Sadler, 1989; Dixson & Worrell, 2016; Ontario Ministry of Education, 2010). Understanding the assessment tools and strategies used in contemporary mathematics classrooms is, therefore, essential to enhance teaching and learning practices.

This research emerges from a desire to explore how teachers implement performance assessments in mathematics education. Specifically, it investigates how teachers integrate performance tasks into their instructional practice and examines their perceptions of whether these tasks influence students' understanding of mathematical concepts. Additionally, the study examines how teachers view the role of performance assessments in fostering deeper mathematical learning. By focusing on teachers' perceptions and practices, the study seeks to illuminate the perceived benefits and challenges of using performance assessments compared to traditional assessments.

The study focuses on performance assessments in mathematics education to uncover how these tools are employed as part of instructional practices. Key areas of interest include the types of tasks teachers identify as performance assessments, the criteria for success, and the modifications provided for students requiring additional support. The study also seeks to understand teachers' perspectives on the benefits and limitations of performance assessments

compared to traditional assessments, as well as their views on whether performance assessments help students succeed in math.

Conducted within a district school board in southern Ontario, the study involved interviewing three elementary teachers who actively use performance assessments in mathematics. Although the study is limited to one school board, its findings may contribute to the broader understanding of assessment practices and current approaches to performance assessments in classrooms.

Purpose of the Study

The purpose of this case study is to explore and document current practices in using performance assessments in mathematics classrooms. Additionally, the study investigates how teachers adapt their instructional approaches to implement performance assessments effectively.

For a task to qualify as a performance assessment, it must pose authentic problem-solving scenarios, require the application of multiple skills and strategies, include contextualized tasks, incorporate critical thinking, and culminate in the creation of a final product (Dixson & Worrell, 2016; Fuchs et al., 1999; Popham, 2014). Such assessments allow students to collaborate and communicate with peers, fostering strong relationships and enhancing problem-solving skills (Darling-Hammond et al., 2008). By providing opportunities for students to demonstrate their thinking and collaboratively devise solutions, performance assessments are ideal tools for both formative and summative purposes (Lane, 2013; McFeetors et al., 2021).

This research focuses on teachers who use performance assessments in mathematics, examining how these tasks are integrated into instruction and identifying effective practices.

Research Questions

The study addresses the following research questions:

1. What are teachers' perceptions of how performance tasks impact students' understanding of mathematical concepts and big ideas?
2. What are the characteristics of performance assessments used by teachers in mathematics?

Significance of the Study

The findings of this research may have significant implications for mathematics education. By examining how teachers use performance assessments and documenting their practices, this study enriches our understanding of how these assessments influence student learning. The research highlights teachers' perspectives on the benefits and challenges of performance tasks and sheds light on their potential to enhance student understanding through inquiry-based, problem-solving, and student-centered approaches (Suurtamm & Koch, 2014; Thompson et al., 2020).

Research suggests that integrating hands-on activities, inquiry-based learning, problem-solving tasks, and student-centered approaches enhances learning outcomes (Suurtamm & Koch, 2014; Thompson et al., 2020). Well-designed performance-based tasks can "inform shifts in curriculum, instruction, and school design toward student-centered learning practices and greater vertical alignment of curriculum, as well as continuous improvement" (Thompson et al., 2020, p. 1). Consequently, performance-based tasks are powerful tools for fostering meaningful and authentic learning environments.

This study contributes to the growing body of literature on performance assessments by documenting teaching strategies, performance tasks, and key components of effective assessments currently employed in mathematics classrooms. While many studies have discussed the theoretical benefits of performance assessments (Koh & Chapman, 2019; Suurtamm & Koch,

2014; Thompson et al., 2020), fewer have focused on practical implementation in classrooms and teachers' perceptions of these practices. This research contributes to filling this gap, offering a comprehensive understanding of how performance assessments are used in mathematics education and providing insights into their effectiveness and key components.

Chapter 2: Literature Review

Introduction

The National Council of Teachers of Mathematics (NCTM), a professional organization founded in 1920 to advocate for high-quality mathematics instruction, defines assessment in math education as "the process whose primary purpose is to gather data that support the teaching and learning of mathematics teaching practices" (NCTM, 2014, p. 89). Similarly, the *Growing Success* document (Ontario Ministry of Education, 2010) defines assessment as "the process of gathering information that accurately reflects how well a student is achieving the curriculum expectations in a subject or course" (p. 28). While both definitions emphasize the importance of assessment in supporting teaching and learning, they differ in focus. The NCTM definition views assessment primarily as a tool to inform and improve instructional practices, highlighting the role of the teacher. In contrast, the *Growing Success* definition emphasizes the accurate measurement of student achievement in relation to curriculum expectations, focusing more on the learner. These two perspectives complement each other within the context of this study by framing assessment as both a guide for effective teaching and a measure of students' mathematical understanding. Together, they provide a comprehensive foundation for examining how performance assessments function in classroom settings.

Assessment is a critical process aimed at collecting data about students' knowledge and understanding of mathematical concepts and big ideas. This collected data is then used to

enhance teaching practices, inform instructional planning, and support students in advancing their learning (Black & Wiliam, 2010; Dixson & Worrell, 2016; Sadler, 1989). Since "the primary purpose of assessment is to improve student learning" (Ontario Ministry of Education, 2010, p. 28), assessment must be integrated into the learning process and be a central part of instruction rather than a separate, isolated event (Syaiffuddin, 2020). Gulikers et al. (2004) emphasize that "learning and assessment are two sides of the same coin and that they strongly influence each other" (p. 68). Therefore, educators should employ diverse assessment methods to deepen their understanding of students' thinking and learning, and comprehension.

One of the effective teaching practices outlined by the NCTM (2000) is to "implement tasks that promote reasoning and problem solving" (p. 10). Suurtamm et al. (2010) underscore the importance of mathematical instruction that enhances understanding of mathematical concepts through activities that build problem-solving skills. As a result, assessment in mathematics should prioritize evaluating students' conceptual understanding rather than their ability to memorize and apply traditional algorithms and procedures (NCTM, 1995; Suurtamm et al., 2010). Assessment practices must extend beyond traditional paper-pencil tests, which primarily evaluate procedural knowledge. Instead, they should incorporate various tasks that allow students to demonstrate their understanding of key mathematical concepts (Suurtamm et al., 2010).

These diverse assessment methods include observations, performance tasks, reflective journals, projects, portfolios, presentations, and self-assessments (Suurtamm and Koch, 2014). Performance assessments, in particular, are recognized as effective tools for gathering data on students' thinking and serve as a valuable alternative to traditional tests (McFeetors et al., 2021; Popham, 2014). Performance tasks can evaluate a range of skills, including problem-solving,

reasoning, and critical thinking, making them an integral component of assessment practices in mathematics education (Thompson et al., 2020).

Performance Assessments

Performance assessments offer meaningful learning experiences for both students and teachers. McFeetors et al. (2021) argue that these assessments enable students to consolidate their understanding of mathematical concepts while allowing teachers to gain deeper insights into students' mathematical thinking. Performance assessments are commonly used in various non-educational contexts, such as driving tests and music performance evaluations, where the goal is to measure an individual's ability to perform specific tasks at a defined level of competency (McFeetors et al., 2021).

In educational settings, performance assessments are particularly valuable in mathematics, where they assess students' learning, enhance reasoning and problem-solving skills, and provide ample opportunities for students to demonstrate their thinking (Suurtamm et al., 2016). By engaging with these tasks, students refine their problem-solving skills, overcoming obstacles and deepening their understanding of mathematical concepts.

For example, Suurtamm et al. (2010) describe how a Grade 9 teacher incorporated performance-based assessments as culminating tasks at the end of a unit. One task focused on proportional reasoning, where students were asked to plan a field trip for their class using provided information. Another task centered on geometry, offering students a choice: to create a picture using geometric shapes they had studied or to write a short essay explaining how geometry is used outside the classroom. The teacher emphasized the importance of collaboration, encouraging students to work together at the start of a performance task to share ideas, listen carefully, and build on each other's thoughts.

Another form of performance assessment involves research tasks, where students are asked to conduct research, write a paper, and reflect on what they have learned. This type of assessment encourages critical thinking and enables students to engage deeply with the content (Darling-Hammond et al., 1995; Thompson et al., 2020).

These examples underscore the flexibility of performance assessments to adapt to varied classroom contexts, allowing students to engage with mathematical concepts in ways that traditional tests cannot. Researchers have consistently highlighted the benefits of performance assessments, noting their ability to provide a holistic view of student learning. (Dixson & Worrell, 2016; Fuchs et al., 1999; McFeetors et al., 2021; Popham, 2014; Thompson et al., 2020). Unlike traditional paper-pencil tests, performance tasks evaluate a range of skills, including writing, reading, collaboration, self- and peer-assessment, critical thinking, problem-solving, content knowledge, and creativity (Dixson & Worrell, 2016; Fuchs et al., 1999; McFeetors et al., 2021; Popham, 2014; Thompson et al., 2020).

Performance assessments also foster collaboration and communication as students work together to complete tasks (McFeetors et al., 2021). Through trial and error, students develop solutions to problems, assess themselves and their peers, and reflect on their process. They analyze their approaches, identify what worked and what did not, and adjust their strategies accordingly. Sharing their experiences enables educators to gain insights into students' thought processes, conceptual understanding, and misconceptions.

Lane (2013) advocates for the use of performance assessments, noting that they promote "deeper student understanding of content" (p. 321). Encouraging students to think aloud and share their reasoning not only enhances their learning but also equips teachers with valuable feedback to guide future instruction. Therefore, creating a safe environment is essential for the

success of performance assessments. When students feel safe and encouraged to share their thoughts without fear of being judged, they are more willing to take risks and engage in open discussions.

Authentic Assessments

Authentic assessment is closely related to performance assessment, with some researchers noting significant overlap between the two (Archbald, 1991; Syaifuddin, 2020). Archbald (1991) observes that the distinction between authentic and performance-based assessments has blurred over time, though performance assessments have a longer history. Teachers' use of authentic assessment in mathematics often includes performance evaluation, self- and peer-assessment, observation, written assessments, portfolio assessments, project appraisals, and combination assessments (Syaifuddin, 2020). This aligns with Archbald's (1991) assertion that performance evaluation is integral to authentic assessment models.

Syaifuddin (2020) defines authentic assessment as "a form of assessment that asks students to show performance as done in the real world meaningfully; it is the application of the student's knowledge and skills" (p. 1498). This definition highlights the practical and real-world focus of authentic assessment, emphasizing its role in evaluating applied knowledge rather than rote memorization or isolated procedural skills.

Gulikers et al. (2004) propose three conditions for a task to be considered authentic:

1. Assessment and learning must overlap.
2. Students must take ownership of the task in authentic learning.
3. Tasks must be meaningful and relevant to the course content.

Applying these conditions, authentic assessment integrates seamlessly into the learning process. It occurs naturally as teachers teach lessons, pose questions, and engage students in

meaningful discussions about mathematical concepts. Authentic tasks must also align with curriculum expectations and emphasize key mathematical ideas, ensuring relevance to students' learning.

Archbald (1991) describes authentic assessment as "the solution" to the limitations of traditional paper-pencil tests. Unlike conventional assessments, which focus on producing a final product, authentic assessments evaluate learning as an ongoing process. Traditional paper-pencil tests often require students to develop test-taking skills—a separate set of abilities unrelated to the actual content or procedural knowledge being assessed. This discrepancy can lead to situations where students who understand the mathematics fail to demonstrate their knowledge on a test due to unfamiliarity with test formats or expectations.

Authentic assessment addresses these challenges by evaluating students in ways that reflect real-world applications of knowledge and skills. As a result, it provides a more accurate and holistic view of student learning, emphasizing understanding, application, and relevance over rote memorization or standardized test performance.

Teaching Practices and Approaches

Effective teaching practices are essential for promoting authentic learning. Herrington and Herrington (2007) express concerns that teaching strategies disconnected from real-life contexts leave students at a disadvantage. They advocate for authentic learning environments that provide meaningful contexts reflecting how knowledge is applied in the real world. Key elements of authentic learning include engaging students in authentic activities, providing access to performance modeling, encouraging multiple perspectives, creating opportunities for reflection, fostering student articulation, and offering coaching and scaffolding (Herrington & Herrington, 2007).

Authentic learning bridges the gap between classroom instruction and real-world applications, helping students understand the relevance of their learning and its importance in everyday life. Researchers have identified several teaching approaches that facilitate meaningful learning, three of which—Linked Learning, Problem-Based Learning (PBL), and Inquiry-Based Learning (IBL)—align closely with the principles of performance assessments. These approaches connect learning to real-world scenarios, are problem-centered, and enhance critical skills such as collaboration, communication, and reasoning.

Linked Learning Approach

The Linked Learning Approach integrates real-world, project-based tasks with performance assessments. This approach emphasizes hands-on learning, enabling students to apply their knowledge in practical, interdisciplinary contexts (Thompson et al., 2020). For instance, the Oakland Unified School District in California employs the Graduate Capstone Project as a substitute for standardized testing. This project requires high school students to define a research question, conduct research, write a formal paper, and present their findings. One example involved students collaborating to create a mobile application that addressed a community need (Thompson et al., 2020).

This approach mirrors performance assessments by emphasizing student agency, critical thinking, and authentic problem-solving. Thompson et al. (2020) highlight that well-designed performance assessments, such as the Graduate Capstone, prepare students for college, careers, and life by fostering skills like collaboration, creativity, and resilience. Moreover, participating in such assessments shifts teacher practices, encouraging them to adopt instruction aligned with real-world tasks and authentic learning outcomes.

Problem-based Learning (PbL)

Problem-based Learning (PbL) is a pedagogical approach that promotes authentic learning by engaging students in solving real-world problems collaboratively. Barrows (1996, 2002) identifies key characteristics of PbL: it is student-centered, occurs in small groups, involves facilitators (teachers or tutors), uses real-life problems, and fosters self-directed learning. These elements align with performance assessments, which similarly emphasize critical thinking, collaboration, and the application of knowledge.

One example of PbL is the Binary Number System problem, as presented by Szabo et al. (2020), which demonstrates the integration of Problem-based Learning (PbL) in mathematics education. Through a fictional scenario on Binary Island, students explore binary representation by solving a practical problem: determining how to represent 10 EUR using a binary-based currency system with specific exchange rules. This activity follows Pólya's heuristic framework—understanding the problem, devising a plan, carrying out the plan, and reflecting on the solution.

Students develop critical thinking, collaboration, and problem-solving skills while engaging with mathematical concepts through storytelling and structured exploration. Performance assessments are seamlessly integrated, evaluating students' ability to articulate the problem, devise and implement strategies, and reflect on their solutions through rubrics, visual models, and presentations. This activity also fosters 21st-century skills, including adaptability and communication, making it an effective model for authentic, skill-based learning in mathematics (Szabo et al., 2020).

PbL tasks encourage students to think critically and creatively, fostering professional competencies needed in the workplace (Koh & Chapman, 2019). Performance assessments

within PbL environments measure these competencies through tools like rubrics, self-assessments, and peer evaluations.

Inquiry-based Approach

Inquiry-based Learning (IbL) encourages students to explore mathematical concepts through questioning, investigation, and discovery. It aligns closely with performance assessments by focusing on the learning process and fostering critical thinking. IbL is student-centered, allowing learners to take charge of their learning while teachers act as facilitators (Suurtamm & Koch, 2014). Students are encouraged to solve problems without direct instruction on strategies, exploring different methods and reflecting on their effectiveness.

The Inquiry-based Learning (IbL) approach demonstrated by Şen et al. (2021) highlights its effectiveness in enhancing middle school students' mathematical reasoning skills, particularly in the context of ratio and proportion. By focusing on relationships among concepts rather than direct instruction, IbL creates a collaborative environment where students actively engage in exploration, questioning, and justification.

Two examples illustrate the implementation of IbL. In the first, students analyzed ratios using representations such as a/ba/b and a:ba:b through contextual scenarios involving apples, oranges, and watermelons. They justified why ratios remain constant and explored their mathematical properties. The second example extended this understanding by asking students to simplify proportions in a problem comparing the heights of two individuals. Both activities encouraged critical thinking and deepened students' conceptual understanding through guided discussion and reflection (See Appendix C: IbL Approach Examples).

This approach aligns seamlessly with the goals of performance assessments in mathematics education, which evaluate students' reasoning, problem-solving, and ability to

articulate their understanding. In particular, performance assessments assess not only the accuracy of students' solutions but also their ability to justify and explain their reasoning, a central focus of IbL. By emphasizing meaningful, real-world problems, IbL integrates effectively into performance assessments, providing a comprehensive evaluation of students' cognitive and collaborative skills.

This example demonstrates how IbL activities can be designed to assess students' performance authentically. It underscores the importance of engaging students in reasoning and justification tasks that align with the principles of performance assessments, thus fostering both conceptual understanding and critical skills.

Inquiry-based assessment emphasizes the process of exploration as much as the final answer. Darling-Hammond and Ascher (1991) and Serafini (2001) argue that inquiry-based assessments are more effective than large-scale assessments because they prioritize understanding and application over rote memorization.

These approaches, Linked Learning, PbL, and IbL, align closely with the focus of this study on performance assessments, as they all integrate performance assessments into their instructional frameworks. Each approach prioritizes real-world applications, critical thinking, and student agency, which are fundamental to performance-based tasks. Within these approaches, performance assessments serve as key tools to evaluate students' ability to apply knowledge and skills in authentic contexts, encouraging deeper engagement and fostering meaningful learning experiences.

By integrating these approaches, teachers create authentic learning environments where students can engage deeply with mathematical concepts and develop skills essential for future success.

Ontario Mathematics Curriculum

The Ontario Mathematics Curriculum (2020) emphasizes student-centered learning, focusing on conceptual understanding and problem-solving skills rather than rote memorization. Teachers are encouraged to use inquiry-based learning to engage students in exploring mathematical concepts and making real-world connections. This approach supports a variety of learning styles, ensuring that instruction is differentiated to meet the diverse needs of students. Assessment is integral to this approach, with formative assessments used to monitor ongoing student progress and provide immediate feedback to guide instruction. Summative assessments, such as tests or projects, evaluate students' understanding at the end of a unit, while diagnostic assessments identify prior knowledge and learning gaps. The curriculum also promotes self-assessment and peer assessment to foster metacognitive skills and ownership of their learning (Ontario Ministry of Education, 2020).

The *Growing Success* document, which focuses on assessment, evaluation, and reporting, aligns with the Ontario Mathematics Curriculum by providing detailed guidelines on how assessment should be integrated into teaching practices. It emphasizes the importance of using a variety of assessment methods to gather a comprehensive picture of student progress and achievement. The document stresses that assessment should not only measure final outcomes but also support ongoing learning by providing actionable feedback. It advocates for clear learning goals and success criteria to ensure that students understand what is expected of them and how they can improve. Through its focus on fair, transparent, and consistent practices, *Growing Success* helps teachers design assessments that are both meaningful and aligned with the curriculum, ensuring that student progress is accurately reflected and reported (Ontario Ministry of Education, 2010).

Conclusion

In summary, the literature highlights the importance of integrating authentic and performance-based assessments into mathematics education to foster meaningful learning experiences. These assessments align with contemporary teaching pedagogies that emphasize problem-solving, critical thinking, and real-world application of mathematical concepts (Suurtamm & Koch, 2014; Thompson et al., 2020). Approaches such as Linked Learning, Problem-Based Learning (PbL), and Inquiry-Based Learning (IbL) provide frameworks for creating student-centered, authentic learning environments that reflect the demands of modern education. Each approach emphasizes student agency, collaboration, and critical thinking, which are fundamental to performance assessments (Herrington & Herrington, 2007; Koh & Chapman, 2019).

Despite the demonstrated benefits, the literature also highlights challenges, including the lack of teacher familiarity with authentic assessment practices and the reliance on traditional paper-pencil tests (Sabri et al., 2019; Suurtamm & Koch, 2014). Addressing these challenges requires professional development opportunities that empower teachers to develop the knowledge and skills necessary for implementing performance assessments effectively.

Overall, the reviewed literature supports the argument that performance assessments are a critical component of mathematics education. These assessments align with broader educational goals of fostering student-centered learning and equipping students with the skills needed for future success. The integration of performance assessments, supported by robust teacher knowledge and innovative teaching practices, has the potential to transform mathematics education, enhancing both teaching and learning experiences. This chapter lays the groundwork

for exploring how teachers implement performance assessments in mathematics education, aligning with the goals and research questions of this study.

Chapter 3: Methods

Introduction

Assessments play a crucial role in a student's learning journey as they identify the student's current level of understanding and the support they need. Thus, assessments are an integral part of both learning and teaching.

Performance assessments are tools that assist teachers in evaluating students' learning and development. This study sought to explore what performance assessments look like in classrooms and examine teachers' perceptions, thoughts, and experiences regarding their implementation. The research questions were:

1. What are teachers' perceptions of how performance tasks impact students' understanding of mathematics concepts and big ideas?
2. What are the characteristics of performance assessments that teachers use in the classroom?

This chapter outlines the research approach, design, sample selection, data collection, data analysis methods, and ethical considerations.

Design

Research Approach: Constructivism

This study employed a social constructivist framework. The qualitative approach focused on understanding the meaning that participants constructed about their experiences, aligning with Merriam and Tisdell's (2016) definition of qualitative research: "understanding the meaning people have constructed; that is how people make sense of their world and the experiences they have in the world" (p. 15). From a constructivist perspective, Creswell and Creswell (2018) stated that the goal of research is "to rely as much as possible on the participants' views of the

situation being studied. The questions become broad and general so that the participants can construct the meaning of a situation" (p. 46). Accordingly, the study built upon participants' experiences and their perspectives on implementing performance assessments.

The research question used the verb *impact* to allow flexibility, focusing on teachers' perceptions of performance assessments without limiting responses to positive or negative effects. This aligned with Merriam and Tisdell's (2016) assertion that qualitative researchers aim to understand how participants interpret their experiences and construct meaning.

I analyzed the data to gain a deep understanding of the participants' perspectives on performance assessments in mathematics**.** This research followed an inductive process, gathering data to build concepts and themes rather than testing hypotheses (Merriam & Tisdell, 2016). While the approach was inductive, findings were interpreted and discussed in the context of existing knowledge.

Methodology: Case Study

The study employed a case study methodology to explore the bounded system of elementary teachers' perceptions of performance assessments. Case studies allow for in-depth exploration of a specific phenomenon within its natural setting. Creswell et al. (2007) defined case study research as "a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports) and reports a case description and case-based themes" (p. 245). Yin (2017) similarly described case studies as investigations of "a contemporary phenomenon in depth and within its real context" (p. 18).

This study focused on teachers' perceptions of performance assessments, forming themes and codes to analyze the results qualitatively. The case study method was chosen because it aligned with the goal of understanding participants' experiences and thoughts in a real-life context (Harrison et al., 2017).

Sample Selection

Purposive sampling and criterion-based selection were used to identify participants. The inclusion criteria required participants to be elementary teachers who used performance-based tasks in mathematics assessments. To recruit participants, I reached out to the principals and math coaches with whom I had previously worked, asking if they could recommend teachers who utilized performance assessments. Olivia, who I knew was using performance assessments, was directly approached to ask if she would be willing to participate. Shayne was recommended to me as someone who uses performance assessments in his teaching. After being given his X account information to review his practices, I reached out to him to ask if he would be willing to participate. Liz was recommended to me by one of the principals. In all cases, participation in the study was entirely voluntary; the teachers were under no obligation to participate and were informed that their decision would not affect their professional relationships or standing in any way. In total, three elementary teachers were recruited to explore the impact of performance-based tasks on students' mathematical understanding and to examine how each participant's experience varied.

Participant/Case Descriptions

The educational backgrounds and teaching experiences of the participants provide valuable context for understanding their perspectives on performance assessments. Each teacher

brought distinct insights shaped by their unique professional journeys. To maintain anonymity, pseudonyms were used for all participants.

Case 1: Liz

Liz is a seasoned educator with 23 years of teaching experience, specializing in early primary grades (junior kindergarten to Grade 6). Currently teaching Grade 2, Liz has not pursued any Additional Qualification (AQ) courses in mathematics beyond her initial teacher training in a Bachelor of Education program. She acknowledges her "basic normal Bachelor of Education" background and emphasizes hands-on, practical approaches to teaching mathematics. Liz's reliance on informal strategies and observation to assess young learners' understanding underscores the importance of adaptability and creativity in her approach to performance assessments.

Case 2: Shayne

Shayne is an experienced educator with 22 years of teaching, including nine years teaching high school mathematics and several years teaching grades ranging from kindergarten to Grade 10. Currently serving as an Instructional Coach for Elementary Mathematics, Shayne brings extensive expertise to his role. Educated in India, he holds a Bachelor of Education and has spent the last eight years teaching in Ontario, Canada. To enhance his qualifications, Shayne completed Additional Qualification (AQ) courses in Mathematics for primary grades, Grades 7 and 8 Mathematics, Special Education Part One, and English Language Learners Part One. Shayne's rich and diverse teaching background shapes his approach to performance assessments, emphasizing flexibility and real-world applications.

Case 3: Olivia

Olivia is a Grade 3 teacher with 14 years of teaching experience across all primary grades (Grades 1 to 6). She has completed Additional Qualification (AQ) courses in Mathematics Part One for primary grades and has attended numerous math workshops organized by the school board to support schools with historically low EQAO results. Olivia's commitment to professional development reflects her dedication to improving her teaching practices and supporting student achievement in mathematics. Her experience working in a compensatory school setting informs her focus on creating engaging, accessible assessments for diverse learners.

Trustworthiness of the Interpretations

To ensure the credibility and consistency of the findings, data triangulation was employed using two sources: video recordings of teachers' interviews and artifacts of student work. Merriam and Tisdell (2016) emphasized that triangulation involves "comparing and cross-checking interview data collected from people with different perspectives" (p. 245).

Member checks were conducted by sharing interpretations with participants to confirm their accuracy. Participants reviewed the findings to ensure their perspectives were accurately represented. This approach strengthened the internal validity of the research, as "participants should be able to recognize their experience in your interpretation" (Merriam & Tisdell, 2016, p. 246).

Data Collection Methods

Data were collected through virtual interviews conducted over Zoom. The interview protocol included a mix of highly structured and semi-structured questions (What are the benefits of using performance assessments in math? What are the challenges you face when you use

performance-based assessments?). The structured questions gathered demographic information, while the semi-structured format provided flexibility to explore participants' experiences in depth (Merriam & Tisdell, 2016). The semi-structured approach allowed the researcher to adapt questions based on participants' responses, responding to the situation as it unfolded (Merriam & Tisdell, 2016). Each interview lasted approximately 45 minutes, with follow-up interviews conducted if clarification or additional information was required. Patton's (2015) six question types, as cited by Merriam and Tisdell (2016), were used as a guide to develop the interview questions (see Appendix B).

I triangulated data from multiple sources shared with me by the participants through OneDrive to ensure a comprehensive understanding of the research topic, which focused on performance assessments in mathematics education. I analyzed artifacts of student work, which provided valuable evidence of students' mathematical thinking and understanding. I also reviewed pictures shared through OneDrive, which visually documented the classroom environment and instructional strategies. By combining these diverse data sources, I was able to strengthen the validity and depth of my findings. While classroom artifacts and rich descriptions of performance tasks were collected through interviews, no classroom video footage was gathered. All references to student engagement or task implementation are based on the participants' reflective accounts during interviews and not from direct classroom observation or video evidence.

Data Analysis Methods

The data analysis process began during data collection, as recommended by Merriam and Tisdell (2016). Transcripts from the Zoom interviews were downloaded, reviewed, and edited for accuracy. Early analysis allowed me to identify gaps or emerging themes and refine subsequent

interview questions. Open coding was used to generate initial themes and categories. Each transcript was thoroughly reviewed, with notes and codes assigned to relevant sections. Merriam and Tisdell (2016) explained that this iterative process involves scanning subsequent transcripts for recurring themes and patterns. The data were then uploaded into NVivo Qualitative Analysis software to facilitate further coding and grouping of themes.

Following Braun and Clarke's (2006) six-phase framework for thematic analysis, I moved through familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and finally producing the report. Familiarization with the data began with multiple readings of the interview transcripts, which I had downloaded in full. Although I did not transcribe the interviews myself, I engaged deeply with the transcripts by reading and annotating them several times to capture tone, emphasis, and emerging patterns in participants' responses.

Since I did not have video recordings of students engaging in the performance tasks, all references to classroom examples and student learning were based on what participants described during their interviews. I paid close attention to these narrative accounts, highlighting quotes that illustrated teachers' observations of student thinking, engagement, or challenges. Throughout this phase, I maintained analytic memos to record my reflections, identify key ideas, and begin mapping connections to the research questions and relevant literature.

This iterative process allowed me to become immersed in the data and to understand each teacher's context and perspective more fully. It also laid the foundation for generating meaningful and well-supported codes and themes in the subsequent stages of analysis.

After each interview, beginning with Shayne, I downloaded the transcript and immediately began open coding. I read through the transcript thoroughly, highlighting significant

excerpts and labeling them with initial codes that responded directly to my research questions. Some of these early codes included “students pay attention to the process, not only the product,” “students take task ownership,” and “teacher workload.” These codes reflected Shayne’s experiences with assessment practices and classroom dynamics.

The same process was followed for the subsequent interviews. I downloaded the transcripts, highlighted key excerpts, and assigned descriptive codes. As the coding progressed, I compared codes across all three transcripts to identify commonalities and differences. This iterative approach allowed me to refine the initial codes and group them into broader categories. For example, codes such as “students contribute ideas,” “they ask questions,” and “participate in discussions” were grouped into the category “Active Participation.”

From these categories, I developed higher-order themes that captured core findings from the data. This process led to the identification of ten benefits and seven challenges associated with performance assessments. For instance, the category “Student Engagement in Learning Process” developed into the theme *“*Students Pay Attention to the Process, Not Only the Product.” Notably, this theme emerged across all three interviews, suggesting a shared belief among participants in the value of process-oriented learning. Another example is the theme *“*Increased Teacher Workload*,”* which stemmed from codes like “preparing materials,” “finding rich performance tasks,” and “creating and differentiating performance-based tasks to meet students’ needs.”

Overall, the results reflect a nuanced understanding of performance assessments as experienced by classroom teachers. The benefits identified include Building Students’ Confidence in Learning Math, Making Real-life Connections, and Integration of Multiple Subjects, while challenges include the Time-consuming Nature of Performance Assessments,

Limited Resources, and the need to Provide Proof of Assessment for Parents. These themes, grounded in participant voices, highlight the complex and multifaceted nature of implementing performance assessments in educational practice.

Chapter 4: Examples of Performance Assessment

Examples of Performance-based Tasks

Prior to presenting the study findings, it is essential to establish a clear understanding of the types of performance assessments utilized by teachers in mathematics instruction. This contextual foundation is crucial for interpreting the results, as it illuminates the practical approaches the three educators employed to assess student learning. By examining the diverse methods of assessment, including projects, problem-solving tasks, and real-world applications, a deeper insight can be gained into how these practices align with instructional objectives and contribute to the development of students' mathematical competencies.

Performance-based Tasks for Assessment Purposes

Making a 3D Model of a Castle

One example of a performance-based task shared by Shayne involves creating a 3D model of a castle. This task served as a culminating activity designed for "assessment of learning" purposes for Grade 7 and 8 students. The task required students to design and construct a 3D model of a castle or any building of their choice using various geometric shapes, such as cuboids, cylinders, and pyramids. Students were expected to calculate the surface area to be painted and determine the total cost of painting their model. This activity required students to start from scratch, using some materials provided by the teacher while sourcing additional materials on their own.

Shayne highlighted the importance of clearly defined learning goals and success criteria, which he presented through a checklist. This tool allowed students to self-assess their progress and ensure alignment with the task objectives. "Setting clear expectations and co-creating success criteria with students ensures they have a roadmap to follow and can independently

check their progress," Shayne explained. The task also encouraged flexibility, as students were allowed to decide on their roles within their groups, define their contributions, and choose how they would communicate their results.

Curriculum Connection. This task encompassed a range of mathematical concepts, aligning with key curriculum expectations. Specifically, it assessed the following:

1. Mathematical Modelling Skills: The task required students to understand and analyze a problem, develop a mathematical model (e.g., a representation of their structure), and assess the model's effectiveness (Aligned with Overall Expectation C4 in the Ontario Mathematics Curriculum, 2020).
2. Measurement Skills: Students calculated the surface area of their structures, applying their understanding of geometry and spatial reasoning (Aligned with Specific Expectation E2.3 in the Ontario Mathematics Curriculum, 2020).
3. Financial Literacy Skills: Students determined the cost of painting their models, incorporating budgeting and decision-making skills (Aligned with the Overall Expectation F1 in the Ontario Mathematics Curriculum, 2020).

Student Engagement. Shayne observed that this task fostered creativity and collaboration among his students. "Students were deeply engaged in cutting, assembling, and refining their models, which gave them a hands-on understanding of geometry," he said. Additionally, the task encouraged students to reflect on their problem-solving processes, learning from their challenges and successes.

This performance-based task exemplifies how rich, multi-faceted assessments can provide valuable insights into students' mathematical understanding while connecting concepts to real-world applications.

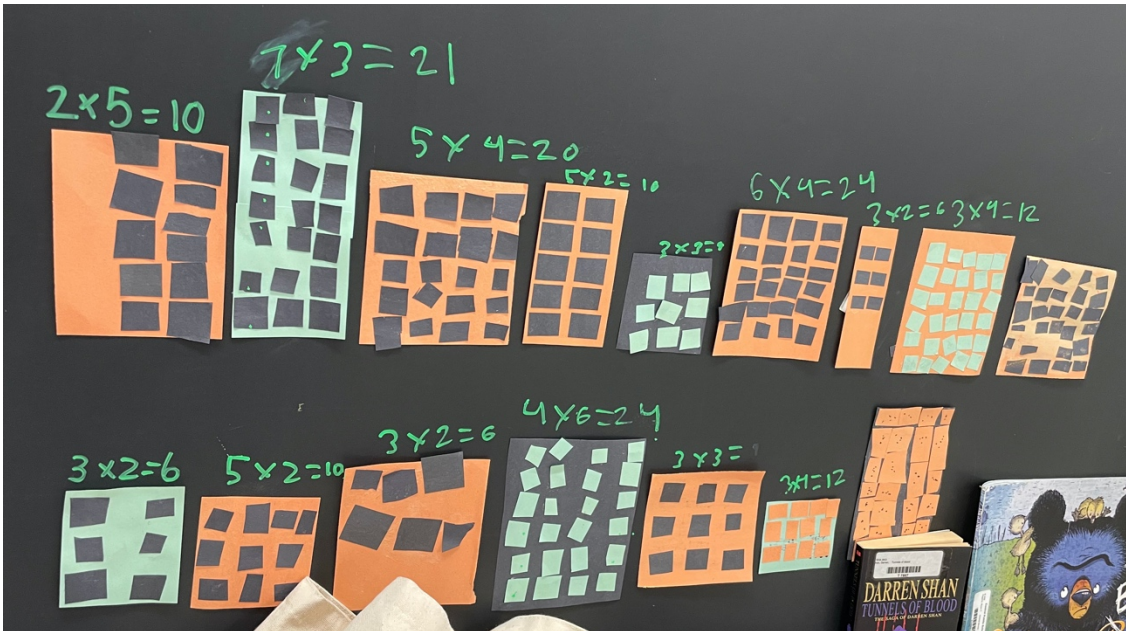
The 3D castle task described by Shayne exemplifies key characteristics of the three pedagogical approaches outlined in the literature: Inquiry-Based Learning (IBL), Problem-Based Learning (PbL), and Project-Based or Linked Learning. The task allowed students to explore geometric relationships, such as calculating surface area and analyzing composite shapes, through hands-on engagement and self-directed investigation. These are core features of inquiry-based learning, as students constructed mathematical understanding through exploration and reflection. In relation to problem-based learning, the task presented an open-ended, real-world challenge that required students to apply mathematical modelling and financial literacy skills to design, build, and paint a structure while staying within a simulated budget. This reflects the emphasis of problem-based learning on student-led problem solving and the practical application of knowledge. Furthermore, the culminating nature of the project, which integrated mathematics, visual design, and financial decision-making, aligns with project-based learning principles. Students collaborated in groups, assumed roles, co-created success criteria, and produced a final product that demonstrated their learning. This task connected classroom concepts to real-life applications, making it a strong example of how performance-based assessments can reflect and support progressive instructional approaches in meaningful ways.

Combining Math with Crafts

Olivia shared an innovative approach to performance-based assessment that merges mathematics with crafts to make learning more engaging for her grade 3 students. She believes incorporating crafts into math assessments fosters creativity and increases student interest in mathematical concepts.

Array City. To assess multiplication strategies, Olivia tasked her students with creating an Array City. Using construction paper, students designed buildings with array windows,

representing multiplication problems visually. For instance, a building with 3 rows of 4 windows illustrated the equation 3×4, helping students build an early understanding of equal groupings within a spatial structure. This visual approach supports the development of multiplicative reasoning by highlighting patterns and structures in numbers, rather than relying solely on additive thinking (Jacobson, 2009). The task also encouraged students to explore the relationship between multiplication and division by examining how the same array could be interpreted in multiple ways, reinforcing their understanding of inverse operations.



Curriculum Connection. This hands-on activity assessed the students' ability to:

1. Representing Multiplication: Students demonstrated their understanding of multiplication as repeated addition or grouping through the use of arrays and other visual representations. This aligns with Ontario Math Curriculum, Grade 3, Specific Expectation B2.6 (2020), which requires students to represent multiplication of numbers up to 10 × 10 using a variety of tools and drawings, including arrays.

2. Connecting Multiplication and Division: The task encouraged students to recognize the inverse relationship between multiplication and division by using arrays and other visual models to represent both operations. This supports Ontario Math Curriculum, Grade 3, Specific Expectation B2.7 (2020), which focuses on representing and solving problems involving multiplication and division using tools and drawings.

Impact on Learning. Olivia observed that this task deepened students' comprehension of multiplication concepts by moving beyond rote memorization. "Through crafting, students engaged actively with the material, allowing them to think critically about how numbers relate to each other in multiplication and division," she explained.

Student Engagement. Craft-based tasks like the Array City were highly engaging for Olivia's students. She noted that students took pride in their creative projects and were excited to display their work in the classroom. This boosted their confidence and enthusiasm for math. Olivia stated, "When students are engaged in crafting, they forget their fear of math and instead focus on showing what they know in a fun and creative way."

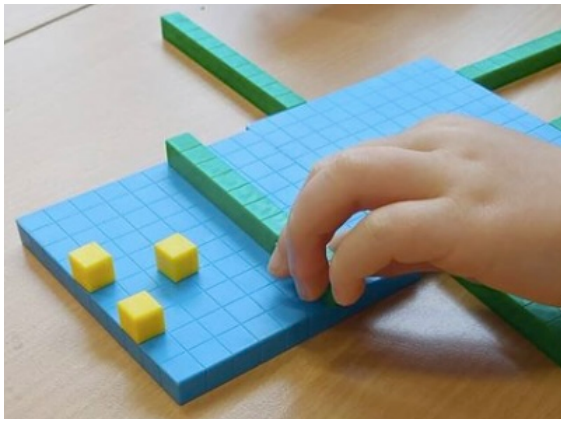
By integrating crafts into mathematics, Olivia successfully transformed assessments into a visual and interactive learning experience, allowing her to evaluate students' understanding while keeping them motivated and engaged.

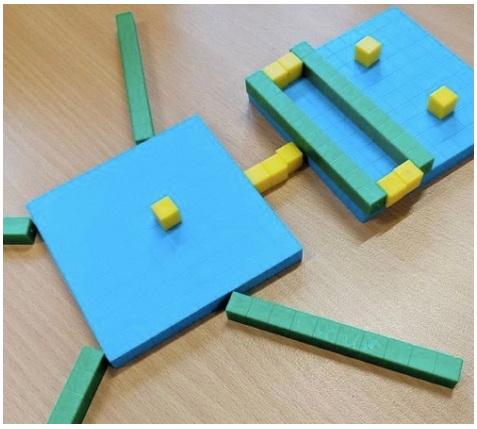
Olivia's Array City task primarily aligns with inquiry-based and project-based learning approaches. By designing buildings with arrays that visually represent multiplication and division, students explore mathematical relationships through guided discovery, embodying inquiry-based learning. At the same time, the creation of a city as a tangible product allows students to engage in a meaningful project that integrates visual and spatial reasoning with mathematical operations, reflecting key features of project-based learning.

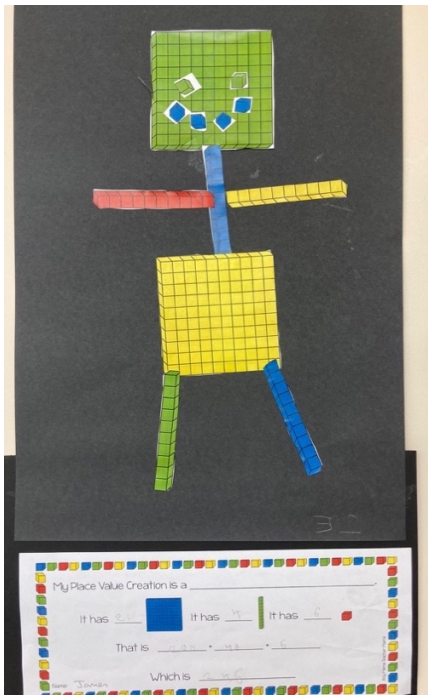
Place Value Robot. Another innovative performance-based task Olivia implemented in her grade 3 class was creating a Place Value Robot. This activity utilized base ten materials, a widely used manipulative in math education, to assess her students' understanding of place value. Students were tasked with building a robot using base ten blocks or one-centimeter grid paper. The materials included unit blocks (ones), rods (tens), flats (hundreds), and cubes (thousands). The robot construction required students to model specific numbers by incorporating a variety of base ten components. For example, a robot might include 3 flats, 4 rods, and 6 unit blocks to represent the number 346.

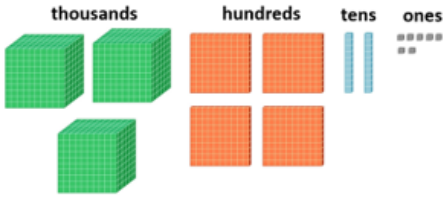
Assessment Criteria. Olivia assessed her students' understanding of place value by asking questions such as: How many hundreds, tens, and ones did you use in your robot? What number does your robot represent? How many total blocks did you use?

These questions allowed her to evaluate whether students could accurately compose and decompose numbers into place value components and understand the magnitude of each place value, such as recognizing the difference between hundreds and tens.









Impact on Learning. Olivia noted that this hands-on activity was particularly effective in helping her students grasp abstract mathematical concepts through physical representation. She explained, "Using base ten blocks allowed my students to visualize the number they were working with. They could see how ones, tens, hundreds, and thousands contribute to the whole, making the concept of place value much more tangible."

The Place Value Robot also encouraged students to articulate their thought processes. Olivia found that her students were more comfortable explaining their reasoning and demonstrating their knowledge when engaged in hands-on activities. "When they built the robots, they could explain what they were doing and why," she shared. This interactive approach gave her deeper insights into her students' understanding than traditional assessments could.

Student Engagement. This task was not only educational but also enjoyable for the students. Building a robot allowed for creativity, making math a more engaging subject. Olivia remarked, "The students were excited to share their robots with the class, and this activity gave

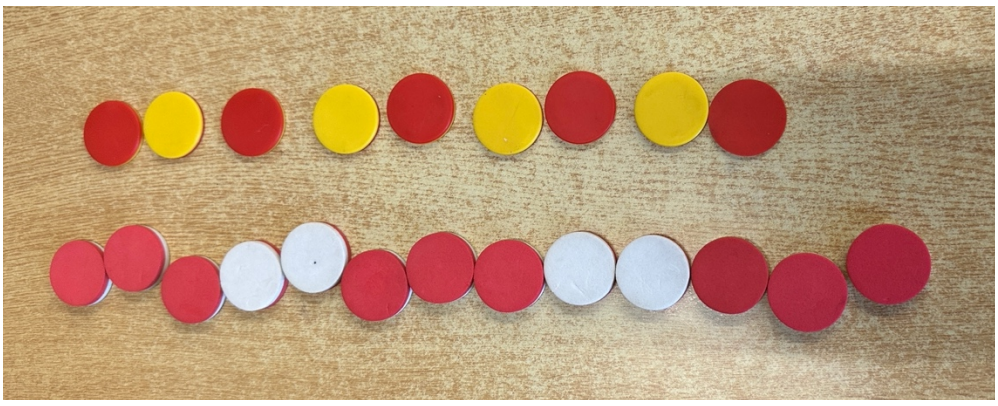
them a sense of accomplishment. They could see math as something they could create and understand, not just solve on paper."

The Place Value Robot proved to be an effective and enjoyable way to assess and enhance students' understanding of place value, enabling them to explore mathematics through a creative and interactive lens.

The Place Value Robot activity implemented by Olivia integrates inquiry-based and project-based learning approaches. Students construct robots using base ten blocks to represent numbers, which supports inquiry by enabling them to explore and make sense of place value concepts through hands-on manipulation. As a project-based task, the robot construction encourages creativity and results in a concrete artifact that demonstrates students' understanding of numerical representations, blending conceptual exploration with purposeful creation.

Exploring Patterns

Liz shared an engaging performance-based task designed for primary students to explore and understand basic algebra concepts through patterns. In this activity, students were asked to create various patterns using different attributes of solid shapes. These patterns included growing, repeating, and shrinking patterns. The task involved sorting shapes based on attributes such as size, color, or type, and then arranging them into patterns that demonstrated these mathematical concepts.



Observations and Assessments. Liz emphasized the value of observing students during this hands-on activity. By watching how students constructed and explained their patterns, she gained critical insights into their thought processes and understanding. She noted that listening to students' discussions and explanations was key to accurately assessing their mathematical capacity building. Liz explained, "Observing their discussions and explanations allows me to see what they know, how they think, and where they might have misconceptions." This approach helped her assess whether students could:

1. Identify and Describe Patterns: Students recognized attributes and relationships in the shapes and used them to create structured patterns.
2. Extend and Create Patterns: Students built upon existing patterns or developed new ones using logical rules.
3. Make Predictions: Students applied their understanding of patterns to predict how sequences would continue.

Curriculum Connections. This task aligns with expectations in the primary mathematics curriculum, focusing on foundational algebraic reasoning. It nurtures critical skills such as recognizing patterns, identifying relationships, and developing predictions—all essential for later algebraic concepts.

Impact on learning. The task's hands-on nature allowed students to actively engage with the material, making abstract concepts more concrete. Liz observed that the activity fostered collaborative learning, as students often worked in pairs or small groups to discuss and refine their patterns. She explained, "This type of task encourages students to verbalize their thinking, compare strategies with peers, and build a deeper understanding of algebraic concepts through active exploration."

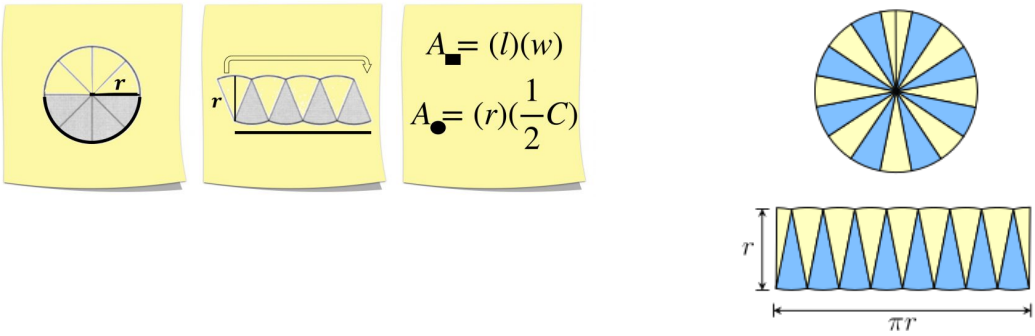
By enabling students to create, describe, and predict patterns, this performance-based task not only assessed their current understanding but also provided opportunities for them to deepen their algebraic thinking in an interactive and meaningful way.

Liz's performance task of creating patterns using attributes of solid shapes reflects both inquiry-based and problem-based learning. Students investigate patterns by sorting and arranging shapes based on size, color, and type, fostering inductive reasoning and discovery typical of inquiry-based learning. The problem-based aspect arises as students engage in recognizing, extending, and creating various pattern types, solving mathematical problems related to early algebraic thinking through hands-on exploration.

Performance-based Tasks for Teaching Purposes

Finding the Surface Area of a Circle

One of the innovative performance-based teaching activities that Shayne implemented in his Grade 8 class involved discovering the formula for the surface area of a circle. This hands-on task aimed to deepen students' conceptual understanding by engaging them in a visual and collaborative activity. Students were provided with paper circles and asked to: 1) Cut the circle into equal parts, such as 16 or 32 partitions, 2) Rearrange the wedges into the shape of a rectangle, and 3) Collaboratively calculate the area of the newly formed rectangle. Through this process, students observed that the area of the rectangle matched the area of the original circle.



Mathematical Connection. The task was designed to lead students to an understanding of the formula for the area of a circle, $A=\pi r^2$, by breaking the circle into parts and rearranging them:

- The height of the resulting rectangle corresponds to the radius (r) of the circle.
- The width is equivalent to half of the circle's circumference (πr).
- Therefore, the area of the rectangle, calculated as height × width ($r \times \pi r$), equals the area of the circle.

Student Engagement. Shayne described the students' active participation and enthusiasm during this task: "The students were very engaged in cutting the circles and rearranging the parts. Everyone was busy working and collaborating, which created a productive classroom atmosphere." He also highlighted the lasting impact of this activity on students' retention: "Students kept recalling this activity whenever we discussed finding the surface area of a circle later. If they had learned it differently or if I had just given them the formula, they probably would have forgotten it."

Impact on Learning. This task enabled students to visualize mathematical concepts by physically transforming a circle into a rectangle, allowing them to see how its area corresponds to its radius and circumference. The activity also promoted collaboration and communication, as it required teamwork and discussion, which fostered reasoning and interpersonal skills. Rather than simply memorizing the formula, students developed a deeper conceptual understanding by exploring the fundamental relationship between a circle and its area. Shayne concluded that this hands-on approach was significantly more effective than traditional methods. He noted, "This activity helped students deeply understand the relationship between the area of a circle and the

rectangle shape that is created with the circle wedges. It provided a strong foundation that they could build upon in future lessons."

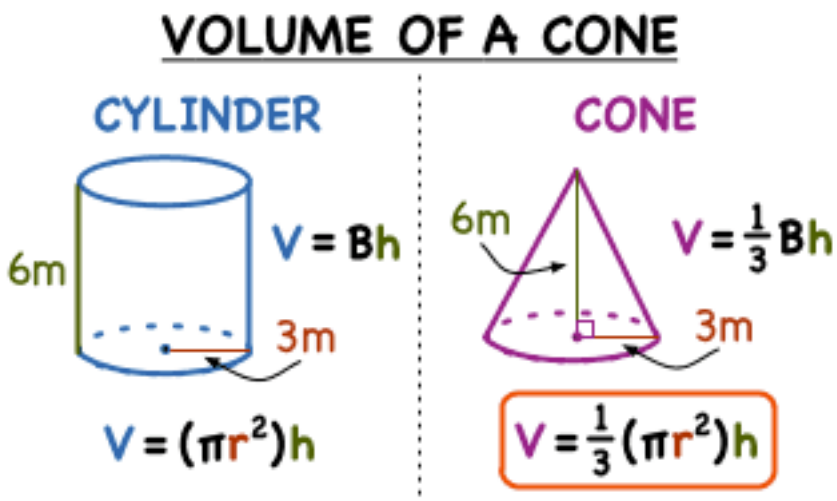
The Finding the Surface Area of a Circle activity is an excellent example of how performance-based tasks can make abstract mathematical concepts accessible and memorable through hands-on learning and collaboration.

Shayne's activity to discover the formula for the surface area of a circle illustrates inquiry-based and problem-based learning. Students physically manipulate paper circles, cutting and rearranging them to observe geometric properties firsthand, embodying the inquiry-based approach through guided exploration and discovery. Concurrently, the task presents a real mathematical problem to solve, the derivation of the circle's area formula, engaging students in problem-solving that deepens conceptual understanding.

Comparing the Volume of a Cone with the Volume of a Cylinder

In this performance-based task, Shayne asked his Grade 7 and 8 students to create both a cone and a cylinder, each having the same height and radius, in order to compare their volumes. The main goal of this task was for students to understand that the volume of a cone is one-third the volume of a cylinder.

Students were tasked with constructing models of a cone and a cylinder using materials such as clay, paper, or other craft supplies, ensuring that both shapes had identical dimensions, including the same height and radius. After building their models, the students calculated the volume of each shape using the appropriate formulas: $V_{cylinder} = \pi r^2 h$ for the cylinder and $V_{cone} = 1/3\pi r^2 h$ for the cone. This exercise allowed them to compare the calculated volumes and gain an understanding of the relationship between the two, reinforcing the concept that the volume of a cone is one-third that of a cylinder with the same dimensions.



Shayne used this activity to help students visualize and comprehend abstract concepts like volume. He emphasized that, while the mathematical formula is important, seeing and manipulating the models allowed students to grasp the real-world significance of the relationship between a cone and a cylinder's volume.

Shayne explained, "Even for Grade 7 and 8 students, visual aids like models are crucial for understanding more abstract math concepts. When they make the shapes themselves, they can better see and feel the difference between the cone and the cylinder."

Student Engagement. The hands-on nature of this task helped engage students by involving them directly in the learning process. As they built the models, they were actively involved in applying the formula and concepts to real-world objects, which helped them make connections between abstract mathematical ideas and tangible objects. Shayne mentioned, "The students were excited to see how their hands-on work connected directly with the math they had learned in class. They really enjoyed building the models and applying the formulas to find the volumes."

Through this task, students were able to visualize mathematical concepts by physically constructing a cone and a cylinder, allowing them to observe the differences in volume between

the two shapes. They deepened their understanding of the relationship between the volumes, reinforcing the concept that a cone's volume is one-third that of a cylinder with the same height and radius. Additionally, the task required students to apply mathematical formulas for volume in a hands-on context, moving beyond theoretical knowledge to practical application. This activity also fostered critical thinking and problem-solving as students analyzed their findings and engaged with the mathematical principles underlying the task.

Shayne found that the task also sparked critical thinking. Students discussed potential errors or issues with their models and how to ensure accuracy in their calculations. The activity encouraged collaborative problem-solving, as students worked together to build the shapes and share their insights about the volume relationship.

Impact on Learning. This activity is an example of how performance assessments can deepen students' understanding of mathematical concepts. Shayne explained, "By providing a hands-on experience, students were able to internalize the mathematical principles in a way that a textbook or lecture might not achieve. This is why modeling is so important—it helps students see math in action." The Comparing the Volume of a Cone with the Volume of a Cylinder task not only taught students about volume but also reinforced the importance of visual learning and active participation in mathematical concepts, enhancing both understanding and retention.

In the task comparing cone and cylinder volumes, Shayne incorporates inquiry-based and problem-based learning approaches. Students construct models of cones and cylinders with identical dimensions and calculate their volumes, fostering inquiry through hands-on experimentation and investigation of geometric properties. The task also frames a clear problem, understanding why the cone's volume is one-third that of the cylinder, requiring students to apply formulas, test hypotheses, and draw conclusions grounded in mathematical reasoning.

Playing Math Games

Olivia emphasized the importance of math games in fostering student engagement and addressing learning gaps. She shared how games are a crucial tool in their classroom, enabling students to practice and master a variety of mathematical concepts in an enjoyable and interactive way.

Engagement and Learning Through Games. Olivia believes that math games capture students' attention and actively involve them in their learning process. She explained, "Students enjoy playing games, and at the same time, they learn and practice a variety of math concepts." The interactive nature of games keeps students focused and motivated, particularly when compared to more traditional methods like worksheets. For Olivia, games also provide an avenue for students to explore math concepts without the pressure often associated with formal assessments. By reducing stress, students are more willing to take risks, make mistakes, and learn from them, all of which are vital aspects of conceptual understanding.

One of the key resources Olivia relies on is Lawson's *What to Look For,* a math program provided and endorsed by her school board. This program includes continuums for subtraction, addition, multiplication, and division, which help assess students' current strategies and guide instruction. It also offers a variety of games and lessons designed to teach fundamental math concepts, address misconceptions, and bridge learning gaps, with each activity tailored to meet specific student needs. Additionally, the program includes workshops for teachers, where facilitators model lessons and provide strategies for effective classroom integration. Olivia finds this resource particularly valuable as the games are well-aligned with her students' needs and structured to identify and address misunderstandings effectively.

Promoting Math Dialogue and Peer Support. Liz also emphasized the value of math games and manipulatives in encouraging student engagement and deeper learning. She shared that games naturally lead to meaningful math discussions among students. As they play, students are prompted to explain their thinking, negotiate strategies, and justify their answers, which Liz believes strengthens their conceptual understanding. She explained, "When students talk to each other about their math thinking, they often clarify ideas in ways that even I couldn't." For Liz, these peer conversations often reveal students' thought processes more clearly than formal assessments. She also observed that students who might be reluctant to participate during whole-class lessons often become more confident and vocal when engaged in game-based learning activities. By promoting collaboration, peer support, and mathematical reasoning, Liz views games as a powerful tool to foster both academic growth and a positive attitude toward math learning.

Benefits of Games for Classroom Management. Olivia emphasized the significant role that games play in managing classroom behavior, highlighting their ability to keep students engaged and reduce disruptive behaviors. She explained that games create an interactive and dynamic learning environment, where students who might struggle to stay attentive during traditional lessons often thrive. By incorporating hands-on and collaborative elements, games provide an opportunity for students to actively participate in their learning, making the classroom more manageable and inclusive.

A key advantage of math games is their student-centered approach, which Olivia finds particularly effective. Unlike traditional methods that may rely on passive learning, games require students to collaborate, strategize, and solve problems together. This active participation fosters a sense of involvement and accountability among students. Furthermore, Olivia observed

that even the most disruptive students are drawn to the tactile and social aspects of gameplay. These elements help channel their energy productively, reducing off-task behavior and creating a more harmonious classroom environment.

In contrast, worksheets often present challenges in maintaining student engagement. Olivia noted that students, particularly those who face difficulties with reading or attention, are more likely to leave worksheets incomplete or become distracted. Games, therefore, serve as an effective alternative, enabling these students to engage meaningfully and contribute to their learning in a way that suits their strengths.

Olivia contrasted the success of games with the challenges of using worksheets in her classroom. She described instances where students leave worksheets blank or become distracted, particularly those who struggle with reading or who are easily disengaged. “The most disruptive students engage more in hands-on activities and can participate that way versus when I do a lesson with a worksheet,” Olivia said. Games, therefore, provide an inclusive and supportive alternative that allows all students to contribute and learn effectively.

Math games, as shared by Olivia serve as a dynamic and effective tool in her classroom. They not only support students in developing their mathematical understanding but also foster engagement, reduce classroom disruptions, and provide a more inclusive environment for learning. By integrating resources like Lawson’s What to Look For and creating her own games tailored to her students’ needs, Olivia has found a practical and impactful way to make math both enjoyable and meaningful for her students.

Olivia’s use of math games to support student engagement and learning illustrates the potential for inquiry-based learning, and depending on the context, can support problem-based or project-based approaches as well. Math games encourage students to explore strategies, test

ideas, and engage in self-directed learning, key features of inquiry-based education. When integrated thoughtfully, games can form part of larger projects or challenges, or present authentic problems to solve, thus connecting to project-based or problem-based learning frameworks.

Chapter 5: Results

Introduction

The analysis of this study centers on interviews conducted with three elementary teachers from different schools within the same school board. These educators incorporate performance assessments into their mathematics instruction, each with unique experiences and perspectives. In this chapter, I analyze participants' examples and thoughts about how they use performance assessments in their mathematics classrooms. During the course of discussion, the findings reveal the multifaceted benefits and impacts of using performance assessments in mathematics education that teachers reported on students' learning, challenges teachers encounter, and the characteristics of these assessments in classroom settings. Additionally, the participants provided solutions to mitigate the challenges and suggested success criteria for effectively implementing performance-based tasks.

Study Purpose Overview

This qualitative case study investigates how elementary teachers implement performance assessments in mathematics education. The study explores teachers' strategies, adaptations, and perceptions regarding these assessments. The research is guided by two primary questions:

1. What are teachers' perceptions of how performance tasks impact students' understanding of mathematics concepts and big ideas?
2. What are the characteristics of performance assessments that teachers use in mathematics?

The goal of this study is to document current practices, analyze teachers' experiences, and provide insight into why elementary teachers incorporate performance assessments in mathematics instruction.

To address Research Question 1: What are teachers' perceptions of how performance tasks impact students' understanding of mathematics concepts and big ideas? The participants highlighted numerous benefits of performance assessments in fostering student learning and deepening their understanding of mathematical concepts. These assessments encourage active engagement, critical thinking, and meaningful connections to real-world applications. For instance, Shayne described how the 3D model of a castle task not only reinforced geometric concepts such as surface area and volume but also integrated real-world skills, such as budgeting and planning. Shayne reported that students were able to see the direct connection between mathematics and everyday tasks, such as determining the cost of painting a building, which significantly enhanced their understanding of the material.

Similarly, in a task where primary students explored patterns using solid shapes, participants noted that students gained a deeper grasp of basic algebra concepts by manipulating and creating patterns based on different attributes. This hands-on approach provided students with a concrete understanding of abstract ideas like variables and relationships, which are fundamental to algebraic thinking. Teachers observed that students were more likely to retain these concepts due to the interactive, tactile nature of the task, allowing them to directly connect the mathematics to visual and physical representations.

However, despite these positive outcomes, the participants also identified several challenges they faced in preparing and implementing these tasks effectively. For example, in the case of the 3D castle model, Shayne noted the complexity involved in managing group work, sourcing materials, and ensuring that all students remained engaged and focused on the mathematical objectives. Additionally, the time required for such tasks often posed a challenge, as teachers had to balance these rich, project-based assessments with the demands of other

curricular components. Similarly, in the pattern exploration task, while students demonstrated a strong understanding of algebraic concepts, Liz found that providing sufficient scaffolding for younger students to articulate their thinking was difficult, particularly in terms of guiding them through the abstract nature of patterns.

These examples, as reported by the participants, illustrate the perceived impact of performance-based tasks in enhancing students' understanding of mathematical concepts, while also revealing the complexities teachers must navigate to implement such tasks effectively.

Benefits of Using Performance Assessments and Their Impacts on Students

The participants in this study shared multiple benefits of incorporating performance assessments into mathematics education. These assessments not only enhance student engagement and understanding but also foster critical thinking, collaboration, and problem-solving skills. Below is a list of benefits, followed by detailed examples and direct descriptions from the participants:

1. Students Pay Attention to the Process, Not Only the Product
2. Assessing Mathematical Knowledge Rather than Reading Comprehension
3. Math Talks, Peer Assessments and Formative Assessments
4. Students Take Task Ownership
5. Building students' Confidence in Learning Math
6. Making Real-life Connections as Math Becomes a Real Subject
7. Integration of Multiple Subjects
8. Students Become Better Problem Solvers and Critical Thinkers
9. Active Participation
10. Improves Motor Skills and Enhances Hands-on Skills

Students Pay Attention to the Process, Not Only the Product

Shayne highlighted that performance assessments encourage students to focus on the learning process rather than solely on the final product. He explained, “When working on a performance-based task, I find that students demonstrate their step-by-step learning and are more concerned about the process, not only finding the final answer and completing the task.” This step-by-step approach allows students to explore multiple methods, learn through trial and error, and document their journey toward a solution.

For Shayne, understanding the process is crucial because it offers insight into students’ reasoning, the steps they took, the challenges they faced, and how they overcame them. He shared, “The process and the steps students take are more important than the final product or answer. Students demonstrate their thinking by describing the process and the steps they had taken to solve the task.” This focus on process helps teachers identify areas of strength and confusion, enabling more targeted instructional interventions.

In contrast, traditional paper-pencil tests emphasize the final product, often overlooking the valuable thought processes students use to arrive at answers. Shayne expressed concern that these tests fail to capture the depth of students’ understanding, as they do not allow students to articulate their thinking.

Assessing Mathematical Knowledge Rather than Reading Comprehension

Olivia emphasized that performance assessments allow teachers to evaluate mathematical understanding without being hindered by students’ reading abilities. She explained, “I think that performance assessments ensure we are assessing the skills we want rather than reading comprehension of questions.” This distinction is particularly important in Olivia’s context, as she works at a core (compensatory) school where many students struggle with literacy.

Olivia finds that her students engage more effectively with hands-on tasks than with traditional worksheets, which often require substantial reading and writing. She explained that performance tasks offer a more transparent insight into her students' understanding of mathematical concepts, allowing them to showcase their thought processes verbally or through actions instead of relying solely on written responses. She added, "Students are not stressed like they are in a testing environment, and they can show more of what they know, and they are not scared of math."

Math Talks, Peer Assessments and Formative Assessments

Performance assessments create opportunities for meaningful math discussions, collaboration, and formative assessments. Shayne shared, "There is lots of scope for peer assessment and formative assessment during performance-based tasks, and tasks progress with lots of math conversations." These assessments encourage students to discuss their ideas with peers, collaboratively plan their approach, and share strategies.

Shayne described the benefits of math talks, where students come together as a group to solve a problem, share their strategies, and explain their reasoning. He said, "I have noticed a math talk going on in different groups when they are working on their projects. Everyone has something to offer to the group." Math talks foster a deeper understanding of mathematical concepts and allow students to learn from their peers' perspectives.

Liz also emphasized the value of conversations during performance tasks, stating, "The information you get from it is far richer than a paper-pencil test." She shared an example of a student who struggled with traditional assessments but excelled in class discussions. Through one-on-one conversations, Liz discovered that the student understood the concepts but had

difficulty translating them onto paper, underscoring the importance of performance-based assessments for capturing true understanding.

Students Take Task Ownership

Performance assessments play a pivotal role in encouraging students to take ownership of their learning. Shayne highlighted this benefit, stating, “It helps to boost their social and emotional learning skills in mathematics because they have ownership of their learning and feel proud of learning mathematics.” This sense of ownership emerges from the active and engaged nature of performance assessments, where students are not passive recipients of knowledge but active participants in their educational journey.

Shayne explained that one of the primary methods performance assessments foster ownership is by encouraging students to take on specific roles and responsibilities within group tasks. He emphasized that these roles are not arbitrary but are thoughtfully assigned to ensure they are meaningful, allowing students to engage deeply with the material and contribute uniquely to the group’s success. For instance, some students might focus on presenting findings, while others handle calculations or create visual representations. By assigning these responsibilities, teachers empower students to feel accountable for their contributions, which enhances their engagement and sense of purpose.

Building Students’ Confidence in Learning Math

Shayne, Liz, and Olivia collectively emphasized that performance assessments play a significant role in building students’ confidence and self-efficacy in mathematics. They explained that these tasks empower students by encouraging them to take ownership of their learning, actively engage with mathematical concepts, and showcase their understanding in meaningful ways. Shayne highlighted how performance assessments foster confidence through

their hands-on, interactive nature, stating, “Students gain more confidence in mathematics when they do these performance tasks.” Similarly, Olivia observed that such tasks enable students to recognize their abilities and contributions, adding, “Performance assessments help students build more confidence in math as they feel they can achieve something and have something to share.”

By shifting the focus away from rote memorization and emphasizing authentic, engaging challenges, performance assessments transform how students view mathematics. Liz noted that when students see their efforts reflected in successful outcomes, they experience a sense of accomplishment and pride, which is particularly impactful in a subject that often feels intimidating. This supportive environment not only enhances students’ self-esteem but also motivates them to approach math problems creatively, collaboratively, and with greater confidence. Through these experiences, students develop a deeper appreciation for the problem-solving process and are inspired to tackle increasingly complex challenges with enthusiasm.

Making Real-life Connections as Math Becomes a Real Subject

Shayne emphasized that connecting mathematics to real-life scenarios is critical for making the subject more engaging and meaningful for students. He remarked, “Many people believe that mathematics is a dry subject, but it is one of the most interesting subjects as long as it is connected with real-life scenarios.” This perspective highlights the transformative potential of contextualizing math within real-world situations, as it shifts the focus from abstract computations to tangible applications that resonate with students’ everyday experiences.

When mathematics is grounded in real-life contexts, it becomes more accessible and engaging, allowing students to see its relevance beyond the classroom. Shayne explained that performance assessments provide an ideal framework for achieving this by incorporating tasks that mimic real-world challenges. For example, students might calculate the cost of painting a

model structure, use geometry to design stable bridges, or apply measurement concepts to determine the height of a tree. These activities not only teach mathematical principles but also demonstrate how those principles are used in professions such as engineering, architecture, and business.

Olivia supported this perspective, adding, “It is easier to make connections to real-life applications.” By designing performance tasks that align with authentic scenarios, teachers help students bridge the gap between theoretical knowledge and practical use. Olivia’s approach reflects the importance of creating learning experiences that are relatable and engaging, particularly for students who might otherwise view math as irrelevant or intimidating.

Olivia emphasized that real-life connections deepen students’ understanding of mathematical concepts. When they can see how math applies to problems they encounter in their daily lives, they are more likely to internalize the material and retain it over time. Furthermore, these connections inspire curiosity and critical thinking, as students explore how mathematical principles can solve meaningful problems. By rooting math in real-world scenarios, performance assessments do more than teach skills; they cultivate an appreciation for mathematics as a dynamic and essential tool. This approach not only engages students but also empowers them with the knowledge and confidence to apply math in their personal and professional lives.

Integration of Multiple Subjects

Olivia emphasized the unique ability of performance assessments to integrate multiple subjects, offering a cohesive and streamlined approach to curriculum delivery. This integration allows teachers to address learning goals across various disciplines simultaneously, making the most of instructional time while creating richer, more meaningful learning experiences for students. Performance assessments encourage students to draw connections between subjects,

helping them understand how concepts and skills from one area can apply to others. Olivia highlighted the value of this interdisciplinary approach in breaking down the silos that often exist in traditional education, fostering a more holistic understanding of knowledge.

To illustrate this, Olivia shared an example of combining science and math in a performance-based task where students built stable structures using geometric shapes. This task not only addressed science concepts related to structural stability and strength (Ontario Science Curriculum, Grade 3, Specific Expectation D2.3, 2022), which requires students to identify factors that affect the stability and strength of structures, but also aligned with mathematics learning goals, such as identifying and working with 2D and 3D geometric shapes (Ontario Math Curriculum, Grade 3, Specific Expectation E1.2, 2020), which focuses on composing and decomposing two-dimensional shapes and three-dimensional objects. By engaging in this hands-on activity, students could see how the principles of geometry inform real-world engineering and design challenges. Olivia noted that such tasks increase student engagement, as learners become more invested in projects that demonstrate the practical relevance of their education. This approach not only meets curriculum expectations in both subjects but also equips students with problem-solving skills, creativity, and an appreciation for the interconnectedness of knowledge across disciplines.

Students Become Better Problem Solvers and Critical Thinkers

Performance assessments are powerful tools for fostering critical thinking and problem-solving skills in students by allowing them to approach mathematical tasks from multiple perspectives. These assessments encourage exploration and creativity, moving beyond traditional right-or-wrong answers and focusing instead on the process and reasoning behind solutions.

Shayne highlighted this transformative aspect of performance assessments, stating, "There is no right or wrong answer, but they are doing something to the best of their potential." This open-ended approach allows students to explore various strategies, make decisions, and refine their thinking as they progress through the task. By engaging in such tasks, students are challenged to consider different angles, develop logical reasoning, and justify their solutions, all of which are key components of critical thinking.

In addition to fostering critical thinking, performance tasks improve observational skills. As students work through complex problems, they become more attuned to details, patterns, and relationships within the mathematical concepts they are exploring. Shayne emphasized how these tasks enhance mathematical understanding, stating that students not only arrive at solutions but also gain deeper insights into the principles underlying their work.

By providing students with opportunities to think critically, solve problems, and observe the nuances of mathematical concepts, the participants collectively emphasized that performance assessments serve as a holistic approach to learning. They equip students with skills that extend beyond the classroom, preparing them for real-world challenges that require analytical and creative problem-solving abilities.

Active Participation

Performance assessments actively involve all students, transforming them from passive listeners into engaged participants. Shayne elaborated on this, stating, "Students actively participate to break the monotony of the routine paper-pencil task or the lecture method," highlighting how these tasks create dynamic learning experiences. Unlike traditional methods, which may cater to a limited range of learning styles, performance assessments provide opportunities for hands-on exploration, group collaboration, and individual creativity. This active

engagement fosters deeper learning as students become personally invested in the task, applying critical thinking and problem-solving skills to achieve their goals.

Improves Motor Skills and Enhances Hands-on Skills

Shayne observed that performance assessments enhance students' motor skills by engaging them in hands-on activities that require precision and dexterity. He provided an example where students constructed castles, explaining, "For example, when students work on building castles, they learn paper cutting and measurements using measuring tools and how to do some calculations." This type of task not only involves applying mathematical concepts such as measurement and geometry but also builds practical skills, such as using tools and following detailed procedures. By integrating these physical and cognitive processes, students develop a deeper understanding of the subject matter while honing fine motor coordination.

The participants collectively emphasized that performance assessments deliver a broader and richer understanding of students' capabilities. Unlike traditional assessments, these hands-on tasks reveal not only what students know but also how they apply that knowledge in collaborative and real-world contexts. The interactive nature of performance assessments fosters engagement, encouraging students to work together and explore diverse solutions to problems. This collaborative learning environment enables students to exchange ideas, support one another, and develop critical skills like teamwork and communication.

Challenges Faced by Teachers

The study revealed several challenges teachers encounter when implementing performance assessments in mathematics education. While these assessments provide numerous benefits, their execution poses significant hurdles. These challenges are discussed in detail below, supported by the participants' experiences and insights.

Time Consuming Nature of Performance Assessments

The participants unanimously identified the time-consuming nature of performance assessments as a significant challenge. Shayne explained, “The biggest one I find is that performance assessments are time-consuming because many times you need one full week for that kind of project, so if you try to spend time on each and every activity, you will not be able to finish curriculum-specific expectations in that school year.” This extended timeframe required for planning, executing, and assessing performance tasks often leaves teachers feeling pressed for time, especially in meeting the demands of a packed curriculum.

Olivia also highlighted the difficulty of providing individual attention during performance tasks, stating, “There is not enough time to reach each student while they are working on these performance-based tasks.” Liz echoed this sentiment, particularly in the context of early primary education: “I do not have enough time to do everything in my day, especially in the early primary when you have so many students that need your guidance and follow-up, so it takes so long to go to each group and see how they are working and what they are doing.”

Keeping Students on Track

Maintaining student focus during performance assessments was another challenge. Shayne described the difficulties of keeping all students engaged: “Sometimes students are not focused. It is very difficult in some classes to keep students on track. There are so many issues going on in the classrooms; maybe someone has some kind of disability, or maybe students with behavioral issues. In these cases, keeping the students on task is a little bit difficult.”

Liz shared a similar perspective, particularly in busy classrooms. She explained, “When you have a very busy class, you try to keep occupied. Sometimes, I worry that kids cannot give

their full, honest answers or performance because there is chaos in the rest of the classroom, but it is only me, so I can do what I can do." This challenge underscores the importance of effective classroom management strategies during performance assessments.

Increased Teacher Workload

Performance assessments significantly increase the workload for teachers, both in terms of preparation and execution. Shayne remarked, "Teachers themselves did not learn in this way, so they believe it is impossible to use performance-based tasks because they have not learned all those tasks in the same way. They also need to do tons of work. They have to prepare very well for those activities and again teachers are so busy. They do not have that much time to explore those many resources."

Liz also commented on the resources available through the school board, noting that they often require additional effort to locate and utilize: "We do have the Math Professional Learning Environment (PLE), and there is some really good stuff there. The problem is it is all about looking for it on your own, and if I had known what to look for, I probably could have done that. I am not sure when they expect me in my personal time to go dig through things."

Olivia and Liz further pointed out the need for differentiation, which adds another layer of complexity to teachers' workloads. Olivia explained, "I have to ensure that the task is differentiated to meet the needs of all my students, and not all of them are already differentiated, so I have to do some extra work to differentiate." Liz agreed, stating, "Not one size fits all," emphasizing that tasks often need to be adjusted to suit students' diverse needs.

Limited Resources

Shayne observed that teachers often face limitations in available resources, which impacts their ability to implement effective performance assessments. He noted, "Teachers do

have limited resources, and I also believe that not all the activities fit into the framework of performance-based tasks."

Olivia added that the lack of manipulatives sometimes prevents her from fully implementing performance tasks, while Liz highlighted issues with the quality of available tasks: "Some of the ones that you get given do not really assess what you want them to assess. It is like, what are you actually asking me because you are so wordy? Are you asking me to decode and pick out important information? Or are you actually asking me to solve a problem? But that is just the makeup of the assessments, which sometimes are the problem."

Connecting Tasks to the Curriculum

Shayne emphasized the importance of aligning performance tasks with curriculum content, noting that this can be a challenge for some teachers. He explained, "If a teacher is not able to connect that activity with the topic or the content, then you will lose the fidelity of the curriculum, so making connections is very important." This challenge highlights the need for teachers to have a deep understanding of curriculum expectations to effectively integrate performance assessments.

Provide Proof of Assessment for Parents

Olivia shared that gaining parental support for performance assessments is challenging because parents are accustomed to traditional methods. She stated, "Having proof of assessment for parents is a challenge. It is hard for them to understand a different way of teaching and assessment than how they learned when they were also students." Parents often request tangible evidence of their child's learning, such as worksheets or quizzes, which adds to teachers' workloads as they attempt to provide alternative forms of proof. However, performance assessments can offer rich evidence of student learning through anecdotal notes, checklists,

rubrics, photographs, videos, and student reflections. These forms of assessment capture a student's ability to apply concepts in real-world contexts, demonstrating critical thinking, problem-solving, and collaboration skills that may not be evident in traditional paper-based tasks. By sharing this evidence with parents, teachers can help bridge the gap between traditional expectations and performance assessment practices.

Addressing Students' Needs After Assessment

Liz expressed frustration in supporting students after identifying their struggles through performance assessments. She explained, "Sometimes, even though you get the information of what students are struggling with, it is really hard to get them past those challenges and come up with a way that helps everybody. Like I can see where your error is. I know what I need to help you with, but I do not know how to get you to that part." This challenge highlights the need for additional training and resources to help teachers use assessment data effectively to support student learning and develop a better understanding of students' developmental trajectories.

Balancing Benefits and Challenges

Despite the challenges, the participants agreed that the benefits of performance assessments outweigh the obstacles. These assessments provide a comprehensive view of student learning, emphasizing conceptual understanding, collaboration, and problem-solving. However, addressing the challenges requires targeted solutions, such as additional resources, professional development, and parental education. The following section will outline participant-suggested solutions to help teachers overcome these challenges and effectively implement performance assessments.

Suggested Solutions to Challenges in Implementing Performance Assessments

Prior to presenting the suggested solutions, it is worthwhile to examine the accessible and available assessment resources. This examination provides a comprehensive understanding of the tools currently at educators' disposal, shedding light on their effectiveness, limitations, and alignment with instructional goals.

Accessible and Available Assessment Resources

While limited resources present significant challenges to implementing effective performance assessments, it is crucial to consider the tools and materials available. The school board provides a range of resources designed to support teachers, and participants also referenced external platforms they have used over the years. However, effectively accessing and utilizing these resources remains a challenge, as highlighted by the participants. The following sections examine the resources provided by the school board and other online platforms, exploring their potential benefits and the barriers to their effective use.

Resources Offered by the School Board

The school board offers various assessments and resources intended to support teachers in implementing word problems and tasks with real-life connection. These materials are accessible through Brightspace, the board's online platform, where the math team regularly adds courses and resources. The board has also developed Long Range Plans that include lessons, PowerPoints, and diagnostic and summative assessments, all aligned with the Ontario Math 2020 Curriculum.

Despite the availability of these resources, not all teachers are utilizing them. A significant reason is the lack of Professional Development (PD) sessions to introduce and train teachers on how to effectively use these materials. Participants expressed that they do not have

time to independently review and familiarize themselves with the new resources. Liz shared her frustration, “We lack some of the training like they say, oh here it is. You have it all on Brightspace. Well, that is great, but that is not training for me, and I am not sure when you are expecting me to go dig through things.”

Additionally, while math coaches are available to assist teachers in navigating these resources, accessing their support is challenging. Liz noted, “We do have math coaches. It depends on who your math coach is that year; they can be a phenomenal resource sometimes. Well, specifically right now, they are really focusing on grades 3 and 6, so if you do not teach grade 3 or 6, kind of getting access to them is a challenge because they have been mandated to focus on those grades.” Each math coach is assigned to multiple schools, and their priority is often supporting grades 3 and 6 due to standardized testing pressures. This allocation leaves teachers of other grades with limited access to guidance and support.

Ready-made Online Resources

In light of these challenges, some teachers have turned to ready-made online resources, even though the school board does not officially endorse assessments from certain online platforms. Participants admitted that over the years, they have purchased and utilized these resources because they are ready-made and easy to use. Olivia explained, “Ready-made lessons save teachers time and effort, as we do not have enough preparation time for all this work.”

These resources provide convenience by offering complete lessons, assessments, and rubrics, which is particularly helpful given the increased workload associated with creating performance-based tasks from scratch. Teachers who design their own performance tasks often need to develop accompanying rubrics and assessment tools, adding to their already substantial responsibilities. However, reliance on non-board-approved resources raises concerns

about alignment with curriculum expectations and the quality of assessments. Liz mentioned, "Some of the ones that you get given do not really assess what you want them to assess... But that is just the makeup of the assessments, which sometimes are the problem."

The participants proposed several solutions to address the challenges they encountered when implementing performance assessments in mathematics education. Their suggestions highlight strategies to improve both teacher and student experiences while optimizing the effectiveness of these assessments.

Setting Clear Expectations and Instructions

Shayne emphasized the importance of establishing clear expectations from the start of the school year, particularly when introducing performance-based tasks. He shared, "Keeping these challenges in mind, I just try to follow some expectations in my classroom. From the beginning of the school year, and especially for a performance-based task, I set up some expectations in the classroom, and I keep reminding my students from time to time because some students need those reminders."

Clear expectations reduce disruptive behavior, helping students understand what is required of them and providing a structure they can follow. In addition, Shayne highlighted the value of co-creating learning goals and success criteria with students. "Setting up the task's objectives is essential in performance assessments," he stated. "As a class, we co-create and discuss the success criteria for that task. Then, I ask them how they would like to see their final product if this is their project. What things must it show as a complete project? So that is how we co-create the success criteria."

Co-planning and Co-teaching with Grade Partners

Collaborating with other teachers can help alleviate the workload associated with planning and implementing performance assessments. Shayne explained, “Co-planning means we plan with other teachers. If we are working in two or three different classrooms, we can co-plan and co-teach with other grade partners to have more ideas. Sometimes, a teacher has an idea, and another teacher has a different one, so we collaborate to do those kinds of projects together. So, we co-teach, co-plan, and co-reflect with other teachers, which is very helpful.” This approach fosters collaboration, bringing diverse perspectives to task design and ensuring that teachers can share responsibilities for instruction and assessment.

Engaging Parents through Open Conversations

Olivia noted that many parents struggle to accept performance assessments because they are unfamiliar with non-traditional teaching and assessment methods. To address this, she suggested proactive communication: “Having conversations with parents about why I do it, and its benefits can convey the importance of performance assessment, and hopefully, with time, they can recognize the difference and get to the point where they understand that performance assessments are more effective than traditional paper-pencil tests.” By explaining the purpose and benefits of performance assessments, teachers can build trust with parents and help them understand the advantages of these methods over conventional testing.

Increasing Access to Math Coaches

Liz expressed the need for greater access to math coaches, who currently focus primarily on grades 3 and 6. To address this, Liz suggested increasing the number of math coaches available to support all grade levels. She also emphasized the value of these coaches in helping teachers navigate the Math Professional Learning Environment (PLE) on Brightspace. She

remarked, “It would be helpful if educators could have access to math coaches who can show them where and what to look for and walk them through how to use that PLE.”

Providing More Training, Workshops and Professional Development Sessions

Liz stressed the importance of additional training and professional development opportunities to help teachers effectively use available resources and apply them to their instruction. She shared her frustrations about the lack of adequate training, noting that while resources are made available on Brightspace, simply providing access is not equivalent to proper training. She highlighted the challenge of finding time to navigate and review these materials independently amidst their busy schedules.

She proposed that professional development sessions focus on practical applications: “There needs to be more training. There needs to be time given. There needs to be more math coaches who can be accessible to all teachers regardless of the grade level they teach. We need to focus more on the application, so the school board has provided many resources. Can someone please show me how to apply all this stuff?”

Enhancing Teachers’ Knowledge

Shayne highlighted the necessity of strong content knowledge for successfully implementing performance assessments. He explained, “Knowledge of the content to be taught can enhance educators’ comfort level. So, if someone has to use those performance tasks in mathematics, they must have a strong knowledge and understanding of the math content of their grade level as well.”

Olivia also emphasized confidence with the curriculum, stating, “Teachers need to be confident with the curriculum and the idea of having multiple solutions to one problem.” This

confidence allows educators to model and explore different problem-solving strategies with students.

Conversely, Liz contended that while a strong mathematical background can be beneficial, it is not a strict requirement for effectively implementing performance assessments. Instead, she emphasized the importance of teachers having a clear understanding of the purpose and objectives behind each assessment task. For Liz, the critical factor lies in comprehending what the assessment is designed to evaluate whether it focuses on knowledge and thinking, application of concepts, or computational skills. This clarity ensures that teachers can align the tasks with their instructional goals and accurately interpret students' responses.

Liz argued that without this understanding, even well-designed tasks may fail to meet their intended outcomes, as teachers might misinterpret the objectives or fail to provide the necessary scaffolding for students. She highlighted that effective implementation hinges on teachers being able to discern the core competencies the assessment is targeting and tailoring their approach accordingly. By focusing on the purpose and outcomes of the tasks, teachers can maximize the potential of performance assessments to provide meaningful insights into students' learning and abilities.

Creating Open-ended Questions

Olivia emphasized the importance of equipping teachers with the ability to craft open-ended questions that align seamlessly with their instructional goals while also connecting to real-life scenarios. She highlighted that open-ended questions are a powerful tool in mathematics education as they provide students with opportunities to explore multiple approaches and solutions rather than being confined to a single correct answer. Such questions encourage

students to think critically and engage deeply with the material, as they require them to analyze, interpret, and apply mathematical concepts to various contexts.

Olivia underscored that integrating real-life scenarios into these questions not only makes math more relatable but also helps students see its relevance in their daily lives. For example, questions that involve budgeting, measurements for a construction project, or calculating the time and distance for a trip enable students to connect classroom learning to practical applications. This approach fosters a problem-solving mindset, where students can explore different strategies, collaborate with peers, and justify their reasoning. Olivia emphasized that by engaging with open-ended, real-world questions, students develop a deeper understanding of mathematical principles while building the confidence to apply these skills in authentic situations beyond the classroom.

Conclusion

The participants' suggested solutions aim to address the challenges associated with performance assessments. By setting clear expectations, collaborating with teaching partners, engaging parents, increasing access to math coaches, providing more professional development, enhancing teachers' knowledge, and designing open-ended questions, educators can overcome these obstacles and effectively implement performance assessments. These strategies create a pathway for performance assessments to become a more manageable and impactful component of mathematics education.

Characteristics of Performance Assessments in Mathematics

To answer Research Question 2: What are the characteristics of performance assessments that teachers use in mathematics? The participants shared their philosophies of assessment and provided examples of performance tasks implemented in their classrooms. Their insights highlight the flexible, authentic, and meaningful nature of performance assessments and their alignment with instructional goals.

Philosophies of Assessment in Mathematics

Flexibility of Performance Assessments

Shayne emphasized the inherent flexibility of performance assessments, explaining that they allow students to take ownership of their roles, contributions, and communication strategies. He described performance assessments as tools that provide students with choices, enabling them to engage with tasks in ways that suit their strengths and preferences. “They offer flexibility as they allow students to decide on the responsibilities they would like to take, how they will contribute, and how they will communicate their learning,” Shayne stated.

Similarly, Olivia viewed performance assessments as opportunities for students to experiment with strategies, take risks, share their ideas, and learn through authentic, meaningful activities. For both Shayne and Olivia, the ultimate goal of performance assessments is to enhance students’ understanding of mathematical formulas and concepts. However, they both stressed that careful preparation and alignment with learning goals are essential for these tasks to be successful.

Hands-on and Authentic Learning

Shayne highlighted the value of learning by doing, asserting that students achieve a deeper understanding when they actively engage in problem-solving. He explained, “Students

learn better when they experience doing things themselves. They learn from their mistakes and get more experience working independently and collaboratively."

Performance-based tasks encourage students to be hands-on, reflect on their challenges, and explore multiple solutions. This approach not only develops problem-solving and critical thinking skills but also promotes perseverance and self-efficacy.

Alternative to Traditional Worksheets

Liz preferred performance assessments over traditional worksheets, especially for younger students. She observed that worksheets often fail to capture her students' true understanding of mathematical concepts. "Performance assessments are better as they do not require my grade 2 students to write and complete a worksheet," she explained. Instead, hands-on tasks allow Liz to identify her students' strengths and misconceptions more effectively. Over the years, Liz learned that younger students are more likely to demonstrate their knowledge and skills through activities that do not rely heavily on written responses. For her, performance assessments offer a more accurate and comprehensive picture of her students' mathematical thinking.

Why Teachers Choose Performance Assessments

Performance assessments offer a distinctive approach to evaluating student learning, setting them apart from traditional paper-and-pencil tests. These assessments emphasize engagement, authenticity, collaboration, and flexibility, creating opportunities for students to demonstrate their understanding in meaningful and practical ways.

Engagement in the Learning Process

A defining characteristic of performance assessments is their ability to engage students actively in the learning process. Unlike traditional tests that often emphasize rote memorization

and static responses, performance assessments encourage students to delve into mathematical concepts through hands-on tasks and real-world applications. By connecting learning to their everyday experiences, these assessments make math more relevant and meaningful for students.

Show their Thinking

One of the key advantages of performance assessments is the opportunity they provide for students to demonstrate their thinking. Rather than relying solely on written responses, students can explain their reasoning orally or visually, making their thought processes transparent to both themselves and their teachers. Additionally, these assessments require students to interact directly with the material through practical activities such as building models or conducting experiments, which naturally captures and sustains their attention.

Interact with the Material

Olivia's experience in her classroom exemplifies the engaging nature of performance assessments. She observed that hands-on tasks not only allow students to showcase their understanding but also reduce the stress often associated with traditional written tasks. She explained, "Students show their thinking and explain it orally," emphasizing how performance assessments cater to diverse learning needs by providing multiple avenues for students to express their knowledge.

Authenticity and Real-Life Connections

Performance assessments must be authentic, requiring students to engage in meaningful tasks that relate directly to real-life scenarios. This authenticity allows students to see the relevance of mathematics in their everyday lives, making the subject more applicable and accessible while deepening their understanding of mathematical concepts. By mirroring real-world problems, these tasks encourage students to think critically and apply their knowledge in

practical ways. Shayne highlighted the importance of this connection, stating, “Mathematics is one of the most interesting subjects as long as it is connected with real-life scenarios.” He observed that students not only remember but also better understand mathematical concepts when they are presented within the context of situations they encounter in their daily lives, further emphasizing the value of authentic performance assessments.

Collaboration and Communication

Collaboration is a fundamental aspect of performance assessments, fostering an inclusive and dynamic learning environment where students work together to achieve common goals. Within group tasks, students take ownership of their learning by setting individual objectives and determining their roles, which enhances their engagement and accountability. Through these collaborative efforts, students strengthen their communication skills as they share ideas, explain their reasoning, and learn from their peers. This process not only promotes critical thinking but also builds self-confidence, as students recognize that there is no single “right” answer or fixed method to solve a problem. Shayne emphasized the collaborative nature of performance assessments, noting that they encourage teamwork and inclusivity. He explained, “All the students learn to work as one big team. Everyone feels included, and no one is left out.” This equitable approach allows each student to contribute based on their strengths, ensuring that every learner feels valued and empowered in the classroom.

Flexibility in Problem-Solving

One of the most notable benefits of performance assessments is their inherent flexibility, which allows students to engage with tasks in diverse and personalized ways. These assessments accommodate varying levels of readiness and individual problem-solving preferences, making them accessible to all learners. Students have the freedom to choose their strategies and decide

on the steps they will take to complete the task, fostering a sense of autonomy and ownership. This approach shifts the focus from merely achieving the correct answer to valuing the process of exploration and creativity. Shayne highlighted this adaptability, explaining, “Students have the freedom to decide how to approach the task, what strategies to use, and what steps to take.” This flexibility ensures that performance assessments cater to a wide range of abilities, enabling all students, regardless of their background or skill level, to actively participate and find success in the learning process.

Building Confidence and Self-Esteem

Performance assessments empower students by moving away from rote memorization and emphasizing meaningful, hands-on learning. This approach not only deepens understanding but also builds self-confidence and instills a sense of accomplishment in students. By engaging in authentic tasks, students gain the skills and assurance needed to approach challenges with resilience and creativity. Olivia highlighted this impact, noting that performance assessments help students feel capable and confident, enabling them to tackle more complex problems with determination. Similarly, Shayne reflected on the transformative nature of these tasks, observing that students often take pride in their achievements, particularly when they succeed in solving real-world problems. These positive experiences foster a sense of empowerment, making mathematics more approachable and enjoyable for learners.

Conclusion

The characteristics of performance assessments—engagement, authenticity, collaboration, flexibility, and confidence-building—make them a powerful tool in mathematics education. By connecting learning to real-world contexts and encouraging students to explore, communicate, and collaborate, performance assessments support a holistic understanding of

mathematics, equipping students with the skills they need for success in and beyond the classroom.

Chapter 6: Discussion and Conclusion

Introduction

This chapter synthesizes the findings presented in Chapter 4 with the literature reviewed in Chapter 2, providing a comprehensive discussion of the study's results. The chapter addresses the research questions:

1. What are teachers' perceptions of how performance tasks impact students' understanding of mathematics concepts and big ideas?
2. What are the characteristics of performance assessments that teachers use in mathematics?

This chapter connects the findings to existing research, highlights implications for teaching and policy, and provides recommendations for future research. The chapter also discusses the study's limitations and concludes with reflections on its significance.

Discussion of Findings

Research Question 1: Teachers' Perceptions of Performance Tasks

The findings revealed that teachers perceive performance assessments as transformative tools that foster deeper engagement, critical thinking, and real-world connections. These perceptions are consistent with prior research that underscores the benefits of performance tasks in creating meaningful and student-centered learning experiences (Suurtamm et al., 2010; Thompson et al., 2020).

Impact on Student Understanding

The study revealed that performance assessments significantly enhance students' understanding of mathematical concepts by encouraging active engagement, critical thinking, and real-world applications. Teachers observed that tasks such as the "3D Model of a Castle"

enabled students to explore complex mathematical ideas, for example geometry and measurement, through practical activities like budgeting and cost calculations. This aligns with Suurtamm and Koch's (2014) assertion that performance assessments foster inquiry-based, student-centered learning, and help students contextualize mathematics within real-world scenarios.

The hands-on and interactive nature of these assessments further deepened students' conceptual understanding. For example, in the task "Finding the Surface Area of a Circle," students not only calculated surface areas but also visualized how formulas are derived through practical manipulations, such as rearranging circle segments into a rectangle.

Moreover, teachers reported that performance tasks improved students' retention of mathematical concepts. Unlike traditional assessments, which often emphasize rote memorization, these tasks encouraged students to internalize their learning by applying it in meaningful ways. This observation supports Black and Wiliam's (2010) argument that formative assessments focused on understanding lead to long-term learning outcomes, making performance tasks a powerful tool for enhancing both comprehension and retention.

Benefits of Performance Assessments

Teachers identified several key benefits of performance tasks. One significant advantage was their focus on process-oriented learning, which encourages students to document and reflect on their reasoning and strategies. Additionally, performance assessments were recognized for their inclusivity, allowing students of diverse abilities to demonstrate their understanding through various modes, such as hands-on or verbal approaches. Teachers also highlighted the ability of these tasks to connect mathematical concepts to real-world contexts, making learning more engaging and relevant to students' lives. Lastly, performance assessments were found to build

students' confidence and reduce math anxiety by fostering a sense of ownership and achievement in their learning process.

Focus on Process. Participants emphasized that performance assessments prioritize the learning process rather than merely the final product. This finding is consistent with Sadler's (1989) emphasis on formative assessment as a bridge to close learning gaps. Shayne's observation that students articulate their thought processes during performance tasks underscores the alignment with formative assessment principles, where feedback is ongoing and integrated into learning. "Students demonstrate their thinking by describing the process and the steps they had taken to solve the task" (Shayne). This focus contrasts traditional paper-pencil tests, which tend to evaluate outcomes without capturing the reasoning or decision-making processes behind solutions (Black & Wiliam, 2010).

Reduce Barriers. Assessments should provide all students with a fair opportunity to demonstrate their understanding, yet traditional paper-pencil tests often create obstacles for those who struggle with literacy, language barriers, or test anxiety. These challenges can disproportionately affect students in diverse learning environments, particularly in compensatory schools where educational inequities are more pronounced. Performance assessments serve as a powerful alternative by removing these barriers and offering multiple pathways for students to engage with mathematical concepts, ensuring that all learners, regardless of their reading or writing abilities, can actively participate and succeed.

Addressing Literacy Challenges in Mathematics Assessment. Performance assessments offer a more inclusive approach to evaluating student learning by allowing students to demonstrate mathematical understanding through multiple modalities, reducing the disadvantages faced by those with reading or writing difficulties. Traditional paper-pencil tests

often obscure students' true mathematical abilities by placing a disproportionate emphasis on literacy skills. Olivia, who teaches at a compensatory school, serving students from low-income backgrounds or communities where socioeconomic factors contribute to educational challenges, observed that many of her students struggled with reading and writing, which negatively impacted their performance on written math assessments.

Compensatory schools often have a higher proportion of students with learning gaps, English Language Learners (ELLs), and those with special education needs, many of whom face additional barriers such as food insecurity, housing instability, and limited access to educational resources. Given these challenges, students in compensatory schools may find it difficult to succeed in traditional testing environments, where strong literacy skills are often required to interpret and respond to assessment questions. Olivia found that performance-based tasks helped eliminate these barriers by allowing students to engage in verbal explanations, hands-on demonstrations, and collaborative discussions, enabling them to showcase their mathematical thinking without being solely dependent on written responses.

Differentiated Instruction and Multiple Pathways to Learning. By prioritizing conceptual understanding over rote memorization, performance assessments provide students with multiple entry points into learning, accommodating a wide range of strengths and abilities. Olivia noted that students who struggled with written expression often flourished when allowed to articulate their reasoning aloud or use physical models to represent mathematical concepts. This idea aligns with Syaifuddin's (2020) argument that authentic assessments promote accessibility and inclusivity, ensuring that all students, regardless of their academic background, can actively engage in the learning process.

Building Confidence Through Performance-Based Learning. In addition to reducing anxiety, performance assessments foster confidence and a sense of accomplishment in students who might otherwise feel discouraged by traditional assessments. Olivia observed that when students engaged in hands-on tasks, they appeared more confident and willing to take risks, as the pressure of writing a correct answer was removed. This finding aligns with Bandura's (1997) theory of self-efficacy, which suggests that students who feel competent in their ability to perform a task are more likely to engage actively, persist in their learning, and develop confidence in their mathematical abilities.

Shayne further emphasized that performance tasks help students develop a growth mindset by leading them to see mistakes as learning opportunities rather than failures. When students worked on real-world problems or group-based projects, they became more comfortable experimenting with different strategies and refining their understanding. He noted that students took greater pride in their work when they had control over how they demonstrated their learning, reinforcing their belief that they could succeed in mathematics. This idea supports Bandura's (1997) concept of self-efficacy, which posits that confidence grows through repeated success and meaningful learning experiences.

Fostering Collaboration, Communication and Peer Support. In addition to individual confidence, performance tasks encourage collaboration and peer interaction, benefiting students who may struggle with independent written assessments. Shayne emphasized that group work and discussions provided students with opportunities to refine their thinking, listen to different perspectives, and engage in mathematical discourse. He observed that students who struggled with traditional assessments often thrived in collaborative settings, where they could exchange strategies, clarify misunderstandings, and build knowledge together. This reflects Suurtamm et

al.'s (2016) research, which highlights that mathematics learning should be a social and interactive process, allowing students to develop deeper conceptual understanding through shared experiences rather than working in isolation.

Conclusion: Transforming Mathematics Learning Through Inclusive Assessments. Ultimately, performance assessments remove barriers by offering students alternative ways to express their understanding, fostering confidence, and accommodating diverse learning needs. By shifting away from rigid, literacy-dependent assessments, these tasks align with research advocating for inclusive, student-centered approaches that prioritize engagement, accessibility, and real-world applications of mathematics. This is particularly significant in compensatory school settings, where addressing educational inequities requires flexible and adaptive assessment methods that allow all students to succeed.

Real-World Applications and Integration. The study highlights the value of real-world connections in performance tasks. Teachers, particularly Shayne, emphasized that mathematics becomes more meaningful when linked to practical applications. Tasks like calculating the cost of painting a model structure or measuring the height of a tree bring math to life, as students can see its relevance beyond the classroom. This finding aligns with Herrington and Herrington's (2007) call for authentic learning environments that connect classroom instruction to real-world contexts. These tasks not only deepen conceptual understanding but also prepare students for future academic and professional challenges (Thompson et al., 2020).

Challenges in Implementation

Despite the benefits to student learning inherent in performance assessments, the findings revealed significant challenges associated with implementing authentic performance assessments. These challenges mirror those highlighted in the literature, including time

constraints, teacher workload, and resource limitations (Suurtamm & Koch, 2014; Syaifuddin, 2020).

Time-Consuming Nature. Participants consistently identified the time-intensive nature of performance assessments as a significant challenge, both in planning and execution. Shayne observed that some tasks, such as those requiring extensive student engagement, often spanned an entire week, leaving little room to address all curriculum requirements. This concern aligns with Dixson and Worrell's (2016) findings regarding the difficulty of incorporating performance tasks into already demanding schedules.

Additionally, teachers noted that balancing the allocation of time with maintaining student focus and addressing diverse learning needs was particularly challenging. These observations reflect Suurtamm and Koch's (2014) assertion that implementing rich, inquiry-based assessments frequently conflicts with the rigid timelines imposed by curriculum structures, further complicating their integration into daily instruction.

Classroom Management. Classroom management emerged as a significant challenge, particularly in keeping students engaged and focused during performance tasks. Shayne's experiences with behavioral issues underscored the need for clear instructions, structured roles, and consistent monitoring to maintain the momentum of these activities. Similarly, Liz and Shayne noted that the difficulty of maintaining student focus was amplified in large or busy classrooms, where distractions were more prevalent.

Effective classroom management strategies, such as setting clear expectations and co-creating success criteria with students, were identified as critical for minimizing disruptions and ensuring the successful implementation of performance tasks. These findings align with

Herrington and Herrington's (2007) emphasis on the importance of well-managed learning environments as a foundation for successful authentic learning experiences.

Resource Limitations and Professional Development. Teachers expressed frustration over limited resources and inadequate training. While the school board provides online platforms and tools, participants noted that accessing and utilizing these resources independently can be challenging. Liz's concern about the lack of professional development underscores the need for targeted training to help teachers implement performance assessments effectively.

Parental Perceptions. Olivia raised the challenge of gaining parental support for performance assessments. Many parents remain accustomed to traditional methods and may question the validity of alternative assessments. This finding highlights the importance of proactive communication to educate parents about the benefits of performance tasks.

Research Question 2: Characteristics of Performance Assessments

The participants described performance assessments as flexible, authentic, and engaging tools that align with modern pedagogical approaches. Their examples illustrated how performance tasks integrate multiple skills, encourage collaboration, and foster critical thinking. These findings resonate with the characteristics of performance assessments described by Darling-Hammond et al. (2008) and McFeetors et al. (2021).

Flexibility and Authenticity

Performance tasks are designed to replicate real-world challenges, making learning both meaningful and engaging. Shayne and Olivia shared examples like building a Place Value Robot or calculating the height of a tree, which highlight how these authentic tasks encourage problem-solving and the practical application of knowledge. These assessments are also characterized by their adaptability and authenticity. For instance, tasks such as the "Place Value Robot" and

"Array City" enabled teachers to customize activities to address diverse learning needs while maintaining alignment with curriculum objectives. This flexibility aligns with Popham's (2014) assertion that effective assessments should cater to individual learning styles and readiness levels. Furthermore, the real-world relevance of these tasks enhanced their authenticity, creating powerful connections between classroom learning and practical, everyday contexts.

Collaboration and Critical Thinking

Participants emphasized the collaborative nature of performance assessments, noting that these tasks foster teamwork, critical thinking, and communication skills. For instance, Shayne's "Finding the Height of a Tree" activity required students to construct clinometers and apply trigonometry in an outdoor setting. This task not only reinforced mathematical concepts but also encouraged students to collaborate, share strategies, and reflect on their learning process. These observations align with Koh and Chapman's (2019) emphasis on the importance of 21st-century skills, as well as Lane's (2013) assertion that performance tasks prepare students for real-world scenarios by promoting effective teamwork and communication.

Hands-On Engagement

Tasks like "Comparing the Volume of a Cone with a Cylinder" engaged students through tactile and visual exploration. By constructing models and calculating volumes, students transitioned from theoretical understanding to practical application. This approach supports Suurtamm et al.'s (2010) argument that hands-on activities enhance conceptual understanding and retention.

Flexibility and Student-Centered Learning

Performance assessments provide flexibility by allowing students to approach tasks in ways that suit their strengths. Shayne noted that students take ownership of their learning by

choosing roles and strategies within group projects. This flexibility ensures inclusivity and accommodates diverse learning needs.

Connecting the Study Results to the Curriculum

This study investigated how elementary teachers implement performance assessments in mathematics education, with a focus on their perceptions and the characteristics of the assessments used. Through detailed interviews and artifact analysis, this research uncovered both the benefits and challenges of performance assessments, as well as their alignment with broader educational frameworks, including the Ontario Mathematics Curriculum (2020) and the *Growing Success* (2010) assessment policy document.

The Ontario Mathematics Curriculum emphasizes conceptual understanding, real-world application, and student-centered instruction, with assessment practices intended to be integrated into daily teaching rather than treated as isolated events. This aligns directly with the performance-based tasks observed in this study, which prioritize student engagement, critical thinking, collaboration, and authentic problem-solving. For instance, Shayne's 3D model of a castle incorporated expectations related to financial literacy, measurement, and spatial reasoning, while Olivia's integration of crafts and multiplication arrays reflected visual representation and operational fluency. These tasks exemplify how teachers interpret and apply curriculum expectations in practice—moving beyond traditional assessments to fulfill the curriculum's emphasis on inquiry and application.

Moreover, the *Growing Success* document outlines that the "primary purpose of assessment is to improve student learning," and encourages the use of varied assessment strategies, including performance tasks, peer and self-assessments, and observations. The study participants consistently utilized such practices. Their methods mirrored the policy's call for

transparent success criteria, opportunities for feedback, and assessments that reflect the full range of curriculum expectations. The connection between the curriculum goals, teacher practice, and student outcomes was clearly evident, indicating that performance assessments, when used effectively, fulfill the aims of both the Ontario curriculum and broader pedagogical best practices.

Connecting Study Results to the Literature

The findings of this study closely align with the existing literature on performance assessments in mathematics education, supporting and extending prior research on their pedagogical value. As outlined in Chapter 2, performance assessments promote authentic learning by engaging students in real-world problem-solving, critical thinking, and hands-on tasks (McFeetors et al., 2021; Suurtamm & Koch, 2014; Thompson et al., 2020). This study reaffirms those conclusions through the voices and practices of Ontario teachers who have implemented such assessments in diverse elementary classrooms.

For example, participants in this study highlighted that students paid attention to the process, not just the product—a theme also emphasized by Popham (2014) and Suurtamm et al. (2010), who argue that performance tasks reveal the thinking behind mathematical solutions rather than focusing solely on correct answers. Similarly, the emphasis on building students' confidence and reducing math anxiety resonates with the literature on how performance-based tasks can create inclusive and supportive environments (Dixson & Worrell, 2016; McFeetors et al., 2021). Olivia's observation that performance assessments separate mathematical ability from reading ability is particularly noteworthy, as it highlights a form of equity in assessment practices—an issue also raised by Archbald (1991) and Darling-Hammond et al. (1995), who advocate for authentic assessments that provide multiple entry points for diverse learners.

The integration of multiple subjects through performance assessments, as demonstrated in this study, mirrors the interdisciplinary nature of Linked Learning and Problem-Based Learning (PbL) approaches described in the literature (Koh & Chapman, 2019; Thompson et al., 2020). Olivia's combination of math and science expectations in a single task directly reflects how performance assessments can streamline curriculum delivery while enriching student learning experiences; in particular, the integration of 2D and 3D shapes in Geometry with the science focus on building strong and stable structures.

The Ontario Mathematics Curriculum (2020) and *Growing Success* (2010) documents both emphasize inquiry-based learning, real-world application, and formative feedback. The participants' use of tasks like building 3D models, engaging in Math Talks, and using manipulatives aligns directly with these documents' call for differentiated, student-centered, and conceptually rich instruction. The data gathered in this study provide concrete, practical examples of how these curriculum goals are being realized in contemporary classrooms.

Another key connection lies in the role of student agency and ownership, which was a major theme in the findings. Shayne and Olivia emphasized how performance tasks give students responsibility over their learning. This supports the work of Herrington and Herrington (2007), who assert that authentic learning environments must provide opportunities for student articulation, reflection, and ownership. The participants' use of co-created success criteria, choice in task format, and group decision-making all reflect these best practices.

The importance of dialogue and collaboration, such as Math Talks and peer assessments, also aligns with the literature on Inquiry-Based Learning (IbL) and constructivist approaches. Both Şen et al. (2021) and Suurtamm & Koch (2014) highlight that students' mathematical reasoning deepens when they are encouraged to justify their thinking and engage in discussion—

exactly what the participants observed through performance tasks that invited explanation and group problem-solving.

Additionally, the findings support Lane's (2013) argument that performance assessments allow for formative insights into students' thinking. Teachers in the study repeatedly noted that the information they gained from observing and listening to students during performance tasks was "richer than a paper-pencil test." This echoes the position of Black & Wiliam (2010) and Sadler (1989), who argue that formative assessment must be responsive and embedded in instruction—not just an endpoint.

Importantly, participants described the challenge of aligning tasks with curriculum expectations, which reveals a tension also identified by Sabri et al. (2019) and Suurtamm et al. (2010). These researchers note that even when performance assessments are valued, teachers often struggle with planning time, resource access, and confidence in designing curriculum-aligned tasks. The findings of this study confirm this issue and offer insight into how some teachers mitigate it through collaboration, co-planning, and use of board-provided resources like Lawson's What to Look For.

Finally, the study offers real-world validation of the flexibility of performance assessments. This flexibility supports differentiated instruction, as performance tasks can be adapted for student strengths, interests, and needs. McFeetors et al. (2021) and Syaifuddin (2020) stress this point, showing how performance tasks can be modified while still maintaining rigor and alignment with curriculum goals.

Together, these connections show that the research does more than confirm what's already known. It extends and contextualizes the literature by providing rich, classroom-based examples from Ontario teachers. The findings help bridge the gap between theoretical

recommendations and the day-to-day realities of practice, especially in relation to curriculum implementation, student engagement, and assessment for learning.

Conclusions

The findings of this study underscore the transformative potential of performance assessments in mathematics education. Teachers perceive these assessments as valuable tools for fostering conceptual understanding, critical thinking, and real-world application. Performance assessments empower students by encouraging ownership of their learning, building confidence, and promoting collaboration. However, challenges such as time constraints, classroom management issues, and resource limitations must be addressed to maximize the effectiveness of performance tasks. Professional development, targeted training, and collaborative planning can equip teachers with the skills and strategies needed to overcome these obstacles.

Recommendations

Based on the findings, the following recommendations are proposed: Teachers should establish clear expectations and co-create success criteria with students to promote accountability and reduce classroom disruptions. Collaborative planning among teachers, such as co-teaching and sharing performance task ideas, can alleviate the workload and provide new perspectives on effective implementation. School boards should prioritize ongoing professional development to build teachers' confidence and capacity in using performance assessments. Workshops that focus on practical applications, curriculum alignment, and differentiated instruction are particularly valuable. Teachers should proactively engage parents by communicating the purpose and benefits of performance assessments through newsletters, workshops, or open houses. Leveraging ready-made resources while customizing them to suit specific classroom needs can save time and ensure alignment with curriculum goals. Finally, policymakers should integrate

performance assessments more flexibly into the curriculum, recognizing their value in fostering deeper mathematical understanding.

Implications for Practice

Implications for Teaching Practice

Teachers should integrate real-world, authentic tasks into mathematics instruction to make learning more engaging and relevant for students. By designing tasks that reflect practical applications, students are more likely to see the relevance of mathematics in their daily lives, fostering deeper connections to the subject. Performance assessments should also emphasize students' reasoning and problem-solving processes, prioritizing the learning journey over simply achieving correct answers. This process-driven approach aligns with formative assessment principles and enables teachers to identify areas of strength and areas requiring additional support. Furthermore, performance assessments can be used to promote collaboration by incorporating group tasks that require teamwork, communication, and critical thinking. When students work together to solve problems, they develop social and interpersonal skills that are essential for both academic success and future professional contexts.

Implications for Professional Development

The findings highlight the critical need for targeted professional development to support teachers in effectively designing and implementing performance assessments. Training programs should prioritize equipping educators with practical strategies for creating authentic tasks, aligning assessments with curriculum goals, and managing classroom dynamics efficiently. Workshops and structured sessions can help teachers foster meaningful learning experiences while addressing curriculum expectations.

Professional learning communities can further enhance this effort by facilitating the exchange of best practices among educators, fostering collaboration, and offering a platform for sharing innovative ideas. Expanding access to math coaches is also essential, as they can provide personalized guidance, help teachers navigate available resources, and address implementation challenges. Additionally, training programs should include instruction on leveraging online platforms, such as the Math Professional Learning Environment (PLE), ensuring teachers can effectively utilize the tools and support systems provided by the school board. Together, these initiatives can empower teachers to optimize the use of performance assessments in their classrooms.

Resource Development

Participants highlighted the importance of access to high-quality, ready-made performance tasks. School boards should prioritize the development and dissemination of resources that align with curriculum standards. Workshops and guidance from math coaches can further enhance teachers' ability to adapt these resources for their specific contexts.

Parental Engagement

To address resistance from parents accustomed to traditional assessments, educators should proactively communicate the value of performance tasks through workshops, newsletters, and open house events. Demonstrating how these assessments foster deeper understanding and real-world skills can build trust and support among parents.

Implications for Policy

Implications for Policy and Curriculum Design

To address the time constraints associated with performance assessments, curriculum planners should incorporate greater flexibility within instructional timelines, allowing teachers

sufficient time to implement and assess these tasks without sacrificing curriculum coverage. Schools should also proactively engage parents by educating them on the benefits of performance assessments and their role in fostering deeper learning. By building parental understanding and support, schools can create a more collaborative environment for student success.

Curriculum Alignment

Policymakers should ensure that curriculum frameworks explicitly support the integration of performance assessments. Emphasizing their role in fostering critical thinking and problem-solving skills can promote widespread adoption of these practices.

Support Structures

Education systems should allocate resources for math coaches and professional learning opportunities, enabling teachers to refine their use of performance assessments. Additional funding for materials and resources can further alleviate the logistical challenges associated with these tasks.

Recommendations for Future Research

Future research should focus on exploring the long-term effects of performance assessments on student achievement, engagement, and critical thinking. Investigating how these tasks influence sustained learning outcomes could provide valuable insights into their effectiveness over time. Additionally, further studies should examine strategies for addressing the practical challenges of implementing performance tasks, such as time constraints and resource limitations, to identify scalable and efficient solutions.

Research on the impact of targeted professional development is also essential, particularly in understanding how training programs enhance teachers' ability to design and

deliver performance assessments effectively. Expanding the scope to include a diverse range of schools and districts would offer a broader perspective on best practices and potential obstacles, helping to identify factors that contribute to successful implementation. Finally, exploring the application of performance assessments in other subject areas and incorporating student perspectives would deepen our understanding of their versatility and impact across educational contexts.

Scope and Nature of the Study

It is important to note that this study does not aim to produce generalizable conclusions, as generalization is not the goal of qualitative inquiry. Rather than being viewed as a limitation, this reflects a foundational characteristic of qualitative case study research, which seeks to provide rich, contextualized understandings of complex phenomena. The findings represent a deep exploration of the practices, beliefs, and experiences of three educators in one Ontario school board. While these insights are not statistically generalizable, they are analytically meaningful and contribute valuable knowledge to the ongoing conversation about assessment reform in mathematics education.

The intended goal of this study was to document and analyze how performance assessments are implemented in real classroom contexts, how they support or challenge curriculum expectations, and how they impact teaching and learning. Based on the detailed data collected, these goals were successfully met. The study offers practitioners and policymakers a grounded, real-world look at how curriculum-aligned, authentic assessments are being enacted in Ontario classrooms, and where further support may be needed.

Final Reflection

This study highlights the significant role of performance assessments in transforming mathematics education. While challenges exist, the benefits of these tasks in fostering deeper understanding, engagement, and real-world connections are undeniable. By addressing the identified barriers and implementing the recommendations outlined, educators can leverage performance assessments to create dynamic and meaningful learning experiences that prepare students for success in mathematics and beyond.

Conclusion

This chapter has discussed the findings of the study in relation to the existing literature, emphasizing the transformative potential of performance assessments in mathematics education. Despite the challenges identified, the benefits of these assessments—including deeper conceptual understanding, enhanced engagement, and the development of critical thinking skills—underscore their value. By addressing the barriers through targeted professional development, resource allocation, and policy support, educators can fully harness the potential of performance assessments to enrich teaching and learning experiences.

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Appendix A: Information Letter and Consent Form

Lakehead UNIVERSITY

Faculty of Education

Information Letter

Dear potential participant,

The title of my research project is Performance Assessments versus Standard Assessments in Mathematics Education. My research question is what performance assessments do teachers currently use in mathematics instruction, and what are teachers' perceptions of how performance tasks impact students' learning? I would like to interview you about your assessment methods in mathematics and your perceptions of how your assessments impact your students' learning. The interview will take approximately 30-45 minutes to complete. I would also ask if you can bring anonymous student work samples to the interview. You may decline to answer any question.

Taking part in this study is voluntary. Before you decide whether or not you would like to take part in this study, please read this letter carefully to understand what is involved. After you have read the letter, please ask any questions you may have.

PURPOSE

The purpose of my research is to extend the knowledge about performance assessments in mathematics and whether teachers are using them. As it was mentioned in Growing Success (2010), "The primary purpose of assessment is to improve student learning" (p.28). Many researchers have stated that performance assessments are authentic assessments and that performance assessments not only assess students' learning but may also enhance reasoning and problem-solving skills. Since teachers play a critical role in the learning, teaching, and assessment processes, this study aims to understand teachers' beliefs, knowledge, and pedagogy about performance assessments in mathematics. My research question is: what are teachers' perceptions of how performance tasks impact students' understanding?

WHAT INFORMATION WILL BE COLLECTED?

Participants will be interviewed about their beliefs about mathematics teaching assessments and their perceptions of the project. Interviews can be in person or online (See Appendix A for the interview questions). Interviews will be approximately 30 to 45 minutes long. These interviews will be video recorded, and all video recordings will be transcribed. All data collected (video recordings) will be transcribed and coded in an effort to describe how teachers use performance assessments in mathematics using NVivo Qualitative Analysis Software coding platform. After conducting the research, a summary of findings will be sent to the teachers involved.

WHAT IS REQUESTED OF ME AS A PARTICIPANT?

Participants will be asked to bring anonymous samples of student work. Participating teachers' information will be removed from the data at the report writing stage. The only people who will be able to identify participants in any written reports will be the researcher and perhaps other participants.

WHAT ARE MY RIGHTS AS A PARTICIPANT?

Your participation in my research project is entirely voluntary. As a research participant, your rights include:

- the right to not participate;
- to withdraw at any time during the data collection phase without without any penalty and your decision to participate or not will not affect your employment status,
- to continuing and meaningful opportunities for deciding whether or not to continue to participate;
- to opt out without penalty and to have any collected data removed from the database and not included in the study (until completion of the data collection phase of the study; if you choose to opt out any data pertaining to your participation will be destroyed);
- to privacy, anonymity and confidentiality; and to safeguards for security of data.
- If audio taping of the interview is needed, your consent to do so will be obtained.

WHAT ARE THE RISKS AND BENEFITS?

This study will offer insights into ways of using performance assessments to support learning and teaching practices in mathematics. Although data will be board specific, it will contribute to an understanding of the usage of performance assessments in mathematics education that will have much broader relevance. Results will be made available to help inform professional initiatives. Results will also be shared with teachers to continue to work towards providing adequate assessment practices that support students' learning and understanding of math concepts.

HOW WILL MY CONFIDENTIALITY BE MAINTAINED?

Your anonymity and confidentiality as a participant in the research will be guaranteed, as far as possible, through the use of pseudonyms in the data analysis and reporting processes. Pseudonyms for teachers and schools will be used and all identifying features will be removed prior to report completion. A summary of the findings will be sent out to the teachers, school board and schools involved. I also plan to publish a summary of the findings in an academic journal. No individuals, schools, or boards will be identified in any reports or articles. The researcher has no conflicts of interest, financial or otherwise, in conducting this research.

WHAT WILL MY DATA BE USED FOR?

Your data will be used for research purposes only. It will be used during our data analysis process to help us to come up with the study findings. All data collected (video recordings) will be transcribed and coded in an effort to describe how teachers use performance assessments in mathematics using NVivo Qualitative Analysis Software coding platform.

WHERE WILL MY DATA BE STORED?

All data collected (video recordings) will be securely stored by me in password protected files on my personal computer while completing the study. Paper files as well as external hard drives will be stored in a locked cabinet in my office. Additionally, anything linking names to pseudonyms will be securely and separately stored by me in a password protected file separate from the research data. Materials will be kept on file for a minimum of seven years following the completion of the project.

HOW CAN I RECEIVE A COPY OF THE RESEARCH RESULTS?

I will send the research participants a written report of the findings.

WHAT IF I WANT TO WITHDRAW FROM THE STUDY?

As a research participant, you have the right to withdraw at any time during the data collection phase without any penalty.

RESEARCH ETHICS BOARD REVIEW AND APPROVAL:

I have completed the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial Course on Research Ethics*. If at any time, you have any questions or concerns regarding the project, please feel free to contact me by email, edawood@lakeheadu.ca, or by telephone, 416-854-9115, or you may contact my supervisor, Dr. Ruth Beatty by email, rbeatty@leakeheadu.ca or by telephone, 705-330-4008 ext. 2619.

This study has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team, please contact Sue Wright at the Research Ethics Board at 807-343-8010 ext. 8283 or research@lakeheadu.ca.

Your support as a participant will be a valued component to my study. Thank you.

RESEARCHER CONTACT INFORMATION:

Elain Dawood
edawood@lakeheadu.ca
416-854-9115

Faculty of Education

Lakehead University
Participant Consent Form

Study title: Performance Assessments versus Standard Assessments in Mathematics Education

I, _____, (participant name) have read and understood the above information, including the potential risks and benefits of the study. I hereby consent to my participation in the research.

I understand:

- The potential risks and benefits of the study;
- I am a volunteer and may withdraw from the research at any point during the data collection period;
- I may choose not to answer any questions;
- All information gathered will be treated confidentially;
- All data collected (e.g., video or audio recordings) will be securely stored by the researcher in password protected files on the researcher's personal computer while completing the study. Paper files as well as external hard drives will be stored in a locked cabinet in the researcher's office. Additionally, anything linking names to pseudonyms will be securely and separately stored by the researcher in a password protected file separate from the research data. Materials will be kept on file for a minimum of seven years following the completion of the project.; and
- I will not be identifiable in any written documents resulting from this research, unless I explicitly agree to have my identity revealed.

Furthermore, I understand that I will be provided with a summary of the results.

_____ _____ _____

(Print Name) (Signature)
(Date)

I hereby consent to be audio and/ or video recorded as indicated by my signature below.

_____ _____ _____

(Print Name) (Signature)
(Date)

Please sign and return this form to me, the researcher. A copy of this consent form will be provided to the supervisor. For further information concerning the completion of this form, please contact:

Elain Dawood – edawood@lakeheadu.ca or 416-854-9115

And/or the supervisor: Dr. Ruth Beatty – rbeatty@leakeheadu.ca or 705-330-4008 **ext.** 2619

Appendix B: Proposed Interview Questions

- How long have you been teaching?
- What grade do you teach this school year?
- What grades have you taught before?
- What is your education? Do you have any qualifications in mathematics?
    - Do you have undergraduate courses or a degree in mathematics?
    - Do you have any additional qualifications or math specializations? ← avoid compound questions… they confuse people. One thing you may do, as part of the methodology, is provide the sample questions to participants in advance.
- What is your understanding of what performance-based tasks are?
    - Do you use them in your classroom? If so:
    - How long have you been using performance-based tasks in your teaching practices?

- What are your experiences with performance assessments? Please explain.
- Tell me how you use performance assessments in mathematics?
    - Can you give me specific examples of the kinds of performance assessments you have used?
    - Please describe the process you used to develop or implement this assessment?
    - Please reflect on whether this was a successful or unsuccessful assessment mode for you. Please explain or provide some examples.
- What are the benefits of using performance assessments in math?
    - Can you give me some examples of some benefits that you observed other teachers use????
- What are the challenges you face when you use performance-based assessments?
    - Can you give me some examples of some challenges you faced in the past?
    - How did you deal with these challenges in the past? Please provide some examples or details to explain the challenges and how you might have overcome these challenges.
- What do you think was the hardest thing for you to be able to implement performance assessments?
- In your opinion, what are the benefits or drawbacks of using performance-based tasks in mathematics on your students?
- In your opinion, do performance-based assessments/tasks enhance math skills/ understanding/ achievement? Why or how?

- What are the mathematical knowledge teachers need to use performance assessments?
- What are the skills teachers need to use performance assessments?

    - How did you learn these knowledges or skills?
    - How might other teachers learn about performance assessments? How might you teach other teachers about them?

Appendix C: IbL Approach Examples

The following examples are taken directly from Şen et al. (2021):

In the first session, the students were given the following instructions:

- Instead of receiving direct descriptions and explanations, the students should focus on their relationships among concepts.
- Individual and group work will be done.
- The activity, worksheets, and reflective logs will be included in the lesson.
- Everyone's ideas are important, and everyone should engage in discussion rather than be concerned about right and wrong answers.

After the above instructions were given, a discussion environment was created by asking the class questions to assess their existing knowledge and establish a comfortable environment in which they could express their views freely. Student answers to the question "What is ratio?" were written on the board. The views of the students were revealed additive or multiplicative comparison with this question. Then, the students were asked to give a general explanation of proportion.

Then, meaningful problems that related to the students' daily lives were presented.

Example 1. Affixing images of apples, oranges, and watermelons to the blackboard, the teacher stated, "A farmer gathered ripe apples, oranges, and watermelons from the field and put them in the basket." The teacher then asked about the meaning of the expressions "apples to oranges ratio" or "apples to watermelon," and what their mathematical representations would be. Then, "why" questions related to the representations were posed. The students were asked to make explanations and justifications. How the mathematical representation of the rate is expressed, how many different representations can be made $\frac{a}{b}$, and the a/b and a:b representations were mentioned. For example, the apple to orange ratio is said to be the simplest notation, as 8/6. It is emphasized that the ratio is constant and different multiples express the same ratio. For proportion, the simplest notation simplification is used. Through this process, the students learned about ratio and proportion.

Example 2. By affixing a picture of two persons to the board, in which one person is tall (185 cm) and the other is short (110 cm), the students are asked to describe the proportions. The teacher attempted to associate the simplification operations used in Example 1 with the problem described in Example 2. For this purpose, the students were asked questions such as "How can the proportions be written in their simplest form?"