Generalist Intermediate Phase Teachers' Experiences of Teaching Mathematics Through Music Integration (Gauteng, South Africa)

by

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This study is dedicated to:

My father and mother, who granted me the inner strength to reach this dream.

My husband and daughter, your love and encouragement have been my pillars of strength.

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הכבוד לו

To Him be the glory

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Abstract

By embracing the influential role of music in education, teachers can establish an environment that nurtures learners' curiosity, creativity, and enthusiasm for acquiring knowledge. Research suggests that incorporating innovative teaching approaches into pedagogy can promote deeper learning and inspire learners.

Viewed through the framework of constructive alignment, this thesis introduces a qualitative, single case study delving into how generalist teachers experienced and perceived the integration of music and mathematics within an educational framework. Central to this study were the integrated music-mathematics lessons. These lessons combined interactive, creative, hands-on, and collaborative elements. Rooted in a constructivist approach, the research findings highlight the significance of maintaining a balance between a learner-centred approach and providing adequate teacher support. The outcomes suggest that effectively incorporating music into mathematics instruction does not demand formal music qualifications or advanced musical proficiency. Moreover, the research underscores the significance of adapting teaching methods and activities to accommodate diverse learning preferences. Ultimately, the findings illustrate that the integration of music and mathematics not only enriches the learning experience for learners but also enhances teaching possibilities for educators.

Keywords: music education, music-mathematics integration, conceptual understanding of music, conceptual understanding of mathematics, constructive alignment in education, constructivism., generalist teacher, Intermediate Phase

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Chapter 1: Introduction and Background to the Study

“There is geometry in the humming of the strings, there is music in the spacing of the spheres”- Pythagoras (Murchie, 1961, p. iv)

1.1 Introduction

Education serves a fundamental and irreplaceable role in equipping learners with essential knowledge, skills and attitude vital for their success in future pursuits. This process nurtures their capacity to identify, form connections, and apply various problem-solving approaches, and engage in creative and evaluative thinking. The affirmative impact of music on learners' cognitive, emotional, and physical development, thereby enhancing their knowledge acquisition across diverse academic disciplines, is widely recognised in academic discourse (Hoque, 2016).

Hallam (2015) proposes that research reveals the inclusion of music as an integral part of education offers numerous benefits that extend beyond mere aesthetic appreciation. Music has the potential to enhance cognitive abilities such as memory, attention, and spatial-temporal skills. This viewpoint is supported by Miendlarzewska and Trost (2014), who assert that active interaction with music, whether through listening, performing, or engaging in creative activities, uniquely stimulates learners' cognitive processes. This stimulation activates various neural pathways, promoting holistic brain development (James et al., 2017). Additionally, the intricate nature of music nurtures learners' capacity to analyse patterns, discern structures, and establish connections between different elements, thereby sharpening their analytical skills and problem-solving capabilities (Sarrazin, 2016).

According to Jensen (2005), incorporating musical connections into the presentation of information enhances learners' capacity to retain factual knowledge and grasp fundamental concepts. Music possesses a distinctive ability to captivate attention and engage learners, thereby rendering the learning experience more enjoyable and memorable. Through the integration of music into lessons, teachers can adeptly tap into learners' inherent musicality and apply it as a powerful tool for acquiring knowledge, skills, and shaping attitudes.

Consequently, it is imperative for a classroom to cultivate an atmosphere wherein learners exhibit enthusiasm toward independent exploration and discovery of new knowledge (Serin, 2017). By embracing the influential role of music in education, teachers can establish such an environment that nurtures learners' curiosity, creativity, and enthusiasm for acquiring knowledge. A classroom that integrates music fosters a sense of delight and engagement, thereby motivating learners to actively participate, take intellectual risks, and cultivate an enduring passion for learning.

1.2 Background to the Study

As a music and mathematics teacher for 30 years, I have come to realise from my own experiences in the classroom that incorporating music into Intermediate Phase learning practices can significantly improve learners' focus and readiness to learn. I have found it concerning that mathematical concepts often require repeated explanations; a concern not present in the environment of my music instruction. Learners spontaneously refer to learning materials from years past (I teach grades 4 to 7), a phenomenon notably absent in the realm of mathematics. This raised questions about why learners could readily retain musical knowledge but struggled with the recall of mathematical concepts.

I observed that learners displayed a more practical approach in the music class, characterised by laughter, joy, and a closer teacher-learner relationship, which was notably absent in the mathematics class where learners seemed more tense.

Given the multitude of correlated concepts between music and mathematics, my interest was intrigued, leading me to explore the integration of these two subjects with the aim of enhancing my learners’ understanding of mathematics. Despite witnessing improvements in the learners' mathematical proficiency, I aspired to undertake formal research on the subject, driven by a desire to enrich my own knowledge and refine my teaching methodologies.

Additionally, I have found that teachers often do not provide enough opportunities for active exploration in the Intermediate Phase Mathematics classroom, which can hinder optimal learning experiences. According to Kokkidou (2013), teachers should embrace new styles of communication, teaching, and learning to prepare learners for solving life challenges.

Recent studies suggest that combining creative and innovative teaching approaches into pedagogy can promote deeper learning and inspire learners (Bereczki & Kárpáti, 2021; Kovač et al., 2023; Kukulska-Hulme et al., 2022; Naz & Murad, 2017; Sinay et al., 2017; Sølvik & Glenna, 2021). Effective communication, creativity, critical thinking, innovation, and teamwork are learning outcomes that are more closely associated with integrated education than with narrower, disciplinary education (Lamb et al., 2017; Lucas, 2019; OECD, 2019).

Interdisciplinary understanding can be defined as providing "more than one perspective on the same subject" (De Greef et al., 2017, p. 29). Integrated learning involves linking ideas and learning experiences in different subject areas within the curriculum, allowing learners to solve problems and actively participate in increasing their understanding and application of conceptual links between subjects.

As a qualified and experienced teacher of both music and mathematics, I employ an integrated music-mathematics approach in my classes and have discovered that music can promote and enhance creativity in mathematics learning. I find that integrating music concepts into mathematics learning environments comes naturally to me, but my fellow mathematics teachers, who were trained as general educators, may lack musical understanding and may not be able to fully appreciate the benefits of a music-mathematics integrated approach.

I firmly believe that the gap between the educational vision for 21st-century knowledge and skills and current teaching practices in Intermediate Phase mathematics can be bridged by adopting active music integration and appropriate pedagogy to fully engage learners. I also believe that active learner interaction provides an opportunity to include creativity and innovation in learning experiences, which will enrich and enhance learners' understanding of both subjects.

1.3 Rationale and Research Problem

Researchers have identified that conventional approaches to teaching mathematics in schools globally, which involve textbook-based lectures and a lack of emphasis on conceptual comprehension (Duffy & Brennan, 2022; Mathema & Bista, 2006; Panthi & Belbase, 2017; Serbessa, 2006), are associated with diminished performance in mathematics (Furner & Berman, 2005; Mullis et al., 2020). Negative attitudes towards mathematics among some teachers (Sokolowski & Ansari, 2017) and lack of teaching experience (Panthi & Belbase, 2017) have been identified as contributing factors to inadequate academic performance in mathematics among learners. In South Africa, the overall achievement level in Intermediate Phase mathematics remains lower than the long-term achievement goal of the Department of Education (Msomi, 2018). Therefore, a more effective and creative teaching and learning approach is necessary.

The South African National Curriculum Statement Grades R-12 (Department of Basic Education, 2011a) and policy statements for teaching and learning in South African schools (Department of Basic Education, 2011a) explicitly encourage integration across the curriculum. The Life Skills policy document, which includes the study area Creative Arts, highlights that "integration is fundamental" (Department of Basic Education, 2011b, p. 9). Similarly, the policy statement for Mathematics supports integration "to develop understanding and skills necessary to learn subject content that is related" (Department of Basic Education, 2011c, p. 8).

In South Africa, Creative Arts is a component of the Life Skills subject in the Intermediate Phase, and it includes four art forms: music, dance, drama, and visual arts. The Intermediate Phase refers to the educational stage that typically encompasses Grades 4 to 6 in the South African schooling system. During this phase, learners build upon their foundational knowledge and skills in various subjects, including mathematics and music. Primary school teachers who are generalists are expected to teach all subjects, including Creative Arts. However, many of these teachers lack the necessary knowledge, skills, and confidence to teach music effectively (Burak, 2019; De Villiers, 2017; Hallam et al., 2009; Stakelum, 2008; Wiggins & Wiggins, 2008).

Jeanneret and DeGraffenreid (2012) suggest that empowering generalist teachers to effectively integrate music into the classroom can have a significant impact on learners' attitudes toward learning and their enthusiasm for specific subjects. This notion is supported by the research conducted by An et al. (2011), Chao-Fernández et al. (2020), and Robertson and Lesser (2013), who have explored alternative approaches to combining music pedagogy with mathematics.

Music activities can provide a meaningful context for connecting mathematical concepts (An et al., 2014), making a strong case for integrating music into effective mathematics teaching and learning. The incorporation of music can enliven the mathematics class and enhance the learning experience for learners.

Over the past decade, numerous studies have explored the integration of music in early childhood education (De Vries, 2015; Kriger, 2020; Van Vreden, 2016). Researchers have also investigated the impact of musical experiences on academic achievement (DiDomenico, 2017; Geist et al., 2012; Holmes & Hallam, 2017) and examined how music can be used to enhance learning in the classroom (DiDomenico, 2017; Eerola & Eerola, 2013). Research has also focused on developing preservice teachers to integrate music into other parts of the curriculum (Burak, 2019; Luton, 2021; Potter, 2021). However, there is limited research published that focuses on using an active music learning methodology to teach mathematics in the Intermediate Phase in South African schools (Dhlamini, 2009; Lovemore et al., 2021).

Research suggests that generalist teachers often lack musical knowledge and skills, as well as the confidence to teach or integrate music in their classrooms (Biasutti, 2010; Cloete & Delport, 2015; Kriger, 2020; Lovemore et al., 2021). This study aimed to address this gap by supporting generalist teachers in Gauteng, South Africa, in implementing integrated music-mathematics learning experiences. Empowering generalist teachers to integrate music into their classrooms with confidence can enhance their teaching skills and strengthen learning practices.

Albert Einstein wrote in an essay that “all arts and sciences are branches from the same tree” (Einstein, 2006, p. 7). An integrated curriculum can better prepare learners for the opportunities, challenges, and skills needed in the world today.

1.4 Purpose of the Study

The primary aim of this singular case study was to explore the experiences of generalist teachers, who lacked prior exposure to music instruction, as they navigated the implementation of learning approaches and assessment strategies within integrated learning. Specifically, the study aimed to explore how these educators perceived and engaged with the process of correlating concepts and learning experiences in both music and mathematics. The integration of learning enabled participating teachers to showcase their conceptual grasp of both musical and mathematical domains. The design for teaching and learning was based on constructive alignment (Biggs, 2014), leading to integrated music-mathematics learning experiences. These learning encounters were shared, interpreted, and facilitated by the participating teachers themselves. The integrated music-mathematics teaching and learning experiences incorporated 21st-century learning strategies such as active participation, critical thinking, collaborative teamwork, problem-solving, creative exploration, and reflective practice.

1.5 Research Questions

1.5.1 Primary Research Question

How do generalist teachers in the Intermediate Phase experience the enhancement of mathematics through music teaching and learning?

1.5.2 Secondary Research Questions

- How do generalist teachers comprehend conceptual understanding in Intermediate Phase music and mathematics?
- How do the experiences of generalist teachers demonstrate the effectiveness of constructive alignment as a teaching and learning approach in designing integrated music-mathematics lessons?

- How can the experiences of the teacher participants contribute to the teaching and learning models used in the Intermediate Phase?

1.6 Methodology

This study employs a qualitative case study research approach and is situated within the pedagogical design of constructive alignment for effective teaching and learning. Chapter 3 provides a comprehensive exposition of the research design, approaches, and methods that were employed. Moving forward, Chapter 5 delves into the details of the data analysis process, along with the application of thematic analysis methods.

1.7 Chapter Outline

This study centres around the experiences and perceptions of generalist teachers who took part in the integrated music-mathematics teaching and learning program. The subsequent arrangement delineates the structure of the study:

In the opening chapter, the research is introduced through the provision of a study background. This includes the identification of the rationale, purpose, research questions, and the significance of the study.

Chapter 2 delves into relevant literature concerning the stated research problem. It includes a description of theoretical principles and further explores teaching and learning components associated with the music-mathematics integration explored in this study.

In Chapter 3, the research design, methods, and approach are detailed. This includes the qualitative case study's methodology, data collection, analysis procedures, credibility strategies, researcher's role, and ethical considerations.

Chapter 4 presents the integrated music-mathematics lesson plans, custom-designed for this research study. Furthermore, these lesson plans offer comprehensive and detailed instructions to guide the teacher's implementation.

In Chapter 5, a description of qualitative data analysis is provided, and the resulting themes and categories from the collected data are showcased. The process of thematic analysis led to the identification of three primary themes, accompanied by categories situated within these themes.

Chapter 6 offers an interpretation and discussion of the study's findings by interconnecting existing theories and drawing insightful comparisons to prior research results. This chapter synthesises the literature review, analysed data, and themes derived from the findings.

The concluding chapter provides an overview of the research findings, defines the study's limitations, and discusses potential contributions. Furthermore, it delves into potential areas for future research. The study is concluded with a comprehensive list of references and included appendices.

1.8 Conclusion

The present chapter has provided an overview of the study and its individual chapters. This research aims to bridge this gap by investigating how generalist teachers, who lack prior exposure to music teaching, experience the implementation of integrated teaching and learning approaches between music and mathematics. The subsequent chapter conducts an in-depth review of literature pertinent to this study.

Chapter 2: Literature Review

2.1 Introduction

Chapter 2 presents a literature review that delves into instructional strategies linked with the constructive process of teaching and learning. I initiate this review by establishing a thorough grasp of the constructive alignment approach (Biggs, 1996) since this study is framed within this perspective. The intention is to explore the potential of constructive alignment to enhance mathematics through music, benefiting from its capacity to create well-structured and focused learning experiences (Maffei et al., 2022). Given the tendency of 21st-century skills to embrace interdisciplinary methods (Howard et al., 2019) and holistic understanding (Vivekanandan & Pierre-Louis, 2020), this aspect of the literature was deemed significant for inclusion. Recognising the importance of understanding how learners acquire knowledge, it becomes vital for designing effective educational strategies attuned to their cognitive processes and individual needs. The division of the literature exploration concerning conceptual understanding into three sections was pursued to analyse the interrelationships between these domains and their contributions to integrated teaching and learning. These segments include conceptual understanding in education, as well as in the specific fields of music and mathematics. Lastly, it was imperative to delve into literature concerning various teaching and learning approaches that guided the formulation and implementation of integrated music-mathematics lessons. Notably, constructive teaching and learning, Bruner's (1960) spiral curriculum, problem-based learning, active learning, and inquiry-based learning shed light on how learners construct knowledge, develop skills, and cultivate attitudes.

2.2 Constructive Alignment as a Teaching and Learning Approach

The pedagogical framework known as constructive alignment, formulated by Biggs (1996), explicitly outlines what learners are intended to learn and how they should demonstrate their learning before actual teaching occurs. Moreover, in later research by Biggs (2014), a consistent advocacy for an outcomes-based pedagogical approach is evident. This method prioritises the prior identification of precisely defined learning outcomes before commencing the instructional undertaking.

Constructive alignment includes two fundamental elements (Biggs, 1996). The first, rooted in the constructivist learning theory, fosters a learner-centred methodology (Biggs, 2014), and highlights the active involvement of learners in the process of creating meaning. The second, derived from the instructional design literature, accentuates the alignment between educational goals and learner assessment targets (Biggs, 1996). In a constructively aligned teaching environment, there is coherence among the required knowledge and skills for learners, the chosen teaching and learning activities, and the assessment of the intended learning outcomes (Biggs, 2003; Biggs & Tang, 2011; Genon & Torres, 2020). This alignment reinforces the achievement of learning outcomes and enriches learners' understanding (Kober, 2015).

According to Biggs (2003), an aligned lesson plan can be established through a four-step process. Firstly, the lesson's intended learning outcomes must be clearly defined, indicating the desired level of understanding for learners. Secondly, the teacher should carefully select the most appropriate teaching and learning activities that effectively facilitate the achievement of these specific outcomes. Thirdly, the choice of assessment tasks should harmonise with their intended purpose in evaluating the learners' attainment of the outcomes. Finally, learners should be assigned grades based on their performance in meeting the intended learning outcomes (Biggs, 2003).

Synchronising these components directs the focus toward learners' active engagement and the purposeful construction of knowledge (Hailikari et al., 2021). Once the teacher identifies the desired learning goals, placing emphasis on actively engaging learners during instructional tasks becomes essential (Lombardi, 2019). This active involvement is indispensable for learners to cultivate understanding and acquire skills aligned with the specified learning outcomes (Jaiswal, 2019). Learner engagement encompasses active participation in learning tasks and activities (Anderson, 2003; Lei et al., 2018) promoting knowledge generation through interactions and activities, rather than passive listening to lectures. As a result, it enhances the learning experience and increase motivation to learn (Biggs, 2014; Biggs & Tang, 2011; Delfino, 2019; Herbert, 2010; Martin & Bolliger, 2018). Active learning also holds the potential to foster a deep approach to learning (Lawson, 2011; Roßnagel et al., 2021).

The research mentioned above demonstrates that employing constructive alignment allows teachers to create an effective learning environment that supports and challenges learners, facilitating the meaningful development of new knowledge and skills. Acknowledging the importance of this perspective, constructive alignment was selected as the theoretical framework for this study (see Figure 1). Guided by the principles of constructive alignment, my aim was to cultivate integrated music-mathematics learning by designing and implementing creative learning experiences that aimed to foster meaningful understanding to both the general teachers who participated in this study and the learners to whom they delivered these interdisciplinary lessons. The goal encompassed a deeper understanding of both subjects, refinement of skills, and the cultivation of a positive learning attitude. Acknowledging the innovative nature of introducing a constructive alignment approach within an educational context involving generalist teachers in the South African Intermediate Phase, I found the impetus to initiate this research.

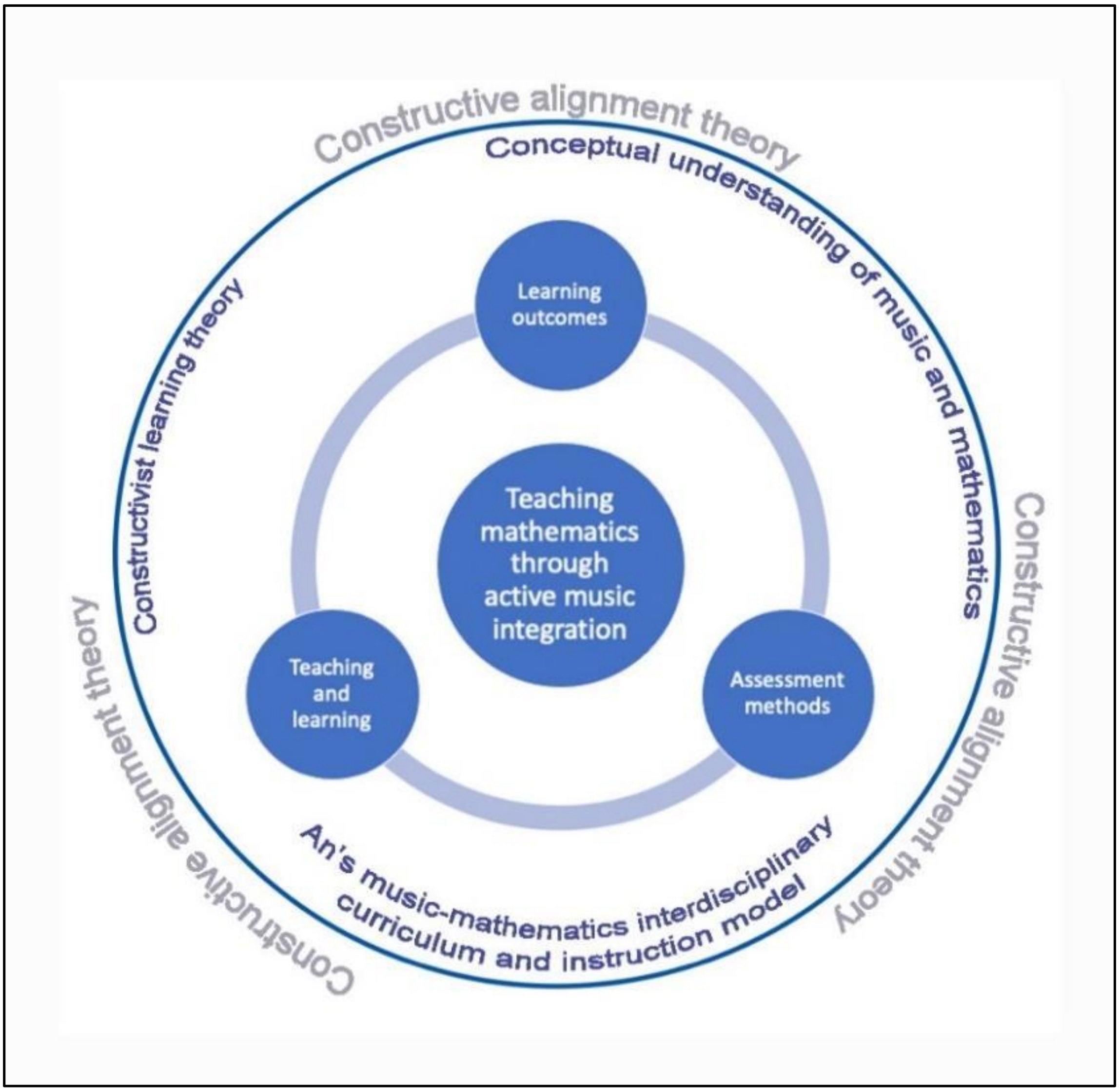
2.3 Constructive Alignment as Theoretical Framework

To underpin the framework of constructive alignment, the theoretical framework (depicted in Figure 1) incorporates ways of thinking about teaching, such as the conceptual understanding of music and mathematics, as well as constructivist learning theory, which highlights the active role of learners in constructing their own understanding.

An et al.'s (2013) music-mathematics interdisciplinary curriculum and instruction model provided guidance for designing and implementing music activities as an integral component of mathematics lessons in this study. The model developed by An et al. (2013) aided in assessing the extent to which music and mathematics were incorporated in each phase, considering the varying degrees of their usage. For my research, I adapted their model to conform with the requirements of Grade 4 classes as per the CAPS curriculums (Department of Basic Education, 2011b, 2011c). The model also aided in assessing the degree to which music and mathematics were integrated in each phase, considering the diverse levels of their integration.

Figure 1

Conceptual Theoretical Framework Embedded in the Constructive Alignment Theory (Biggs, 2003)



Rajasekar et al. (2013) suggest that the research design serves as the foundation for the study, applying a range of well-planned and organised methods, approaches, and techniques to collect data. The research design links the research questions with the research approach (Durrheim, 2006) and consists of strategies and techniques to ensure accurate, reliable, and authentic answers to the research questions (Bogdan & Biklen, 2007; Denzin & Lincoln, 2017).

The research applied a case study design, which is appropriate when the case has clearly defined boundaries and the researcher aims to achieve a thorough understanding of a real-life setting (Creswell & Poth, 2018). Specifically, this study adopts a single case study design bounded by place and time. Music-mathematics integrated learning experiences were presented by six generalist teachers (the participants) at three primary schools in Gauteng, South Africa. The study was conducted in term three during the months of August and September in the academic year of 2022 (see Section 3.4).

Yin (2018) suggests that a case study should address a specific and unique problem. In this study, the authenticity of the case was established by examining the thoughtful reflections of the participant generalist teachers on integrated music-mathematics teaching and learning. As a single case study aims to "improve, not to prove" (Stufflebeam, 2000, p. 283), the emphasis of this study was to explore the teaching and learning of mathematical concepts through active music integration.

2.4 Skills for the 21st-Century

Learners of today are facing the challenges of a rapidly changing world, necessitating the acquisition of essential 21st-century skills to thrive in the global arena. Despite substantial investments in education, De Wet and Rothmann (2022) and Venter and Viljoen (2020) demonstrate through their studies that the South African education sector is not reaching the expected level of success and progress. These findings highlight persistent challenges and gaps that inhibit the desired outcomes within the education system. Addressing these issues and discovering effective solutions is vital for promoting the advancement and enhancement of education in South Africa.

In the realm of music, 21st-century skills empower learners to engage in creative collaboration and effectively communicate their artistic expressions (Saputra, 2021). Integrating these skills into music education harmonises teaching and learning strategies (Chen, 2023) with the demands of a dynamic and interconnected world (Cruywagen, 2018). This approach not only enhances learners' musical experiences (Murillo, 2017) but also equips them with invaluable skills for their personal growth (Chalkiadaki, 2018).

Equally relevant in the field of mathematics, 21st-century skills play a fundamental role in enhancing problem-solving, critical thinking, and the practical application of mathematical concepts within real-world situations(Suh et al., 2021; Szabo et al., 2020). The importance of 21st-century teaching and learning in mathematics lies in its ability to equip learners with the requisite skills, cognitive framework, and proficiencies essential for excelling in an ever-evolving world that is progressively reliant on technology and interdisciplinary insights (Geiger et al., 2015; Yulianto et al., 2019).

As accentuated by De Wet and Rothmann (2022) and Venter and Viljoen (2020), teachers play a vital role in equipping learners with the essential skills needed for success in the contemporary era. Therefore, it is imperative for teachers to actively engage in their professional development to meet the evolving demands of today's classrooms. By proactively enhancing their knowledge and skills, teachers can better meet the needs of diverse learners and foster a more conducive learning environment (Scott, 2023). Notably, the inclusion of 21st-century skills is reflected in the specific objectives of South Africa's National Curriculum Statement (Department of Basic Education, 2011a), as well as the CAPS policy documents for Life Skills

(Department of Basic Education, 2011b) and Mathematics (Department of Basic Education, 2011c).

Table 1 below is a summary of the teaching and learning skills, as well as the corresponding roles of teachers and learners, essential for a 21st-century education, as argued by Bapna et al. (2017), Mentz et al. (2019), Pellegrino and Hilton (2012), and Trilling and Fadel (2009). Their research indicates that these roles and skills collaborate to create a holistic and impactful learning experience. In this context, learners actively cultivate 21st-century skills while being nurtured and guided by teachers who facilitate their progress and development.

Table 1

Skills for the 21st-Century (Bapna et al., 2017; Mentz et al., 2019; Pellegrino & Hilton, 2012; Trilling & Fadel, 2009)

Skills for 21st-century	Learners' role	Teachers' role
Active learning	• Take an active role in the learning process • Engage actively in classroom discussions	• Facilitate meaningful opportunities for active learning • Create a dynamic and participatory classroom environment • Design engaging learning activities
Creativity Innovation Self-direction Integrity Persistence	• Embrace new ideas • Take responsibility for their own learning • Establish personal goals • Act honestly, ethically, and responsibly in all aspects of their academic pursuits and interactions with others	• Create an environment that promotes creativity • Encourage learners to take risks • Facilitate and support learners in taking ownership of their learning • Model and promote honesty, ethics, and responsibility in their

	• Demonstrate determination, resilience, and perseverance in the face of challenges or difficulties	interactions with learners and colleagues • Foster a supportive and encouraging learning environment that promotes perseverance and resilience
Critical thinking Meta-cognitive skills Analysis Interpretation Problem-solving Logical reasoning Decision making	• Analyse information • Evaluate evidence • Challenge assumptions • Monitor their learning strategies • Critically and systematically examine and evaluate information • Draw meaningful conclusions • Use evidence, facts, and logical principles to support arguments • Take ownership of their decisions • Make informed and responsible choices • Fostering self-directed learning	• Guide and facilitate learners' understanding of information and concepts • Advise and support learners in making connections between ideas • Design tasks that promote learners' active application of knowledge and skills • Provide guidance, support, and resources that empower learners to take ownership of their learning process • Teach and model metacognitive strategies • Guide learners to become aware of their thinking processes • Encourage learners to explore multiple perspectives when solving problems • Assist and support learners in developing their ability to think critically and apply logical principles • Provide opportunities for learners to practice

		decision-making in various contexts
Communication Active listening skills Collaboration Teamwork Negotiation Conflict resolution	• Be attentive during communications • Ask relevant questions • Listen actively • Embrace their roles and responsibilities in a team • Share ideas and perspectives • Actively engage in discussions and activities • Engage in constructive and collaborative processes to reach agreements or resolve conflicts • Openly and respectfully communicate perspectives, while being receptive to understanding the viewpoints of others involved	• Facilitate and encourage debates among learners • Guide and support learners by asking thought-provoking questions • Encourage open communication • Provide timely feedback and scaffold learning experiences to meet the individual needs of learners • Structure collaborative activities • Provide guidelines and strategies for successful teamwork • Monitor and assess group dynamics • Foster a sense of trust and respect in the classroom • Facilitate and guide learners in developing effective negotiation skills • Create a supportive and safe learning environment for addressing and resolving conflicts effectively
Flexibility Adaptability Curiosity	• Demonstrate flexibility, adaptability, and openness to change • Actively seek out new knowledge • Question assumptions	• Adapt instructional strategies to meet learners' needs and cognitive preferences

	• Embrace their inherent curiosity	• Cultivate and nurture learners' natural sense of wonder and inquiry
Reflection	• Actively engage in reflective practices • Access own learning • Identify areas for improvement • Actively seek knowledge and explore new ideas and concepts	• Create a safe and supportive environment • Provide reflection opportunities • Cultivate and nurture learners' natural sense of wonder and inquiry
Lifelong learning	• Engage in exploration and investigation • Demonstrate self-motivation • Seek opportunities to develop and enhance skills	• Providing engaging and relevant learning experiences • Set meaningful goals for learners • Connect skills to real-world and real-life applications

In the context of integrated music and mathematics, where the blending of musical experiences and analytical reasoning takes a central position, the importance of 21st-century skills becomes notable (Braund & Reiss, 2019; Kang, 2019; Meyer, 2021). An interdisciplinary approach requires the application of skills like active listening, collaboration, structured reasoning, innovation, and teamwork allowing learners to navigate the intricate connections existing between music and mathematics(Drake & Reid, 2020).

Therefore, research demonstrates that integrating 21st-century teaching and learning strategies can effectively enhance lessons, foster deeper learning, and equip learners with the essential skills and competencies vital in today's world (Alismail & McGuire, 2015). Supporting this notion, Rahman (2019) agrees that to keep pace with societal advancement, it is imperative for learners to acquire the skills and competencies highly relevant in the current era.

2.5 Current Understandings of How Learners Learn

According to Ambrose et al. (2010), learning is not a process imposed upon learners by external forces but rather an activity they engage in on their own. Wiggins (2015a) further explains that learning is an embodied, constructive process through which learners construct their own understanding based on their experiences. These perspectives underscore the importance of establishing a learner-centred environment, where learners actively participate in the learning process.

Sanger (2020) sheds light on the active involvement of learners in the dynamic process of learning, wherein they participate with their immediate environment and surroundings. This engagement enables the creation of new knowledge, acquisition of skills, and cultivation of positive attitudes (Pérez-Campos et al., 2014). According to the OECD (2009), learning is an interactive process that occurs between the learner and their surroundings, rather than being solely the obligation of the teacher. Over the years, various theories and models of learning have been developed to understand this complex process. As highlighted by Wiggins (2015a), teachers must have a deep understanding of how learners learn to effectively guide their teaching practices. Adopting learner-centred approaches, such as constructive alignment, is central in establishing an environment that supports and nurtures active learning. By harmonising the objectives, activities, and assessments, constructive alignment empowers learners to take an active role in their own learning journey, leading to enhanced educational outcomes (Biggs, 2014).

In recent years, there has been a growing trend of collaboration between researchers and teachers, focusing on authentic classroom environments. The aim of this joint effort is to test and refine new theories, leading to a deeper understanding of the cognitive science of education (Bransfort et al., 2000). To achieve this goal, teachers are required to adapt their instructional strategies to meet the diverse social, cultural, linguistic, and instructional learning needs of learners, while also establishing educational objectives, as proposed by Parsons et al. (2018). Underlining the significance of learner-centred approaches, like constructive alignment, Jaiswal (2019) highlights their vital role in fostering an environment that actively promotes and supports learning.

According to Cardino Jr. and Ortega-Dela Cruz (2020), learners should take responsibility for their own learning, as it not only contributes to academic advancement (Macaskill & Denovan, 2013; Ning & Downing, 2010) but also enhances self-confidence for lifelong learning (Tekkol & Demirel, 2018). To facilitate self-directed learning, teachers play a vital role in creating a supportive and nurturing learning environment (Merriam et al., 2007), offering opportunities for independent exploration and growth.

The importance of employing active and learner-centred teaching methods that promote engagement and empower learners to be in control of their learning process becomes evident. Diverse sensory experiences and hands-on activities can enrich learners' knowledge and skills, ultimately fostering deeper learning (Korkmaz & Karatepe, 2018; Sanger, 2020). In this regard, teachers play an essential role by supporting learners in their quest for knowledge and cultivating essential skills for success, as emphasised by Segolsson and Hirsh (2019).

Active engagement with the learning material plays a vital role in establishing personal connections, which, in turn, enhances knowledge retention and motivation (Watkins & Mazur, 2013). Toffler and Yousafzai (2020) underline that actively engaging in the learning process enables learners to develop a deeper understanding of the material and interact with it in a more meaningful way, thereby fostering increased motivation to continue their learning journey.

Building on this idea, active learning, as highlighted by Hightower et al. (2011), encourages learners to participate actively in a cooperative and creative learning environment, further fostering the positive and safe learning atmosphere that supports constructive alignment and learner-centred approaches. Wibowo et al. (2020) emphasise the significance of collaboration between teachers and learners, as well as learners within groups, in creating such a positive and safe learning environment, which complements the principles of active learning.

In an interactive constructivist classroom, learners are afforded the opportunity to engage in exploratory and self-directed learning, allowing them to actively explore and discover knowledge for themselves (So et al., 2019). This pedagogical approach corresponds with the research conducted by Ramakrishnan and Annakodi (2013), who assert that the brain responds to learning when it feels emotionally safe. Consequently, this instructional method of interactive constructivist teaching cultivates a positive and secure environment, enabling learners to take an active and participatory role in the learning process (Shah, 2019), which, in turn, contributes to greater understanding and motivation among learners (Filgona et al., 2020).

In addition to active involvement, Linton et al. (2014) highlight the significance of learners engaging in conversations and collaborative activities, which foster deeper understanding and knowledge construction. Through active discussions and interactions, learner engagement is heightened, facilitating the acquisition of new knowledge (Feroz et al., 2021), and providing valuable insights for teachers to assess learners' understanding (Resnick et al., 2018). Engaging in social interactions activates learners' brains, as noted by Pritchard (2017), and when these interactions are conducted in a productive manner, they greatly enhance the learning experience (Álvarez-Guerrero et al., 2021). The combination of active discussions, collaborative activities, and productive social interactions creates a dynamic and enriching learning environment that supports learners in their educational journey.

Creativity holds an essential position as a fundamental skill in teaching and learning. Florida (2004) reinforces this notion by asserting that wherever creativity thrives, progress and development are bound to proceed. In the face of the challenges and opportunities of the modern era, learners must cultivate the capacity to think critically, devise innovative solutions, and confront complex problems creatively (Lee et al., 2020). Therefore, Seechaliao (2017) rightfully emphasises creativity as an essential ability in this context.

As stated by Runco and Jaeger (2012), creativity entails generating original and distinctive ideas or solutions that are not only applicable but also practical and valuable in real-world contexts. According to Nakano and Wechsler (2018), creativity is a skill that demands development, and as such, teachers must foster, enhance, and uphold creativity in the classroom to empower learners.

Teachers are faced with the challenge of cultivating learners' creativity by establishing a secure environment for creative thinking and learning, designing activities that revolve around the learners' needs, and encouraging freedom, exploration, and inquiry (Beghetto & Kaufman, 2014; Gholam, 2019). By being role models and demonstrating creative behaviours, teachers significantly influence the development of learners' creativity in the classroom (Venter & Viljoen, 2020; Zulkifli et al., 2022). Exceptional teachers, as highlighted by Henrikson and Mishra (2015), display a high level of creativity in their professional attempts. They achieve this success by adopting strategies such as risk-taking and incorporating real-world learning techniques into their teaching methods (Henrikson & Mishra, 2015). Furthermore, creative teaching involves presenting subjects in imaginative contexts, actively encouraging learners to participate creatively, thereby challenging their capacities to generate ideas, assess them critically, and collaborate effectively, as highlighted by Cremin and Barnes (2018). Incorporating the cultivation of creativity in the classroom along with inventive teaching practices establishes a conducive environment for learners to develop innovation and originality.

Recent studies regarding creativity have revealed a concerning trend. After studying the evidence collected over the past 50 years, it has become apparent that creativity in the United States has shown a consistent decline within academic settings (McCarthy & Blake, 2017). The research of Barbot et al. (2016) also indicates that around the age of nine, when learners are generally in the fourth grade at the start of the Intermediate Phase, creativity experiences the most significant decline. Based on the research conducted by McCarthy and Blake (2017), a potential factor contributing to the diminution in creativity involves learners devoting more time to engaging with interactive media.

In the realm of education, it is widely acknowledged that learners exhibit diverse learning styles and preferences. This acknowledgement brings forth a fundamental responsibility for teachers to ensure that their instructional practices accommodate the individual needs of their learners (Richardson, 2005). Vidergor

(2017) goes even further by suggesting that effective learning incorporates experiences that are affective, interpersonal, and analytical in nature, thereby accentuating the importance of creating a rich and multifaceted learning environment. To achieve this, teachers must incorporate various teaching and learning methods and provide a range of experiences to foster an inclusive and dynamic classroom atmosphere that caters to the diverse needs and preferences of learners (DeLuca & Lam, 2014). By embracing these principles, teachers can better engage their learners and facilitate meaningful learning experiences.

Research on cognition indicates that effective learning entails connecting prior knowledge with new information to facilitate comprehension (Kilpatrick et al., 2001; Scott, 2006; Yeh et al., 2012). Moreover, reactivating both old and new knowledge has been shown to enhance long-term retention (Van Kesteren et al., 2012). Cooperstein and Kocevar-Weidinger (2004) propose that classroom activities promoting the construction of meaning by learners contribute to conceptual understanding, thus making the learning process meaningful and memorable by applying both prior and new knowledge.

To optimise their learning potential, learners should strive to attain a comprehensive understanding of the study materials and be able to employ that knowledge beyond the confines of the classroom (Bransford et al., 2000; Rillero, 2016). Mere memorisation of facts or procedural knowledge without comprehension of their underlying principles or applications is insufficient, according to Sawyer (2014). Connecting learning material to real-world contexts is not only a goal within the South African curriculum but is also accentuated in many educational systems worldwide (Department of Basic Education, 2011a; Koskinen & Pitkäniemi, 2022). The CAPS curriculum strives to offer learners opportunities not just to gain skills and knowledge, but also to put them to use in everyday situations (Department of Basic Education, 2011b, 2011c). By bridging the gap between classroom instruction and real-life experiences, the learning material becomes more engaging, interesting, and meaningful to learners (Enghag et al., 2007).

Gardner's book *Five Minds for the Future* (2006) presents the concept of multiple intelligences, which outlines a framework of intellectual abilities essential for learners to thrive in a rapidly changing world. Within this framework, Gardner (2006) identifies five essential minds or domains that form the basis for designing future curricula:

According to Gardner (2006, pp. 18–19), a "disciplined mind" refers to a learner's ability to acquire in-depth knowledge in a specific subject area, aiming for mastery over time, whether it is in mathematics, science, history, or the arts. Additionally, Gardner and Stork et al. (2010) emphasise the significance of fostering lifelong knowledge in learners, highlighting the importance of teachers dedicating ample time and employing a variety of learning strategies to encourage deep thinking among learners. According to Pendergast et al. (2005), acquiring in-depth knowledge involves dedicated and purposeful learning activities aimed at enhancing knowledge and skills throughout one's lifetime. Therefore, learners need to develop a profound understanding of fundamental concepts (Davis & Gardner, 2012).

The second cognitive ability, known as the "synthesizing mind" (Gardner, 2006, pp. 20–21), involves the learner's capacity to gather, evaluate, and establish meaningful connections among information. Teachers play a vital role in fostering the development of the synthesizing mind by assigning tasks that involve comparing and organising information to construct a coherent whole (Darling-Hammond et al., 2020). To support the growth of this cognitive ability, teachers should design assignments that require learners to compare and organise learning materials, facilitating the creation of a cohesive and integrated understanding (Altındağ & Senemoğlu, 2018).

The "creating mind" refers to the learner's capacity to generate innovative solutions and pose thought-provoking questions (Gardner, 2006, pp. 22–23). Gardner (2006) accentuates that every learner possesses creative thinking abilities, therefore it is important to cultivate creativity within the classroom. Creative thinking implies thinking beyond conventional boundaries, making unique connections, and approaching challenges with a fresh perspective (Gafour & Gafour, 2020). Researchers such as Haynes (2019) and Kaufman and Beghetto (2009) also agree that all learners have the potential for creative thinking, underscoring the need to nurture and develop creativity in the educational setting (Chan & Yuen, 2015). Teachers face the challenge of engaging learners' cognitive abilities by creating a secure environment for creative thinking and learning, designing learner-centred activities, and promoting freedom and exploration (Larraz-Rábanos, 2021).

According to Gardner (2006, pp. 24–25), the "respectful mind" suggests a learner's capacity to demonstrate tolerance, engage in effective communication, and acknowledge the perspectives of others. Gardner (2006) highlights the significance of classrooms as environments where learners can understand the importance of adhering to and valuing something greater than themselves (Morgan, 2021). The development of a respectful mind entails exhibiting tolerance towards others, practicing effective communication, and recognising the viewpoints of fellow learners (Stork et al., 2010). This necessitates creating a classroom atmosphere that fosters a sense of belonging and encourages learners to care for collective interests (Davis & Gardner, 2012).

Lastly, the fifth component is known as the "ethical mind" (Gardner, 2006, pp. 24–25). This aspect involves having a clear sense of purpose and unwavering determination to excel as a learner, worker, and citizen. Gardner (2006) emphasises the importance of individuals going beyond their personal interests and striving to uphold moral principles while cultivating care and concern for one another (Pava, 2008).

Gardner's *Five Minds of the Future* (2006) serves as an invaluable guide for the development of educational curricula, going beyond the traditional focus on knowledge and skills transmission by accentuating the importance of deep understanding, critical thinking, creativity, respect, and ethics (Saeid et al., 2021). This framework encourages teachers to reflect on the broader goals of education and prepare learners for an uncertain and constantly evolving future (OECD, 2019).

According to Davis and Gardner (2012), to foster the development of a *disciplined mind*, teachers should employ personalised and varied instructional approaches. These strategies will greatly enhance their effectiveness in helping learners develop their disciplinary thinking skills.

For learners with a *synthesizing mind*, assignments should be designed to necessitate the comparison and organisation of learning materials to construct a coherent and logical whole (Gardner, 2006). Furthermore, teachers should strive to foster creativity, nurture respect and accountability, and create opportunities for self-directed learning within the classroom. By embracing these principles, teachers can effectively prepare learners for the challenges and demands of the future (Saeid et al., 2021).

Davis and Gardner (2012) accentuate that to cultivate the *creating mind*, learners must be given opportunities to go beyond their current knowledge by posing new questions and offering innovative solutions. They contend that growing the *creative mind* entails more than simply collecting and consuming information; it requires establishing a mind-set that actively seeks new ideas and imaginative solutions. By encouraging learners to pose novel questions and explore uncharted territories, teachers can ignite their curiosity and stimulate their creative thinking abilities (Lucas, 2022).

Cultivating a *respectful mind* entail fostering tolerance, effective communication, and a willingness to acknowledge and consider the perspectives of others (Gardner, 2006). By promoting respectful interactions and creating a safe and inclusive classroom environment, teachers can help learners develop empathy and open-mindedness toward diverse viewpoints (Davis & Gardner, 2012).

According to Gardner (2006), fostering the development of the *ethical mind* requires cultivating a sense of purpose, moral reasoning, and an understanding of ethical principles. Teachers play an important role in this process by facilitating discussions and activities that encourage learners to delve into ethical dilemmas, analyse diverse perspectives, and make connections to real-world ethical issues (Benninga, 2013).

The process of learning is dynamic (Koopmans, 2020) and complex (Cagle & Kovacs, 2009) and varies for everyone (Abdumutalibovich, 2021). It involves a harmonious interplay of curiosity, motivation, engagement, and perseverance. Teachers must not only strive to cultivate Gardner's *Five minds of the Future* (2006) but also enable learners to adapt, innovate, and contribute to a brighter and more sustainable future (Burbules et al., 2020; Oke & Fernandes, 2020).

2.5.1 Conceptual Understanding of Concepts

Developing a deep conceptual understanding of fundamental concepts is an essential element of effective teaching and learning (Phillipson & Wegerif, 2016; Stern et al., 2017). The Curriculum and Assessment Policy Statement (CAPS) recognises the crucial role of conceptual understanding in education, accentuating its significance in the teaching and learning process (Department of Basic Education, 2011b). It is essential to keep in mind, however, that the measurement of conceptual understanding is a subject of debate among researchers, leading to differing opinions and perspectives on the criteria used to assess it (Crooks & Alibali, 2014).

Inglis and Aers (2008) define concepts as the cognitive process of identifying and differentiating specific attributes within a subject of contemplation from other aspects. In contrast, Hoover and Donovan (2013) view concepts as outcomes derived from learners' synthesis and integration of prior knowledge and thoughts, where meaningful connections are formed, and a deeper comprehension is constructed.

Building upon these viewpoints, Konicek-Moran and Keeley (2015) underscore the essential role of concepts as the fundamental elements of thought, forming the foundation of understanding and enabling the comprehension and organisation of knowledge. Concepts serve as building blocks through which learners make sense of the world and establish meaningful relationships between ideas (Chadwick, 2009; Gollub et al., 2002).

Embracing a comprehensive understanding of concepts allows teachers to gain valuable insights into how learners construct meaning, informing instructional strategies that promote deeper conceptual understanding, critical thinking, and the application of knowledge in diverse contexts (Joynes et al., 2019). This perspective stresses the importance of moving beyond superficial knowledge and engaging in higher-order cognitive processes (McPhail, 2020). Learners with conceptual understanding not only comprehend concepts but also think critically, establish connections, and transfer knowledge to varied contexts (Hattie & Donoghue, 2016; Sinatra et al., 2015).

Wiggins (2016) proclaims that learners must actively process, adapt, and critically evaluate their own thinking to attain a profound understanding of a concept. Learners who exhibit understanding possess the ability to effectively transfer and apply the concept to real-life circumstances (Hajian, 2019). According to Wiggins and McTighe (2011), a comprehensive understanding is demonstrated when learners can articulate, define, and express concepts using their own language, adapt concepts to new situations, develop personal perspectives, and communicate with metacognitive awareness. This transformative process of restructuring concepts surpasses mere memorisation of facts or procedural knowledge, as it necessitates active and engaged interaction with the learning material on the part of the learners (Sarrazin, 2016). In the realm of education, comprehension goes beyond mere information acquisition; it involves the adept application of knowledge in diverse contexts (Blaha et al., 2022).

While the CAPS policy (Department of Basic Education, 2011b) identifies the importance of conceptual understanding, the specific methods and tools for evaluating this understanding may vary. Researchers and teachers may employ various approaches, such as formative assessments, problem-solving tasks, or conceptual inventories, to measure the depth of learners' comprehension and their ability to apply concepts in different contexts (Kober, 2015; Gollub et al., 2002; Ozan & Kıncal, 2018). These diverse assessment strategies are designed to capture the multifaceted nature of conceptual understanding and provide insights into learners' knowledge construction processes (Schönborn & Anderson, 2008).

Exploring conceptual understanding is an important aspect of this research journey, as it provides valuable insights into how learners construct meaning. Understanding the significance of conceptual learning in teaching and learning enhanced the design and implementation of the integrated music-mathematics lessons (Chapter 4). In the following discussions, an exploration of the conceptual understanding in music and mathematics will be conducted.

2.5.2 Conceptual Understanding of Music

In the realm of music education, cultivating a comprehensive understanding of music goes beyond imparting basic facts and skills, as teachers strive to foster learners' musical knowledge through active engagement and creative exploration (Krause & Davidson, 2018; Liu, 2021). Recognising the significance of active engagement, Piaget (1973) accentuates the role of discovery in the process of understanding, which is further endorsed by Gruhn (2005), who asserts that deep understanding of music can only be achieved through active involvement. To cultivate musical understanding and foster musicianship, learners are encouraged to participate actively in a range of music-related activities, including singing, performing, instrumental playing, listening, exploration, improvisation, and meaningful discussions (Meissner, 2021). These multifaceted experiences not only deepen learners' comprehension of music but also nurture their musicality, creativity, and autonomy (Sangiorgio & Mastnak, 2020). Simultaneously, engaging in creative processes such as composition, improvisation, and arranging empowers learners to explore their unique musical ideas, express themselves, and cultivate their individual voices within the realm of music (Schiavio & Benedek, 2020). Active participation in these diverse activities not only enhances learners' grasp of musical concepts but also refines their skills and enables them to apply their knowledge in genuine and meaningful musical contexts (Campbell & Scott-Kassner, 2018).

Music education aims to cultivate learners' musical understanding, encompassing knowledge *of* music, knowledge *about* music, and practical knowledge of *how to* create music (Department for Basic Education, 2011b; Rogers, 2020). To achieve this, teachers should employ diverse instructional approaches that cater to the unique needs of individual learners (Hawk & Shah, 2007). By incorporating auditory, visual, and kinaesthetic elements, providing hands-on experiences, and encouraging collaborative learning, teachers enhance the learning experience and promote engagement among learners (Munna & Kalam, 2021). Differentiated instruction can also be applied to offer personalised learning experiences, provide various learning opportunities, and align assessments with individual learning styles, as recommended by Sarrazin (2016). By tailoring instruction to the needs of learners, teachers create an inclusive and supportive environment that fosters active participation and facilitates meaningful musical understanding.

Additionally, the understanding of musical concepts is deeply entangled with our surroundings, our physical experiences, and our social interactions (Lakoff & Johnson, 2003). To develop a comprehensive understanding of musical concepts, learners must grasp the metaphors they create to connect musical concepts with their own bodies and the environment (Oellermann, 2020). Moreover, learners need to comprehend how these concepts interweave and combine to form a cohesive musical structure (Leman et al., 2018). A thorough understanding of musical concepts empowers learners to listen to, create, and perform music with the expertise of professional musicians (Wiggins, 2015b). Music, both as a process and a product, is intricately linked, and our conceptualisation of the qualities of music applies to both its creation and its outcome (Elliott & Silverman, 2013).

Acknowledging that musical understanding is constructed through individual experiences is vital, as each learner possesses their own distinct musical background and encounters (Hallen & Papageorgi, 2016). To address any potential misconceptions or gaps in knowledge, Wiggins and McTighe (2011) propose that teachers ask open-ended questions during class discussions and assessments to assess learners' prior knowledge. By doing so, teachers can gain insights into learners' existing understanding and tailor instruction to meet their specific needs based on the assessment of their prior knowledge.

According to Wiggins (2015a), cultivating a comprehensive musical understanding that mirrors that of musicians is essential. This understanding is achieved by experiencing the various dimensions of music within the context of a complete musical piece, rather than focusing on isolated elements. Wiggins (2015a) argues that by exploring these different angles or dimensions of music, learners can avoid misinterpretation and gain a more holistic perspective. Furthermore, Wiggins (2015a) refers to these dimensions as distinct viewpoints that provide unique insights into the same musical experience. Through engaging with the interconnected dimensions of music, learners develop a deeper comprehension of how music is constructed, thereby enhancing their understanding of the meta-dimensions within the music.

The dimensions and meta-dimensions of music play an important role in designing meaningful music learning experiences (Wiggins, 2015a). By engaging in activities that involve creating, performing, and listening, learners can develop their knowledge and skills in a more insightful way, leading to a deeper level of musical understanding (Vidulin, 2017). These activities allow learners to actively explore and apply their musical knowledge across different dimensions, enabling them to make connections and develop a comprehensive understanding of music.

In a teaching framework proposed by Wiggins (2015a), the central emphasis is on cultivating musical understanding through a systematic approach. The framework comprises the following sequential steps:

Firstly, the teacher identifies a specific dimension or meta-dimension within a musical composition that resonates with the learners, serving as a gateway for active engagement with the music (Wiggins, 2015a). Next, in conjunction with the chosen dimension or meta-dimension, the teacher selects a metaphor that enhances the learners' understanding and connects the abstract concepts of music to something more relatable. Once the learners have identified and experienced the selected dimension or meta-dimension, they are guided to perceive and distinguish other dimensions within the music. Through active listening and detailed observation, the learners articulate their perceptions and describe various noticeable elements, enabling a deeper exploration and comprehensive understanding of the composition's multiple dimensions (Wiggins, 2015a).

In Wiggins' (2015a) teaching framework, the teacher incorporates physical or visual experiences to further enhance learners' comprehension of the selected metaphor and its corresponding dimension or meta-dimension. The aim is to engage learners in a multisensory exploration that reinforces their understanding. The following are the specific steps required for this process:

The learners are exposed to repeated physical or visual experiences aligned with the chosen dimension or meta-dimension, fostering a sense of control and mastery over the associated musical elements. This hands-on engagement deepens their connection to the music and enhances their ability to navigate and manipulate it effectively (Wiggins, 2015a).

To demonstrate their understanding of the dimension or meta-dimension, the learners undertake an evaluation task, which could take the form of a listening exercise, a creative project, or a performance assignment specifically assessing their grasp of the targeted dimension. Importantly, learners are expected to complete this assessment independently, promoting self-reliance and self-assessment, and empowering them to take ownership of their learning process (Wiggins, 2015a).

Wiggins' (2015a) teaching framework emphasises the importance of cultivating the knowledge and skills that support learners in becoming self-directed individuals (Bray & McClaskey, 2013). Rather than simply transmitting content, teachers must prioritise understanding (Lord & Baviskar, 2006). However, it is vital to acknowledge that teaching alone does not guarantee understanding; it is a dynamic and time-consuming process (Kilpatrick et al., 2001; Mills, 2019) that requires patience and ongoing support from both the teacher and the learner (Gillespie, 2005).

Wilson (2022) supports the idea that engaging learners in classroom discussions about music is a valuable approach to enhancing their musical understanding. Through these discussions, learners actively apply, describe, and interpret their knowledge of music, enabling them to deepen their understanding and establish a more meaningful connection with the subject matter, according to Dillon (2007), Mellizo (2020), and Scott (2011).

Eggebrecht and Evans (2010) accentuate the significance of classroom discussions in fostering a deeper level of musical understanding. Learners are encouraged to articulate their thoughts, share perspectives, and engage in critical thinking regarding music (Gravett & Petersen, 2022). In the context of music education, discussions provide a platform for teachers to share their expertise and guide learners in exploring and understanding musical concepts, styles, and techniques (Barrett & Veblen, 2012). Through dialogue and the exchange of ideas, learners gain insights from their peers and the teacher, which expands their knowledge (Peterson & Madsen, 2010) and broadens their understanding of music.

Cultivating a deep conceptual understanding of music empowers learners to engage with music at a profound level, fostering the development of their unique musical identities and establishing a greater connection with the art form. The insights gained from understanding conceptual understanding in music can inform the implementation of specific activities and approaches that are essential in designing the integrated music-mathematics lessons.

2.5.3 Conceptual Understanding of Mathematics

Conceptual understanding in mathematics refers to the capacity to establish relationships between different mathematical concepts, apply them in diverse contexts, and clarify their practical applications (Malatjie & Machaba, 2019). As learners actively participate in the learning process, they progressively attain a complete comprehension of mathematics, which involves abstract thinking, connecting concepts, and demonstrating an understanding of the relationships between mathematical ideas (Siregar & Siagian, 2019; Wrenn & Wrenn, 2009). Additionally, learners need to develop the ability to articulate, discuss, and justify the use of mathematical concepts and methods (Boaler, 2016). In the educational environment, the mastery of conceptual understanding is vital for learners to excel in the classroom (Mills, 2019). Without a strong grasp of fundamental concepts, learners may face challenges when attempting to apply their knowledge to novel situations or solve complex problems (Wilson & Peterson, 2006). This is particularly evident in subjects like mathematics, where a lack of conceptual understanding can hinder learners' ability to make connections between ideas, engage in mathematical reasoning, and develop problem-solving skills (Kilpatrick et al., 2001). Therefore, it is vital for teachers to accentuate the importance of fostering conceptual understanding in their learners to provide them with a sound foundation for academic and professional success.

According to Kilpatrick et al. (2001), a deep understanding of mathematics involves the development of five interconnected elements: procedural fluency, strategic competence, adaptive reasoning, productive disposition, and conceptual understanding. Due to the abstract nature of many mathematical concepts (Mitchelmore & White, 2007), learners must grasp conceptual understanding to fully comprehend the material (Wiggins & McTighe, 2011).

Effective teaching plays a vital role in nurturing learners' conceptual understanding (Turnuklu & Yesildere, 2007). Teachers are instrumental in guiding learners towards a strong conceptual understanding through well-designed learning activities (Yuliandari & Anggraini, 2021). Tasks involving problem-solving, logical reasoning and proof, effective communication, making connections, and using various representations provide valuable opportunities for learners to construct and reinforce their conceptual understanding (Suh, 2007).

Engaging in a variety of activities stimulates learners to employ deep cognitive processes, enabling them to analyse mathematical concepts intensively and establish meaningful connections between ideas (Fitzgerald & Palincsar, 2019). Prioritising conceptual understanding in instructional approaches empowers learners to develop problem-solving and reasoning skills, and effectively apply their knowledge in practical situations (Kilpatrick et al., 2001; Yuliandari & Anggraini, 2021). As highlighted by Guzman (2023), emphasising conceptual comprehension fosters learners' confidence, proficiency, and expertise, ultimately shaping them into skilled mathematicians. Hence, as teachers, it becomes our duty to guarantee that learners have a solid grasp of conceptual understanding, as it serves as the cornerstone for their achievements in both academia and their careers.

2.6 Teaching and Learning as Constructive Processes

Education goes beyond mere knowledge transmission, as highlighted by Edwards and Mercer (2013). To be effective teachers, it is vital to understand how learners acquire knowledge (Wiggins, 2016). Research indicates that learners connect new information with their existing knowledge and experiences (Bransford et al., 2000). This section of the literature study delves into various learning approaches, such as constructivist learning, spiral curriculum, problem-based learning, active learning, and inquiry-based learning. These approaches provide insights into how learners actively construct knowledge, engage with the curriculum, and develop their understanding through dynamic and inquiry-driven methods. The significance of investigating these learning processes within the context of this study lies in the gleaned insights into knowledge construction, skill development, and the fostering of a positive learning attitude. Moreover, it helped me improve my teaching practices and design instruction for integrated music-mathematics lessons that promote meaningful learning experiences and deeper conceptual understanding.

2.6.1 Constructivist Learning Approach

Engaging in meaningful learning experiences has been shown to enhance learners' productivity and effectiveness (Asiksoy & Ozdamli, 2017; Dagar & Yadav, 2016). As an educational theory, constructivism emphasises the active process of constructing knowledge (Mascolo & Fischer, 2005). According to Brooks and Brooks (2001), constructivism involves learners building knowledge from their experiences and interactions with others. Vygotsky (1978) introduced social constructivism, which highlights the role of social interaction in learning, enabling learners to acquire information and develop new skills. By establishing meaningful connections between new information and their pre-existing knowledge, learners actively construct their understanding (Birenbaum, 2003). The constructivist approach fosters learner independence and the development of problem-solving skills (Dev, 2016), creating an empowering learning environment where learners take an active role in building their knowledge. Adopting this approach, teachers create an engaging learning environment, empowering learners to contribute actively to building their knowledge. By designing well-planned activities that promote exploration, discovery, and problem-solving, the teacher fosters the construction of meaning and the application of concepts and knowledge (Gholam, 2019). Learners actively engage with the subject matter, collaborate with their peers, and take ownership of their learning process, leading to increased self-direction and success. This interactive and participatory approach enables learners to actively interact with the content, enhancing their understanding and retention of the material while also cultivating critical thinking, creativity, and problem-solving capabilities (Almulla, 2023).

According to the principles of constructivist theory, learning occurs within the proximal development zone, which represents the space between what a learner can accomplish independently and what they can achieve with the guidance and support of teachers or peers (Vygotsky, 1978). Applying scaffolding, a technique in which learners are guided gradually toward a deeper understanding of a concept or skill

(Acar et al., 2017; Wood et al., 2006), aligns with Bruner's (1960) definition of support, which emphasises using one's own superior knowledge to assist those with less insight.

In a constructivist classroom, the teacher assumes the role of a mentor and co-explorer, guiding learners in the process of constructing knowledge (Kloosterman & Taylor, 2012; Singh & Yaduvanshi, 2015). Instead of simply transmitting information, the teacher presents challenges and provokes curiosity, fostering an environment that encourages active engagement and independent thinking (Moate & Cox, 2015). This facilitative role of the teacher nurtures a supportive and nurturing learning environment, where learners feel encouraged to explore, inquire, and connect based on their own experiences (Lunenburg & Ornstein, 2012; Singh & Yaduvanshi, 2015). Individual learning needs are identified, and instruction is tailored accordingly to effectively support learners in their academic growth (Maher & Seach, 2016). Facilitators create opportunities for learners to independently create and develop while guiding them in learning how to learn (Hattie, 2012; Thomas, 2015). However, not all teachers may possess facilitation skills, so effective strategies should be developed to support teachers in transitioning to a learner-centred approach in their teaching practices (Gillies & Boyle, 2010; Keiler, 2018).

Encouraging collaboration and cooperation among learners facilitates meaningful discussions, idea-sharing, and the collective construction of knowledge (Akpan et al., 2020). Effective social interaction with peers, achieved through communication and discussion, is an important aspect of the learning process (Beyhan, 2013; Mercer & Littleton, 2007). In the constructivist classroom, group interaction is encouraged without promoting competition, as the teacher fosters a safe space for learners to actively participate in collaborative activities by providing necessary resources and guidance (Akpan et al., 2020).

Learning extends beyond the confines of the classroom, encompassing various settings and contexts (Wiggins, 2016). According to Scheer et al. (2012), real-life experiences are comprehensive and interconnected, aligning with constructivist theory, which suggests that learners actively construct meaning based on their personal experiences (Kolb, 1976; Prideaux, 2007). As a result, a holistic educational approach should offer learners opportunities to develop their talents and abilities at their individual paces and in alignment with their preferences (Badjanova & Iliško, 2015).

Motivation plays a vital role in learning, particularly in constructivist classrooms where learners actively engage in their own learning process. Filgona et al. (2020) and Hira and Anderson (2021) emphasise the significance of motivation in sustaining learner engagement and participation. In constructivist settings, teachers foster motivation by establishing connections between the learning content and learners' interests, highlighting the subject matter's relevance, and creating engaging learning experiences (Grigorescu, 2020; Harackiewicz et al., 2016). By nurturing intrinsic motivation and cultivating curiosity, teachers support learners in taking ownership of their learning and developing a lifelong passion for acquiring knowledge (Ostroff, 2016). To promote motivation, teachers can implement effective strategies such as designing learning tasks that are meaningful to learners' lives, setting clear goals, providing diverse activities, and offering regular and meaningful feedback, as proposed by Palmer (2005) and Wiggins (2016).

However, it is important to acknowledge that South Africa faces significant educational challenges, as highlighted by Marias (2016) in relation to overcrowded classrooms and Van der Berg et al. (2016) in terms of teachers lacking adequate content knowledge and pedagogical skills. These challenges can potentially hinder the effective implementation of constructivist principles and lead to a reliance on traditional textbook-based learning approaches, as noted by Booyse and Chetty (2016). These limitations may hinder learners' development of independent thinking and problem-solving skills (Mabena et al., 2021). To adequately prepare learners for effective functioning in a globally interdependent and integrated world, teachers must embrace and adopt improved educational approaches (OECD, 2019). As the landscape of education continues to evolve, teachers must remain open to new ideas, strategies, and methodologies that promote a broader perspective and foster global competence among learners (Erickson et al., 2017).

Research suggests that the integration of constructivism into interdisciplinary learning enhances the learning experience (Akpan & Beard, 2016; Braßler, 2016; Howlett et al., 2016). This could be attributed to the fact that constructivism cultivates an environment wherein learners engage in exploration, interaction, and self-formed comprehension prior to applying these ideas in novel and authentic scenarios (Lillard, 2017; Miller-First & Ballard, 2017). According to Kara (2019), by incorporating various viewpoints and diverse learning modalities, learners develop distinct perspectives on the same concept. Therefore, constructivism offers a diverse array of learning opportunities.

According to Golding (2009), interdisciplinary domains often involve intricate and multidimensional concepts that might present challenges when approached solely through traditional didactic methods. In the specific context of integrated music and mathematics, the application of constructivism implies that learners actively engage themselves in interpreting the complex interconnections that span across these disciplines (Laato et al., 2019). Therefore, Bada & Olusegun (2015) concur that a constructivist approach provides distinctive benefits within this context by notably enhancing contextual relevance and, consequently, becomes exceptionally valuable. Learners develop the ability to recognise the practical significance of the concepts they acquire, thereby extending their understanding beyond the classroom setting (Cetin-Dindar, 2015).

2.6.1.1 Bruner's Spiral Curriculum. Bruner's (1960) spiral curriculum is a fundamental element of his constructivist theory of learning and cognitive development, suggesting that thinking and reasoning are intricately interconnected. The spiral curriculum functions as an educational framework designed to enhance learners' knowledge and skills in a meaningful and interconnected manner (Micu, 2017). Smidt (2013) concurs that through the active process of building upon prior experiences and understanding, learners become proactive knowledge constructors.

The spiral curriculum, as supported by Masters and Gibbs (2007) and Gibbs (2014), goes beyond mere repetition of concepts taught over time. Krueger and Wilson (2018) argue that each application intensifies the complexity of the topic, and breaking down complex concepts into basic elements facilitates the identification of connections and relationships between these fundamental parts. As learners progress, the curriculum delves into more intricate explorations and developments of the concepts, ensuring meaningful learning and a deeper grasp of the subject matter, as noted by Dunton and Co (2019). Revisiting the concepts in a spiral manner provides learners with multiple opportunities to actively engage with the material and establish connections between different facets of the subject, as observed by Murray and Howells (2023). This repetitive process fosters a comprehensive and profound comprehension that transcends superficial knowledge, harmonising with Dunton and Co's (2019) emphasis on cultivating both a broad range of knowledge and a deeper understanding of the subject matter.

To attain an inclusive understanding of their learning, learners must take ownership of the knowledge they acquire, a fundamental principle advocated by Bruner's (1960) spiral curriculum. The curriculum promotes active engagement by encouraging learners to apply their prior knowledge to new topics or situations, regardless of their developmental level, as demonstrated in Johnston's study (2012). Additionally, it enables learners to recognise the interconnections between different content standards, leading to positive learning outcomes (Ireland & Mouthaan, 2020). Bruner's (1960) method surpasses traditional forms of instruction, such as rote memorisation and lectures, as it fosters critical thinking and practical application of knowledge in real-world contexts. Studies investigating the implementation of the spiral approach in revisiting subject content have demonstrated positive effects on academic performance (Dhunny & Angateeah, 2019; Skinner, 2011; Woodward, 2019). By systematically re-examining and expanding upon key concepts, the spiral curriculum equips learners with the necessary skills to think critically, make connections, and effectively apply their knowledge in diverse contexts.

The spiral curriculum provides various advantages, but caution is needed to avoid excessive concept repetition and inappropriate pacing, as highlighted by Snider (2004). However, despite potential limitations, several studies have provided evidence supporting the effectiveness of the spiral approach in enhancing learners' retention and retrieval of learning content (Dhunny & Angateeah, 2019; Madkour, 2015).

In addition to Bruner's spiral curriculum (1960), a vital aspect of his theory of learning and cognitive development is his belief that learning should be discovered rather than merely taught by a teacher. Instead of providing learners with predefined procedures and methods, the teacher should offer resources and assignments that encourage learners to explore, discover, and investigate independently.

Numerous studies have presented evidence of the efficacy of the spiral curriculum in introducing complex topics during the early grades (Johnston, 2012; Madkour, 2015; Woodward, 2019). This approach is consistent with Bruner's conviction that learners can be effectively taught at any stage of development (Bruner, 1960) and supports a logical progression from simple to complex ideas (Davis, 2007). Bruner (1960) emphasised that the human mind is naturally inclined to explore possibilities, underscoring the significance of learning through experiential discovery. Accordingly, learning should be enriched through active engagement in hands-on experiences and investigations, enabling learners to develop a deeper understanding of the subject matter. Hence, incorporating Bruner's (1960) spiral approach into the construction of the integrated music-mathematics lessons in this study cultivates a coherent and profound learning experience for the learners.

2.6.1.2 Problem-based Learning. Problem-based learning (PBL) represents a learner-centred instructional approach that employs real-world scenarios to cultivate problem-solving skills in practical situations (Lapek, 2018). Three core constructivist principles, as outlined by Cain and Cocco (2013), form the foundation of PBL. Firstly, learning is contextual, with learners actively involved in authentic, meaningful problems that mirror real-world challenges. Secondly, learners take an active role in the learning process by investigating, analysing, and generating solutions to problems. Finally, learners achieve their goals through collaborative knowledge-sharing and understanding, working with peers to develop comprehensive solutions (Cain & Cocco, 2013). As a result, PBL provides an effective framework for learners to cultivate critical thinking skills, problem-solving abilities, and a deeper understanding of the subject matter by engaging with authentic, real-life problems (Ali, 2019; Wiggins et al., 2016).

The Department of Education in South Africa has taken a significant step towards promoting a PBL approach by introducing the *Mathematics Teaching and Learning Framework* (Department of Basic Education, 2018). This framework serves as a guide for teachers, emphasising the significance of conceptual understanding in mathematics instruction. The primary goal is to enhance learners' procedural knowledge by providing them with a foundation of mathematical concepts and principles.

Several studies have demonstrated the positive effects of PBL on learning outcomes (Juandi, 2021; Kawuri et al., 2019; Strobel & van Barneveld, 2015). PBL has been shown to improve long-term retention of knowledge, allowing learners to retain and apply what they have learned over an extended period. Furthermore, PBL has been found to enhance learner motivation, a crucial aspect of academic success (Liu et al., 2006), often tapping into learners' intrinsic motivation by allowing them to explore topics of interest and curiosity (Orji & Ogbuanya, 2020).

PBL offers a framework that fosters dynamic and collaborative learning, enabling learners to actively construct knowledge through socialisation and independent understanding (Lauriden & Cruz, 2013; Yew & Goh, 2016), in contrast to the passive engagement of learners in traditional teacher-centred approaches (Hurst et al., 2013; Lapek, 2018). Moreover, PBL promotes interdisciplinary teaching and learning, allowing for the integration of different subject areas (Capraro & Jones, 2013). This makes PBL an appropriate approach to incorporate in the integrated music-mathematics lessons that form an important part of this study.

The contextual learning theory of PBL suggests that learners are more likely to effectively acquire knowledge when they participate in significant, engaging experiences (Abdullah et al., 2019) that provide a sense of purpose and relevance to new tasks and material (Johnson, 2002). PBL provides learners with valuable learning opportunities that not only enhance their subject knowledge but also contribute to the development of independent learning skills and attitudes (Loyens et al., 2015). This, in turn, boosts their confidence and empowers them to think critically and creatively (Birgili, 2015; Ersoy & Başer, 2014; Lapek, 2018; Lindvang & Beck, 2015).

Problem-based learning and interdisciplinary learning are inherently interconnected and mutually reinforcing (Braßler, 2016). Stentoft's (2017) investigation uncovers significant parallels between PBL and interdisciplinary learning, solidifying problem-based learning as a potentially compelling pedagogical approach that fosters learning across a diverse range of disciplines.

Within this framework, as highlighted by El Sayary et al. (2015), problem-based learning exposes learners to real-world, multifaceted challenges that consistently demand insights and knowledge from various disciplines. PBL actively encourages learners to combine knowledge and concepts from diverse fields, resulting in the creation of comprehensive solutions (Tan, 2021). Furthermore, PBL compels learners to analyse problems from different perspectives and angles (Jonassen & Hung, 2008), thereby fostering a comprehensive understanding of the issue and motivating them to consider insights from a broad spectrum of disciplines (Cowden & Santiago, 2016). In this context, Ulger (2018) argues that PBL equips learners with the adaptive capacity to implement new challenges and navigate unfamiliar situations, a skill within interdisciplinary work, where learners frequently encounter unexplored problems.

PBL plays a significant role in this research on integrating music and mathematics. Before designing the integrated music-mathematics lesson series, I consulted the literature to gain insights on how to approach the lessons. The literature indicated that to plan a well-structured and engaging PBL activity, it is important to consider the following key aspects. Firstly, it is vital to define clear educational objectives that align with the curriculum (Akben, 2019). This ensures that the PBL activity serves a specific purpose and integrates seamlessly into the overall learning process. Secondly, selecting a meaningful, real-world problem that captures learners' interest and relates to their existing knowledge is essential, as indicated by the research of Dolmans and Gijbels (2013). The chosen problem should encourage knowledge acquisition, skills enhancement, and foster a growth-oriented mind-set towards learning (Hande et al., 2015). According to the research of Davidson and Major (2014) formulating an open-ended, thought-provoking question to serve as the central focus of the PBL activity is recommended. The PBL question should guide learners to explore the problem from various perspectives, nurturing critical thinking and problem-solving skills (Ghufron & Ermawati, 2018; Savin-Baden, 2014). Furthermore, as indicated by Heong et al. (2020), teachers must provide explicit guidelines and expectations for the PBL activity, encompassing well-defined objectives, assessment criteria, and desired outcomes. The question should also encourage creative problem-solving, facilitate group discussions, and empower learners to take ownership of their learning (Smith & Cook, 2012; Tan, 2021). Lastly, teachers should facilitate reflection throughout the investigation process (Krause & Stark, 2010), guiding learners to assess their own progress and understanding (van der Vleuten & Schuwirth, 2019; West et al., 2013). By taking these key aspects into consideration when designing and implementing the integrated music-mathematics lessons, enriched PBL activities were created that effectively promoted active learning in this study.

2.6.1.3 Inquiry-based Learning. Inquiry-based learning (IBL) is grounded in the constructivist learning theory, which highlights the importance of learners' active involvement in meaningful and coherent activities (Aulls & Shore, 2008; Love et al., 2015). According to Hofer and Lembens (2019), it serves as a guiding framework that complements teaching and learning, equipping learners with essential skills for achievement.

Within a learner-centred approach, IBL encourages individuals to engage in the exploration and investigation of questions and ideas, facilitating reflection, discussion, and the generation of new knowledge based on their discoveries (Caswell & LaBrie, 2017). The essence of IBL lies in learners mastering content and experiences for themselves, rather than passively receiving information (Walker & Shore, 2015).

Through well-planned activities, the teacher directs learning and supports the discovery of concepts as well as the application of acquired knowledge in problem-solving (Gholam, 2019; Hmelo-Silver et al., 2007). Research has firmly established the benefits of IBL, including its effectiveness in developing conceptual understanding (Gholam, 2019; Maxwell et al., 2015) and fostering motivation in the study of music and mathematics (Attard et al., 2021; Oellermann, 2020). IBL also supports the cultivation of deep learning skills and academic performance among learners (Spronken-Smith, 2012) and has been linked to the growth of learners' creativity, positivity, and independence (Spronken-Smith & Walker, 2010; Wood, 2010).

According to Fielding-Wells (2015) the incorporation of IBL aims to capitalise on the inherent connections between music and mathematics, applying them to enhance overall learning outcomes. By integrating the two disciplines, learners can explore and deepen their understanding of concepts in music and mathematics, promoting a holistic and interconnected approach to learning.

The Curriculum and Assessment Policy Statement (CAPS) in South Africa not only encourages but mandates IBL, underscoring its significance in education (Department of Basic Education, 2011b). The National Curriculum Statement Grades R–12 (Department of Basic Education, 2011a) strongly accentuates IBL, prioritising the improvement of creative and critical thinking skills in learners. The central objective of the policy is to empower learners to actively engage in the learning process, enabling them to effectively identify, describe, and solve problems. Moreover, within the framework of IBL, the policy fosters learners' autonomy and collaborative skills, recognising the intricate and multifaceted nature of real-world problems and the need for a holistic understanding of interconnected components to arrive at effective solutions.

2.6.1.4 Active Learning. Active learning, as a teaching strategy that surpasses traditional classroom methods, engages learners in meaningful activities and encourages them to actively participate in their learning process (Prince, 2004). Abdullah and Yang (2019) highlight that by establishing a vital link between theoretical concepts and their practical application in real-world scenarios, active learning aids learners in internalising and better comprehending the subject matter.

Freeman et al. (2014) mention that the learner-centric approach, an important aspect of this current study, cultivates proactivity among learners, resulting in a dynamic and engaging educational experience. Active learning approaches cohere with constructivism, accentuating that learners construct their own knowledge through active engagement (Du et al., 2020). By undertaking activities such as peer review, answering challenging problems, and engaging in discussions, learners can construct their own understanding (Ribeiro-Silva et al., 2022).

Active learning enables learners to develop critical thinking, metacognitive activities, investigation, cooperative learning, analytical thinking, and creation skills, enabling them to solve complex problems, propose viable solutions, make informed decisions, and communicate their ideas effectively (Huggett & Jeffries, 2021; Tang et al., 2020; Warsah et al., 2021). Studies consistently demonstrate that learners learn more effectively in an active learning environment compared to a passive lecture-based one (Ang et al., 2021; Beyleveld et al., 2019; Deslauriers et al., 2019).

Despite its proven efficacy, implementing active learning faces challenges, including resistance to change, limited time and resources, and potential overwhelm for learners (Hwang et al., 2018; Myers, 2016; Nguyen et al., 2021). However, active learning remains valuable, enhancing metacognitive levels, promoting higher-order cognitive skills, and facilitating deep learning and understanding (Chick, 2013; Limbach & Waugh, 2010; Phan, 2018).

Through engaging in reflective processes and discussions, learners can enhance their long-term memory storage of information, concepts, and skills, leading to improved academic achievement (Cowan, 2014; Weinstein et al., 2018). Active learning also encourages learners to critically analyse how they can apply the knowledge acquired to real-life situations (Ren et al., 2021). Overall, active learning fosters a dynamic, engaging, and effective educational experience, inspiring continuous learning throughout learners' academic and professional lives.

According to Walker et al. (2008), active learning provides specific benefits to learners who encounter academic difficulties, as opposed to those who consistently excel academically. Participating in activities that demand analytical, synthetic, and evaluative thinking, such as exploration, integration, and judgment, learners can establish meaningful connections between ideas and develop a comprehensive understanding of concepts (Gogus, 2012; Llorens et al., 2017; Ren et al., 2021). Through active involvement, learners facing academic challenges can construct knowledge, address misconceptions, and refine their understanding, which ultimately leads to enhanced academic achievement.

Engaging in activities that foster personal connections with the material can significantly enhance learners' motivation (Anwer, 2019). Research suggests that active learning promotes a more positive learning experience by enabling learners to interact meaningfully with the material, fostering a sense of ownership and interest in the learning process (Anderson et al., 2006; Cook & Hazelwood, 2002; Freeman et al., 2014; Saville et al., 2011). Encouraging learners to approach their studies with an inquisitive and eager mind-set can result in a deeper understanding of the subject matter and a greater willingness to explore novel ideas and concepts (Czaplinski et al., 2020).

Timely and frequent feedback is crucial for fostering active learning, as emphasised by Hattie and Timperley (2007). Providing learners with immediate and regular feedback helps them recognise and correct any misconceptions they may have, resulting in a deeper understanding of the subject matter. Regularly engaging with both the teacher and peers, particularly during group activities and collaborations, fosters a collective sense of purpose in the classroom (Wu et al., 2020). Immediate feedback has been demonstrated to increase learner engagement and confidence, motivating them to take greater responsibility for their learning (Ryan & Deci, 2017). Moreover, instant feedback has been shown to enhance learners' motivation and self-efficacy, empowering them to take greater ownership of their learning process (Ryan & Deci, 2017).

Active learning and an interdisciplinary approach complement each other (Holzer et al., 2019), cultivating an educational approach that is both immersive and all-encompassing (Hood Cattaneo, 2017). At the core of both methodologies is the learner, who takes a central position in the educational journey (Hernández-de-Menéndez et al., 2019; Sahin, 2015).

Both active learning and interdisciplinary learning involve direct engagement by learners. Khan et al. (2017) underline that active learning encourages learners to participate, share ideas, and collaborate. In contrast, English (2016) suggests that interdisciplinary learning requires integrating insights and viewpoints from various disciplines. These two approaches equally underscore the practical application of knowledge within real-world contexts (Abramovich et al., 2019; Wang & Song, 2021).

Flexibility in learning is highly valued by both active learning and interdisciplinary learning. Active learning allows learners to explore subjects through diverse approaches (Bean & Melzer, 2021), while interdisciplinary learning, as noted by MacLeod (2018), encourages learners to adapt and blend concepts from various disciplines.

In this study, the connection between active learning and integrated music-mathematics lessons lies in their mutual emphasis on engagement, participation, and practical application. Active learning strategies empowered learners to delve into the connections between music and mathematics (Riebe, 2019) fostering a deeper understanding of both subjects while nurturing their creativity and critical thinking skills.

2.7 Integrated Teaching and Learning

The literature on integrated learning presents diverse definitions and applications, making it challenging to establish a uniform understanding of integration in teaching and learning (Civil, 2007; Dowden, 2007; Drake & Burns, 2004; Geist et al., 2012; Russell-Bowie, 2009; Wiggins, 2001). Viladot and Cslovjecsek (2014) aim to foster comprehension, proficiency, and valuation of two subjects simultaneously through integration, while Malik and Malik (2011) define it as combining typically individually taught subjects. This study aligns with Snyder (2001) that learners should acquire knowledge and skills in a meaningful way by integrating various subjects, with the research objective being to integrate music and mathematics with equal significance to subject and content knowledge (Davidova, 2020).

An integrated teaching and learning approach offer numerous benefits, including a deeper understanding of mathematical principles, improved academic success in mathematics (Bairy, 2019; Lim et al., 2017), an engaging and exploratory learning environment (Scott, 2006), and making learning more meaningful for learners (Trinick et al., 2016). Integrating music and mathematics enables learners to deepen their comprehension of mathematical concepts, cultivating problem-solving skills and critical thinking abilities (Wiggins, 2001). Fox and Surtees (2010) state that active engagement in music-making activities enhances attention, fosters creativity, and promotes perseverance in mathematical tasks. Establishing real-world connections and applications to learners' daily lives enhances the meaningfulness of learning and their ability to apply acquired knowledge (Bolak et al., 2005; Jensen, 2005; Leicht et al., 2018).

Springer (2006) highlights that an additional objective of an integrated curriculum is to ensure that teaching and learning have a clear purpose, equipping learners for lifelong learning and success in a rapidly changing world. Engaging in significant integrated experiences allows learners to develop a deeper comprehension of how different subjects are interconnected (Drake & Reid, 2018; Watkins & Kritsonis, 2011), fostering a holistic understanding that goes beyond isolated knowledge in individual subjects. Moreover, an integrated curriculum allows learners to apply the content they have learned in practice, leading to a positive attitude toward learning and increased engagement (Adams, 2007; Lujan & DiCarlo, 2017). As learners become more engaged and find meaning and purpose in their education (Barrett & Veblen, 2012; Bolstad, 2011; Drake & Burns, 2004; Perger et al., 2018), they are motivated to develop a deeper connection to the subject matter (McGrath, 2010; Shilling, 2002; Watkins & Kritsonis, 2011).

The Intermediate Phase of education is a crucial period in learners' mathematical development. During this phase, learners are at a critical juncture where they are forming perceptions about their mathematical abilities and interests, which will influence their approach to mathematics in the higher grades (Protheroe, 2007). The decisions they make during this stage can have long-lasting effects on their attitudes toward mathematics and their future engagement with the subject (Mazana et al., 2019). Therefore, it is essential to provide learners with meaningful and engaging mathematical experiences during the Intermediate Phase to nurture their mathematical confidence, curiosity, and motivation.

Education holds vital importance in South Africa, demonstrated by its active participation as one of the five partners of the Organisation for Economic Co-operation and Development (OECD, 2019). Collaborating with Brazil, China, India, and Indonesia, South Africa played a crucial role in developing *The Future of Education and Skills: Education 2030 framework* (OECD, 2019). This collaborative effort involved policymakers, academics, and teachers from diverse regions worldwide, resulting in a comprehensive understanding of the essential skills and competencies required for learners to thrive in the year 2030.

The framework has paved the way for a substantial transformation of South Africa's educational landscape by 2030, with a specific focus on integrating four knowledge types outlined in the project (OECD, 2019). These domains of knowledge include subject-oriented, interdisciplinary, cognitive, and perceptual skill learning. Emphasising the importance of an interdisciplinary approach, the framework encourages connections between different educational experiences to foster cohesive learning. Learners are urged to develop interdisciplinary thinking skills, bridging gaps between different fields of study. Additionally, the framework acknowledges the value of considering connections and relationships between conflicting concepts, reasoning, and perspectives to achieve a deeper understanding. It also prioritises the acquisition of transferable abilities and perspectives that can be applied across various contexts, preparing learners for the complexities of the future. In alignment with this vision from the OECD (2019), South Africa's education system places significant emphasis on the integration of teaching and learning. This focus on integration and forward-looking skills positions South Africa's educational landscape for a substantial transformation by 2030.

High-performing countries such as Finland, China, Japan, Korea, and Taiwan have demonstrated a keen interest in adopting an integrated approach to teaching and learning that promotes deeper understanding, creativity, and social engagement (Taseman et al., 2020). These countries identify the value of integrating different disciplines and subjects to provide learners with a holistic and comprehensive education. In accordance with Finland's new curriculum (Finnish National Board of Education, 2014), the integration of subjects is mandated through the inclusion of "at least one multidisciplinary learning module" in every school year (p. 52). This requirement aims to promote a holistic approach to education by encouraging the exploration of interconnectedness among different subject areas.

Several countries, including the United States, South Korea, Singapore, and China, have placed significant emphasis on STEAM education to foster interactive and cooperative learning environments. STEAM education adopts an interdisciplinary approach that combines science, technology, engineering, the arts, and math to foster imaginative and reflective thinking, support self-directed learning, facilitate collaborative dialogue, and promote problem-solving skills (Carter et al., 2021; You, 2017). According to Conradty et al. (2023), integrating STEAM disciplines stimulates learners to engage in critical thinking, establish connections between diverse subjects, and apply their knowledge to real-world scenarios, thereby enhancing cognitive abilities and nurturing creativity. The collaborative nature of STEAM education fosters effective communication and teamwork skills as learners engage in interdisciplinary projects, appreciate diverse perspectives, and collectively address challenges (Jantassova et al., 2023; Li et al., 2022a). The experiences gained through STEAM education prepare learners for the cooperative aspect of the present workforce, where interdisciplinary approaches and efficient teamwork are highly valued (Bertrand & Namukasa, 2020). Moreover, the integration of STEAM education not only enhances learners' cognitive abilities and creativity but also equips them with essential communication and teamwork skills necessary for success in the modern world (Madden et al., 2013; Perignat & Katz-Buonincontro, 2019).

Despite the numerous benefits of an integrated curriculum, implementing curriculum integration in schools can face various challenges. One significant concern is the limited knowledge and understanding of curriculum integration among teachers, as highlighted by Niemelä and Tirri (2017). Additionally, teachers have indicated that they lack confidence in integrating music into primary school education (Heyning, 2010; Sirek & Sefton, 2023). Furthermore, Drake and Reid (2018) point out that teachers may have limited familiarity with the content of other subjects, which can hinder their ability to create meaningful connections between disciplines.

Another challenge lies in ensuring that the integration of music is purposeful and meaningful, rather than solely for entertainment purposes (Burnaford et al., 2013). It is essential to avoid superficial integration that lacks educational value. Wiggins (2015a) highlights the importance of preserving the core value of integrated music by ensuring that music integration goes beyond mere entertainment and incorporates relevant music concepts and elements. By integrating music concepts and elements effectively, teachers can create authentic and engaging learning experiences that deepen learners' understanding of both music and other subject areas (Jansen van Vuuren, 2018).

In their work, An et al. (2013) not only formulated an interdisciplinary curriculum that integrates music and mathematics, but also conducted a study examining how teachers designed, adapted, and delivered these integrated lessons.

Their research aimed to explore the process and strategies teachers employ to effectively integrate music and mathematics into their instructional practices. The study involved observing and interviewing teachers who were implementing the interdisciplinary curriculum. The researchers examined the teachers' lesson planning, instructional materials, teaching techniques, and learner engagement during the integrated music and mathematics lessons. They sought to understand how teachers approached the integration process, what challenges they encountered, and how they addressed those challenges. By studying teachers' practices and experiences, An et al. (2013) provided valuable insights into the practical aspects of designing and delivering interdisciplinary lessons that integrate music and mathematics.

The instructional model developed by An et al. (2013) integrated music and mathematics through five distinct phases. Teachers were given the option to create and deliver lessons that integrated music and mathematics using two frameworks. These included a structure centred around designing musical instruments and another built upon engaging in music composition activities. The spectrum of music activities encompassed singing, composition, and instrumental performance, with a central focus on understanding musical values. Simultaneously, the integration extended to a range of mathematical concepts, such as number sense, algebraic principles, functions, measurements, geometry, statistical analysis, and mathematical reasoning.

The following discussion on the integrated music-mathematics lessons from the research conducted by An et al. (2013) offers a brief overview. The central focus of this conversation is to outline the five phases and emphasise the role of music and mathematics within each phase.

In the first phase, the primary focus was on music, involving discussions of the song's lyrics and group chanting. This stage emphasised refining rhythm skills and cultivating an awareness of a steady beat in the music. Progressing into the second phase, the integration of music and mathematics continued, although the emphasis shifted more towards music. In this stage, a song was applied as an educational tool for teaching subtraction. Learners actively participated by singing the song before engaging in reflection. This reflective process resulted in the creation of subtraction-based number sentences, aligning with the problems presented within the song.

During phase three, the teacher assumed the role of guiding learner engagement. Music notation was employed as a medium to convey an understanding of functions. This phase provoked learners to actively discern mathematical ideas embedded within the music they encountered. Notably, this stage accorded equal importance to both the musical and mathematical dimensions of the integrated curriculum.

In phase four, learners applied different colours to symbolise various aspects of the melody. Following this, they proceeded to construct a function chart, correlating musical notation with mathematical representation. Throughout this phase, a balance was maintained between music and mathematics, with an enhanced focus on mathematics.

In the fifth and concluding phase, learners sang three familiar songs. Subsequently, they identified and engaged in discussions about the inherent patterns within these songs. Building upon this foundational understanding, learners went on to compose and perform original music compositions, adhering to the guidance provided in the worksheet. In this last phase the focus was on mathematics (An et al., 2013).

In this study, the development of the integrated music-mathematics lessons was guided by An et al.'s (2013) instructional model, specifically during the Pre-implementation Phase (See Table 2). The integrated music-mathematics lessons for this current study, were further crafted to cohere with the South African Intermediate Phase Curriculum for Life Skills, which includes the subject Music (Department of Basic Education, 2011b), as well as Mathematics (Department of Basic Education, 2011c).

2.8 Conclusion

The literature in this study provided valuable insights into instructional strategies that conform with the constructive process of teaching and learning. Chapter 2 aimed to establish a strong foundation for understanding the constructive alignment approach, current insights into how learners acquire knowledge, the conceptual understanding of music and mathematics, teaching and learning as constructive processes, the integration of 21st-century learning skills, and integrated teaching and learning practices. These instructional techniques directly informed the design of the integrated music-mathematics lessons described in Chapter 4. In the next chapter, the researcher will discuss the methodological framework employed in this study, outlining the research design, data collection methods, and analysis techniques used to investigate the enhancement of mathematics through music in the Intermediate Phase.

Chapter 3: Research Design, Approaches, and Methods

3.1 Introduction

The main objective of this study was to examine the experiences of generalist teachers in the Intermediate Phase concerning the integration of music into the teaching and learning of mathematics. In this chapter, the methodology employed in designing the qualitative case study is presented. The chapter starts by a detailed explanation of the methods and instruments applied for data collection. The data analysis process is also outlined, along with the strategies employed to ensure the credibility and dependability of the findings. Lastly, the chapter addresses the role of the researcher and ethical considerations that were considered throughout the study. By providing a comprehensive overview of the methodology, this chapter establishes a framework for the subsequent analysis and interpretation of the data. The chapter concludes by providing an account of the ethical processes that guided the research.

3.2 Research Method and Design

In this study, a qualitative research approach was used, as it is particularly suited for exploring the nuances of human experiences in social contexts (Mohajan, 2018). Qualitative research is aimed at gaining a comprehensive understanding of individuals' thoughts, ideas, perceptions, and perspectives (Conway et al., 2014; Nieuwenhuis, 2020; Yin, 2018). This approach is particularly advantageous for educational research, as it can provide valuable insights into the experiential and interpretive aspects of educational phenomena.

Besides aiding in the comprehension of educational phenomena, qualitative studies can supply valuable data that guides both policymakers and practitioners in the maintenance or reform of educational systems (Tilley, 2019). Qualitative research is particularly well-suited for exploring intricate, nuanced issues, as it highlights the understanding of the phenomenon under investigation (Yin, 2018). This is of great significance in educational research, where teaching environments frequently mirror the daily experiences of teachers and learners (Cropley, 2021).

This study aimed to explore the relationship between generalist teachers and their teaching experiences. To achieve this goal, Thorne (2000) asserts that researchers should apply a qualitative approach to analyse data collected from diverse perspectives, resulting in the generation of novel insights.

The qualitative approach allowed me to explore deeply into the participants' experiences, facilitating a comprehensive and nuanced understanding of the phenomenon. This method also allowed me to grasp the intricate and multifaceted nature of the participants' experiences, something that quantitative methods might struggle to capture.

The study collected and analysed diverse data forms (see Section 3.4.2) to construct a thorough understanding of how generalist teachers experience the enhancement of mathematics through music in the classroom. Through data collection via interviews, observations, and documents, the study provides a multifaceted and nuanced perspective of the phenomenon being investigated. This approach enabled triangulation, enhancing the study's trustworthiness and validity by cross-referencing data from multiple sources. This study is situated within the framework of constructive alignment as a pedagogical design for teaching and learning. According to Biggs (2014), constructive alignment is an approach that highlights the significance of harmonising the learning outcomes, assessment tasks, and teaching methods to promote purposeful and meaningful learning. This approach promotes more complex and advanced learning by providing authentic learning activities within the discipline and a learning environment that supports the achievement of desired learning outcomes. In this study, the framework of constructive alignment guided the investigation of how generalist teachers experience the advancement of mathematics using musical integration in the classroom, with a specific emphasis on how the approach facilitates the development of meaningful learning.

3.3 The Role of the Researcher

The role of the researcher is to design and conduct a study to collect, analyse, and interpret data to answer research questions or test hypotheses (Sutton & Austin, 2015). The researcher is responsible for selecting an appropriate research method and design, identifying and recruiting study participants, collecting and analysing data, and reporting the findings. Additionally, the researcher must ensure that the study is conducted ethically, that the data is accurate and reliable, and that the findings are valid and meaningful (Maher et al., 2018).

Sowell (2001) suggests that in a qualitative study, the researcher's primary responsibility is to gather verbal and non-verbal information. As Rudestam and Newton (2014) note: "The researcher becomes an instrument of data collection" (p. 1). In this study, I, as the researcher, developed the lessons utilised for conducting integrated music-mathematics lessons within the Grade 4 classes. I personally guided the learning experiences in the classes, which were observed by the participants. Furthermore, I directly engaged with the participating generalist teachers to collect data via individual interviews interactions and observations of the lessons conducted by them.

3.4 Data Collection

Qualitative research is known for generating rich, detailed descriptions of data that can explain real-world phenomena (Maher et al., 2018; Mills, 2018). This study employed various data collection methods, including curriculum analysis, lesson plans used in the integrated music-mathematics lessons, individual semi-structured interviews with participant teachers, and observations documented through video recordings and written field notes. These methods aimed to capture the participant teachers' experiences as they implemented integrated music-mathematics learning for the first time. The sampling strategy, data collection plan, forms of data, data analysis and interpretation, validity and reliability of data collected, and ethical considerations are discussed in the following sections.

Lastly, as a vital component of the data collection process, individual semi-structured interviews were conducted with the participating generalist teachers after their presentation of the integrated music-mathematics lessons. These interviews were designed to provide a platform for the participants to reflect, articulate, and elaborate upon their experiences and perspectives on the empowerment of mathematical concepts through musical applications.

3.4.1 Sampling Strategy

A sample is a carefully selected section of a population from which data is collected for research purposes (Bhardwaj, 2019; Gall et al., 2007). Punch (2005) recommends that sampling decisions consider various factors, such as the settings, processes, and events to be observed, as well as the people to be interviewed. According to Creswell and Poth (2018), the selection of individuals and sites for study should be purposeful and should inform an understanding of the research problem and phenomenon being studied.

The research was conducted in three South African, Afrikaans-medium, middle-class governmental primary schools located in the Tshwane North district of the Gauteng province. The study was carried out in an authentic learning environment where no logistical changes were made for the purpose of the research. Instructional time was not compromised since the integrated music-mathematics lessons were implemented during the scheduled Mathematics classes over a period of nine weeks. The integrated lessons were designed to include mathematical concepts such as length, time, and symmetry, which were prescribed by the Annual Teaching Plan (ATP) (Department of Basic Education, 2022) for term three.

In this study, purposeful sampling was used to select six generalist teachers with no prior experience in music-mathematics integration, who taught Grade 4 mathematics. These teachers were chosen because they demonstrated interest in the topic and willingness to participate (Dörnyei, 2007), and their participation was expected to provide the most relevant information for this research (Leedy & Ormrod, 2021). To protect the identity of these six participants pseudonyms were used. The participants were: in school A, Amy and Marlise; in school B, Divan and Naylene; and in school C, Naylene and Sebastiaan.

3.4.2 Data Collection Plan

The data collection plan for this study comprised four phases. In Phase 1, existing literature and South African policy documents were analysed to examine pedagogical principles and teaching strategies, which were then used to design the integrated music-mathematics lessons. The policy documents used in this study were obtained from the public online domain and included the National curricula for Life Skills, including Music (Department of Basic Education, 2011b), and Mathematics (Department of Basic Education, 2011c) in the Intermediate Phase. These curricula are part of the Curriculum Assessment Policy Statements (CAPS), which serve as the policy framework for learning and teaching in South African schools. Phase 1 concluded with semi-structured interviews conducted with the participating generalist teachers before the integrated music-mathematics lessons were implemented. The objective of these interviews was to gather the teachers' opinions and values concerning the teaching of Mathematics and to explore their personal perspectives on the integration of music and mathematics. The aim was to investigate their conceptual understanding of both subjects. Additionally, the researcher shared the created integrated music-mathematics lesson plans and engaged in discussions with the participants, addressing any questions or concerns they had about the teaching plans.

During Phase 2, the researcher conducted three series of four integrated music-mathematics lessons (see Table 2 and Appendix F) for three consecutive weeks at each of the three participating schools. During these sessions, the two generalist teachers who agreed to be participants (see Section 4.3.1) observed these lessons at each school. The first series of lessons focused on the concept of length, the second series on the concept of time, and the third series on the concept of symmetry. During these lessons, each participating generalist teacher observed the sessions individually. After the first week of lesson presentations, the researcher conducted individual meetings with the participants. These meetings aimed to offer guidance and support to the teachers in incorporating music into their own mathematics lessons.

In phase 3, the participant teachers (see Table 2 and the introduction to participants in Section 3.4.1) from each school delivered the integrated music-mathematics lessons to their own Grade 4 class. The researcher observed the learning experience, taking field notes and recording videos (see Appendix A: Ethics approval) of the participating teachers during the lessons. This process allowed for a comprehensive documentation of the teaching and learning process, providing valuable data for further analysis and evaluation.

Phase 4 involved conducting semi-structured individual interviews with all the participants following the delivery of the integrated music-mathematics lessons and their assessment of learner understanding (see Appendix D). The interviews, detailed in Appendix C (Phase 1) and Appendix D (Phase 4), aimed to gather valuable insights into the teachers' perceptions and experiences of integrating music and mathematics for conceptual understanding. During phase 4, the researcher also addressed any new questions raised by the participating teachers regarding the content or methodology of the integrated music-mathematics lessons. These interactions provided an opportunity to explore further aspects of the integration process and gain deeper understanding from the teachers' perspectives. Audio recordings were made during the interviews, and subsequently, transcriptions were created for the purpose of thorough data analysis. The data collected during these interviews served to complement and expand upon the participants' experiences during the integrated music-mathematics lessons, providing valuable insights for the study.

Table 2 illustrates the research cycle used in this study to collect data:

Table 2

The Research Cycle for Data Collection

Data collection strategies
Phase 1: Pre-implementation phase **Document analysis**
Pedagogical principles and teaching strategies, derived from existing literature and South African Department of Education policy documents, was analysed to design integrated music-mathematics lessons.
Semi-structured interviews
Each participant teacher underwent a semi-structured individual interview (see Appendix A, Schedule 1) conducted by the researcher at a time and place convenient for the participant. The interviews lasted approximately 40 minutes each and were audio-recorded and transcribed for data analysis purposes. The purpose of these interviews was to gather participants' opinions and values regarding teaching Mathematics and to explore their personal perspectives on the enhancement of mathematics through music, with the goal of investigating the conceptual understanding of both subjects. The researcher also shared the lesson plans created and engaged in discussions with the participants, addressing any questions or concerns they had regarding the lesson plans.

<table>
<tr><th colspan="2">Phase 2: Implementation phase

Researcher facilitates music-integrated lessons</th></tr>
<tr><td></td><td>The researcher presented four integrated music-mathematics lessons (Chapter 4) at each of the three participant schools.

School A:
Mathematical concept: Measurement: Length

School B:
Mathematical concept: Time

School C:
Mathematical concept: Symmetry</td></tr>
<tr><td>School A, B, and C
Week 1, 4, and 7</td><td>The researcher conducted integrated music-mathematics lessons targeting two Grade 4 classes at School A, B, and C. Each participating generalist teacher observed the lessons separately. Following the completion of the first week of these presentations (weeks 1, 4, and 7), the researcher held individual meetings with the participants, providing them with guidance and support on incorporating music into their own mathematics lessons.</td></tr>
<tr><th colspan="2">Phase 3: Participant teachers facilitate music-integrated lessons</th></tr>
<tr><td>Weeks 2, 5, and 8
(Teacher A of each school)

Weeks 3, 6, and 9
(Teacher B of each school)</td><td>In each school, the participating teachers conducted the integrated music-mathematics lessons previously presented to a Grade 4 class. The researcher observed the learning experience, took field notes (see Appendix E), and recorded videos (see Appendix A: Ethics approval) of the participating teacher during the lessons.</td></tr>
</table>

Phase 4: Semi-structured interviews	
End of weeks 3, 6, and 9	Following the delivery of the integrated music-mathematics lessons by the participants and their assessment of learner understanding a semi-structured individual interview was conducted with all the participant teachers. The interview schedule can be found in Appendix D. Throughout this stage, the researcher addressed any new questions raised by the participant teachers regarding the content or methodology of the integrated lessons. These interactions potentially provided valuable insights into the participants' perceptions of the enrichment of mathematics with musical elements for conceptual understanding. The data collected during each interview aimed to corroborate and elaborate on the participants' experiences during the integrated music-mathematics lessons. Each individual interview with the participant teachers lasted approximately 60 minutes. To minimise disruptions to the participants' schedules, the interviews were conducted after school hours. Audio recordings were made during the interviews and subsequently transcribed for the purpose of data analysis.

3.4.3 Forms of Data

Qualitative research involved using a range of data collection techniques that drew from multiple sources, including observations, interviews, and documents (Yin, 2018). In this study, these methods were employed and explained in detail to provide a comprehensive understanding of how music can enhance mathematics in primary school classrooms. The data collection methods used in this case study are presented in Table 3.

Table 3

Data Collection Strategies

Data instrument	Representative	Action	Objective	Contribution to answering research questions
Observations	Participants	The participants observed the researcher teaching integrated music-mathematics lessons.	To collect real-time data on the strengthening of mathematics through the infusion of musical elements in the participants' primary school classrooms.	How do the participating generalist teachers implement music-mathematics integrated learning experiences in the Intermediate Phase?
	Researcher	The researcher observed and video-recorded the participating Grade 4 generalist teachers as they implemented their understanding of enhancing mathematics through music.	To gain a comprehensive understanding of the participant teachers' experiences and perspectives on the empowerment of mathematical concepts through musical applications.	How do the experiences of the participant generalist teachers reflect their understanding of constructive alignment as a design for strengthening mathematics through the infusion of musical elements.
Semi-structured interviews	Researcher Participants	The participants answered semi-structured interview questions on their beliefs, opinions, and views regarding their experiences of the integrated lessons, before and after the augmentation of mathematics through music.	To collect data from the participating generalist teachers regarding their observations of the lesson presentations. To collect data from the participants regarding their experience on their own presentations of the integrated music-mathematics lessons.	How can the participants' experiences contribute to the teaching and learning models used in the Intermediate Phase?

Field notes	Researcher	The researcher documented and commented on the physical setting, activities, and interactions of the participant teachers during their presentations of the integrated music-mathematics lessons.	Field notes allowed the researcher to document and comment on the physical setting, activities, and interactions of the participant teachers during their presentations of the integrated music-mathematics lessons. Field notes allowed for the collection of various types of information that participants might not be aware of or able to recall during interviews. Field notes enhanced the data by serving as detailed records of observations, interactions, and contextual nuances during the research process.	How do the participating generalist teachers in the Intermediate Phase experienced the enrichment of mathematics with musical elements. How do the participating generalist teachers comprehend conceptual understanding in Intermediate Phase music and mathematics?
Documents	Researcher	Pedagogical principles and teaching strategies were analysed from existing literature and South African policy documents.	Pedagogical principles and teaching strategies were analysed from existing literature and South African policy documents to design the integrated music-mathematics lessons.	The integrated music-mathematics lessons served as one of the fundamental components in addressing the research questions.

3.4.3.1 Observations. Henning et al. (2004) and Maxwell (2001) underline that participant observation is a research technique involving direct behavioural observation, offering firsthand evidence and deeper insights for investigating phenomena in case study research. This approach to data collection can also be used to enhance the credibility and effectiveness of the study by integrating information from multiple sources, as recommended by Carter et al. (2014). Therefore, in this study, participant observation was applied as a method of collecting real-time data on the enhancement of mathematics through music in primary school classrooms, as well as to obtain a comprehensive understanding of the participating teachers' experiences and perspectives.

During phase three (see Table 2), the researcher assumed the role of a participant-observer (Maree, 2020) and observed six generalist teachers as they implemented their knowledge of music-mathematics integrated lessons in their respective classes. As a participant-observer, the researcher collected data while being recognised by the participants being studied (Creswell & Creswell, 2018). The researcher documented observations and reflections on how the participants presented Intermediate Phase music-mathematics integrated learning experiences.

The researcher recorded observations using video recordings (see Appendix A: Ethics Committee Approval) and supplemented this with field notes to document data. This correlate with the assertion of Phillippi and Lauderdale (2017) that field notes are a fundamental element of rigorous qualitative research. The field notes not only played a critical role in data analysis but also enhanced the data (Creswell & Creswell, 2018). In this study, the field notes enabled the researcher, as a participant-observer, to document and comment on the physical setting, activities, and interactions of the participating teachers during their presentations of the integrated music-mathematics lessons. The data collected through field notes proved to be valuable during the analysis phase of the research, as it shed light on relevant issues (Ritchie & Lewis, 2013). The field notes also presented an opportunity to gather data during the integrated music-mathematics lessons and enabled the collection of various types of information that the participants might not have been aware of or able to recall during interviews (Morgan et al., 2017).

3.4.3.2 Interviews. Interviews are a vital data collection method in qualitative research and are frequently used to explore participants' perspectives, experiences, and meanings related to the research topic (Mason, 2002; Merriam & Tisdell, 2016). As a flexible and interactive tool, interviews allowed the researcher to delve deeper into participants' thoughts and feelings about a particular phenomenon and to generate new insights and knowledge. Interviews offered participants an opportunity to discuss their ideas and experiences in their own words, which was valuable for comprehending the context and complexities of the research topic. (Edwards & Holland, 2013; Ritchie & Lewis, 2013).

An essential aspect of qualitative research interviews is recognising the researcher as a research instrument (Denzin & Lincoln, 2017). Taking on the role of both researcher and interviewer, this position involved deploying expertise and competencies to gather intricate and meaningful data from the participating generalist teachers. This data included the participants' insights into the lesson presentations and their own experiences of delivering the integrated music-mathematics lessons.

The researcher conducted semi-structured individual interviews with the six participants to gather data. Semi-structured interviews were an appropriate data collection method as they allowed the generalist teachers to express their beliefs, opinions, and views regarding their experiences on the empowerment of mathematical concepts through musical applications.

According to Saunders et al. (2016), semi-structured interviews are not standardised but flexible and adaptable. By conducting semi-structured interviews, the researcher had the opportunity to prepare open-ended questions beforehand (see Appendix C and D) that were relevant for gaining insight and understanding (Ritchie & Lewis, 2013) into the phenomenon under study.

Using open-ended questions, a more natural conversation was facilitated with the participating teachers, allowing them to articulate their thoughts and experiences in their own words. The interview protocols (see Appendix C and D) served as a guide during the interviews, providing structure and direction to explore the generalist teachers' experiences.

Establishing trust with participants is essential in qualitative research as it encourages participants to provide honest and candid responses (Creswell & Creswell, 2018). The use of multiple data collection methods, including participant observation and semi-structured interviews, strengthened the validity of the study by triangulating the data and ensuring consistency of findings across different sources (Patton, 2015). Applying a variety of data collection methods enhanced the credibility and trustworthiness of the study's findings, providing a firm groundwork for drawing conclusions and making meaningful interpretations.

The researcher's openness to alternative perspectives and unexpected findings further bolstered the credibility and richness of the data in the study (Creswell & Creswell, 2018). Hence, the researcher's decision to conduct the study at different schools and employ diverse data collection methods exemplified a comprehensive and rigorous approach to qualitative research.

Two semi-structured interviews were conducted with each of the six participating generalist teachers at their respective schools. The first interview (see Appendix C) took place prior to the teachers' observation of the integrated music-mathematics lessons, while the second interview (see Appendix D) occurred after they had experienced the integrated lessons. Each interview had an average duration of approximately 40 to 60 minutes.

To gain insight into the teaching experience and background of each teacher, including their previous use of music for teaching and learning, the researcher posed a series of questions in a consistent order to every participant. The questions aimed to establish a baseline understanding and provide context for the subsequent discussions. Additionally, the researcher explained the research process to the participants before the implementation of the integrated music-mathematics lessons, fostering a shared understanding and facilitating meaningful exchanges.

3.4.3.3 Documentation. Documents are considered one of the primary sources of qualitative data in research, and their use has been highlighted as beneficial for various research purposes (Merriam & Tisdell, 2016). Previous studies have shed light on the significance of documents as a valuable data source, as evidenced by the following discussion.

Corbin and Strauss (2015) accentuate that documents provide a rich source of data that offers insights into a wide range of topics. Moreover, Bowen (2009) points out that documents are often easily accessible and obtainable at a relatively low cost, with many available online or through archives and collections, making them a convenient and cost-effective source of data (Taherdoost, 2021).

According to Bowen (2009), documents can contribute to the attainment of objectivity as they are frequently generated without the researcher's influence, thereby reducing researcher bias, and enhancing the accuracy of the data (Pannucci & Wilkins, 2010). Additionally, Sutton and Austin (2015) highlight that documents can be reviewed multiple times, allowing the researcher to conduct repeated analysis and gain a deeper understanding of the data, a process that can facilitate data triangulation and validate the findings using multiple sources of data (Merriam & Tisdell, 2016).

Documents used in this study to investigate the enhancement of mathematics through music in educational contexts included various educational policy documentation. These incorporated the Intermediate Phase Annual Teaching Plans (Department of Basic Education, 2022), the CAPS policy (Department of Basic Education, 2011a), as well as the policy documents related to music and mathematics (Department of Basic Education, 2011b, 2011c). These documents played a fundamental role in shaping the study's strategy for effectively integrating music and mathematics.

I extended my research efforts to include supplementary writings (Binkley et al., 2010; Department of Basic Education, 2018; Department of Education (DfE), 2022; OECD, 2009; OECD, 2019). By drawing insights from these resources, I aimed to ensure that the integrated lessons I developed were not only aligned with current educational standards but were also well-informed by forward-looking trends and perspectives in education.

3.5 Data Analysis and Interpretation

Qualitative data analysis involves the simultaneous collection and analysis of data with the aim of generating new insights and knowledge. According to McMillan and Schumacher (2010), there is no definitive or incorrect way to analyse data.

Different research questions and methodologies necessitate varying analytical techniques and methods (de Casterlé et al., 2012).

In the realm of academic research, it is imperative for researchers to thoroughly and thoughtfully determine the most fitting approach that supports their distinct research inquiries and contextual framework. According to Miles et al. (2020), data analysis plays a vital role in the research process as it involves systematically organising and interpreting data using diverse analytical techniques and methods to reveal patterns, themes, and relationships within the data. This process encompasses applying various techniques and methods such as coding, categorisation, and thematic analysis (Linneberg & Korsgaard, 2019). By using these approaches, researchers aim to uncover essential concepts, insights, and knowledge embedded within the data. Ultimately, the goal of data analysis in qualitative research is to produce novel perspectives and knowledge by extracting valuable information from the collected data (Ravitch & Carl, 2021).

In this study, the thematic analysis approach, as outlined by Braun and Clarke (2012), was employed as the methodology for examining, identifying, and illustrating recurring patterns. Thematic analysis was used as the method to analyse, identify, and describe repeated patterns (Braun & Clarke, 2012). Thematic analysis involves exploring collected data and representing the data through processes of assigning codes and generating themes (Kiger & Varpio, 2020). Braun and Clarke (2012), assert its significance as a primary method for data analysis in qualitative research. The qualitative data for this study included data collected from individual interviews, national curriculum documents, and observations.

In this research, I employed Braun and Clarke's (2012) six-phase framework for conducting thematic analysis. In Phase 1, I transcribed the semi-structured interviews, scanned, organised, typed, and prepared all data collected from observations, field notes, and documentation. Employing a visual approach, I used different colours to highlight recurring vocabulary, comments, ideas, phrases, and opinions. For Phase 2, I grouped the data into smaller categories and assigned codes to label these categories. Relationships were identified by comparing and contrasting the colour-coded elements, and insights were transferred onto small, coloured cards. These cards formed the basis for Phase 3, where I systematically sorted the relevant data into broad main themes, acknowledging potential overlap and contributions to more than one theme. In Phase 4, I conducted an in-depth review of the identified themes, refining, combining, or separating them as necessary. Moving to Phase 5, sub-themes began to emerge within the data, prompting further refinement and categorisation of the cards into smaller, more specific categories. Finally, in Phase 6, I compiled and submitted the report, ensuring it incorporated evidence closely aligned with the research questions.

My objective during the data analysis phase in this study was to comprehend the Intermediate Phase participating teachers' experiences with active integrated music-mathematics teaching and learning. To achieve this, thematic analysis was employed, actively constructing meanings that accurately described the data and upheld the reliability and credibility of the findings and explanations, as advocated by Kiger and Varpio (2020).

3.6 Ensuring Validity and Reliability

Saunders et al. (2016) explain the importance of validity and reliability in ensuring accurate research results. Validity, as defined by McMillan and Schumacher (2010, p. 407), “refers to the degree to which the interpretations and concepts have shared meanings between the participants and the researcher”.

Similarly, Silverman (2010) views reliability as the consistency of research findings, free from unexpected events.

Joppe (2000) defines reliability as the consistency of a measure and its ability to accurately depict the entire population under study. Additionally, Bogdan and Biklen (2007) suggest that a study is reliable if the same results can be consistently obtained using a similar methodology. To enhance the credibility and validity of the research findings, the researcher employed a triangulation approach, utilising multiple sources of data and qualitative data collection strategies for gathering, analysing, and interpreting data (De Vos et al., 2011; Johnson, 2017).

Cross-verification of findings, as a triangulation strategy, was employed to reduce the risk of bias and provide a more comprehensive understanding of the research phenomenon. Recognising my position as a researcher played a pivotal role, preventing misinterpretation of participants' intended messages. To ensure accuracy and reliability, member checking, also referred to as participant validation, involved providing participants with transcripts to verify the portrayal of their experiences and understandings (Creswell & Creswell, 2018).

Addressing a potential reliability problem in the sequence of teaching lesson plans, observations, and interviews, the researcher implemented a multi-step approach. Providing uniform instruction on lesson plans, observing participants in actual classroom settings, and conducting semi-structured interviews using the same questions in the same order sought to establish a comprehensive and reliable evaluation process.

3.7 Ethical Considerations

In educational research, human subjects are often the primary focus, and therefore, researchers have a moral obligation to ensure the protection of participants' rights and privacy (McMillan & Schumacher, 2010). Ethical concerns can arise from the treatment of individuals before, during, and after the research process (Walliman, 2018).

In this study, the researcher obtained ethical clearance from both the University of Pretoria Research Ethics Committee (Appendix A. Reference number: HUM19/0422) and the Gauteng Department of Education (Appendix B). The principals of the respective schools also gave permission for the study to be conducted at their schools (see Appendix I). These steps were taken to ensure that ethical considerations were properly addressed and that the rights and privacy of the participants were protected.

Throughout the course of this study, ethical considerations were meticulously considered. All participants were informed (see Appendix G) about the research purpose and method before obtaining their written consent (see Appendix H) to participate. Participants were not obligated to participate and had the right to withdraw from the study at any time without providing a reason. The researcher ensured that the dignity of each participant was respected, and that all information provided during the interviews was treated with strict confidentiality. All names used in the findings and discussion are pseudonyms to protect the identity of the participants.

Confidentiality was maintained throughout the study, and upon completion, all documents will be stored in a password-protected format at the School of the Arts: Music, for a minimum of 15 years before being destroyed. The researcher ensured honesty and did not mislead respondents at any stage of the research. To prevent bias in data analysis, the participants were given the opportunity to review the research results. Triangulation of data sources was used to establish credibility and the findings were reviewed with the study supervisors.

3.8 Conclusion

In this chapter, the researcher provided a description of the research design, methodology, and process that were followed in the investigation. The use of a case study research design enabled a thorough exploration of the topic by drawing on multiple sources of data. This approach led to an in-depth understanding of the enhancement of mathematics through music. The use of policy documents, classroom observations, and interviews provided rich data that allowed for a nuanced analysis of the research topic.

The research design and methodology were influenced by the researcher's specific lens, social constructive alignment, which guided the researcher's perspective on the phenomenon under investigation namely, how generalist teachers in the Intermediate Phase experience teaching and learning mathematics through music integration. These choices were deemed the most appropriate approach for addressing the research questions. The researcher also outlines the strategies employed for data collection, the instrumentation used, the methods for data analysis, and the steps taken to ensure research rigor. This was followed by a concise description of the methods employed to ensure trustworthiness and uphold ethical considerations. The subsequent chapter will offer a detailed overview of the integrated music-mathematics lessons that formed a fundamental component of this study.

Chapter 4: Integrated Music-Mathematics Lessons

4.1 Introduction

This chapter introduces the integrated music-mathematics lesson plans that were designed for this research study. To structure the integrated music-mathematics lessons, the researcher analysed pedagogical principles and teaching strategies from existing literature and policy documents in South Africa. These lesson plans were carefully planned and played a vital role in the overall research.

The researcher employed Biggs' (2014) constructive alignment framework to design integrated teaching and learning experiences that combined music and mathematics. Choosing constructive alignment ensured a systematic and intentional approach to teaching. This approach facilitated the alignment of learning objectives, teaching methods, and assessment strategies, fostering a cohesive support system for learners' understanding and application of the content. The framework served as a guide for creating purposeful and integrated learning experiences, promoting effective and meaningful learning outcomes.

Furthermore, the incorporation of 21st-century skills used in the lesson plans aimed to equip learners with essential competencies for success in the modern world. These skills were strategically integrated to prepare learners for thriving in a rapidly evolving and technologically advanced society. By emphasising 21st-century skills, the lesson plans aimed to foster well-rounded and adaptable individuals capable of meeting the challenges of the contemporary landscape. Table 4 illustrates examples of the 21st-century skills employed in the integrated music-mathematics lessons.

Table 4

Examples of 21st-Century Skills Applied in the Integrated Music-Mathematics Lessons

Skills for 21st-century teaching and learning	Example in the integrated music-mathematics lessons
Active learning	Time Lesson 3 Learners modify the tempo of a song by performing it at a slower or faster pace while maintaining a steady beat.
Creativity	Symmetry Lesson 3 Learners take turns in their groups to write a mirror image and form a short melodic phrase.
Innovation	Measurement Lesson 2 Learners use the guidelines provided to plan and construct their own pan flute.
Self-direction	Measurement Lesson 2 Learners explore solving application problems that involve units of length and expand their understanding of the relationship between the various lengths of the straws and the difference in musical pitch.
Integrity	Measurement Lesson 3 Learners acknowledge and value the contributions of each team member during collaborative work.
Persistence	Measurement Lesson 2 Learners demonstrate persistence by successfully completing the construction of a pan flute, overcoming challenges, obstacles, and setbacks along the way.
Critical thinking	Measurement Lesson 2 Learners demonstrate their understanding of the difference in pitch by composing their own melody.
Meta-cognitive skills	Measurement Lesson 2 Learners exhibit metacognitive skills through the formulation of a strategic plan and organisation of resources to address the challenge of designing and constructing a pan flute.
Analysis	Time Lesson 2

	Learners compare *The Syncopated Clock* to *The Little Prince - Equation* by analysing the musical qualities of each piece.
Interpretation	Measurement Lesson 2 Learners define the term *pitch* in their own words.
Problem-solving	Measurement Lesson 2 Learners engage in discussions and collaboratively solve the problem of manipulating the pitch of a sound using various lengths of straws.
Logical reasoning	Time Lesson 2 Learners engage in a class discussion about how tempo can affect our emotions.
Decision making	Symmetry Lesson 4 Each group decide how to arrange the shapes on the paper plate, ensuring that the pattern exhibits symmetry.
Communication	Measurement Lesson 1 Learners listen to *Sabre Dance*, identify, and discuss the contrast in length, between legato and staccato notes.
Active listening skills	Symmetry Lesson 1 Learners demonstrate their understanding of symmetrical rhythms through active listening and analysis.
Collaboration	Measurement Lesson 1 Learners collaboratively decide where to incorporate legato and staccato articulations on the sheet music of *Happy Birthday.*
Teamwork	Measurement Lesson 3 Learners collaborate to generate a list of different measuring tools that can be used to measure the length of objects.
Negotiation	Time Lesson 4 Each group creates a mind map to demonstrate their comprehension of analogue time.
Conflict resolution Flexibility Adaptability	Measurement Lesson 3 Groups identify three short objects and three long objects in or around the classroom. Collaboratively, the group members must measure the objects using the appropriate metric unit and record

	the measurements, as well as the tool they used to measure, on the assignment paper.
Curiosity	Time Lesson 3 Learners construct an analogue clock using provided materials.
Reflection	Measurement Lesson 1 Learners reflect on their own performance of *Happy Birthday* and identify areas for improvement.
Lifelong learning	Time Lesson 2 Learners explore the concepts of seconds, minutes, and hours and their practical applications in daily life.

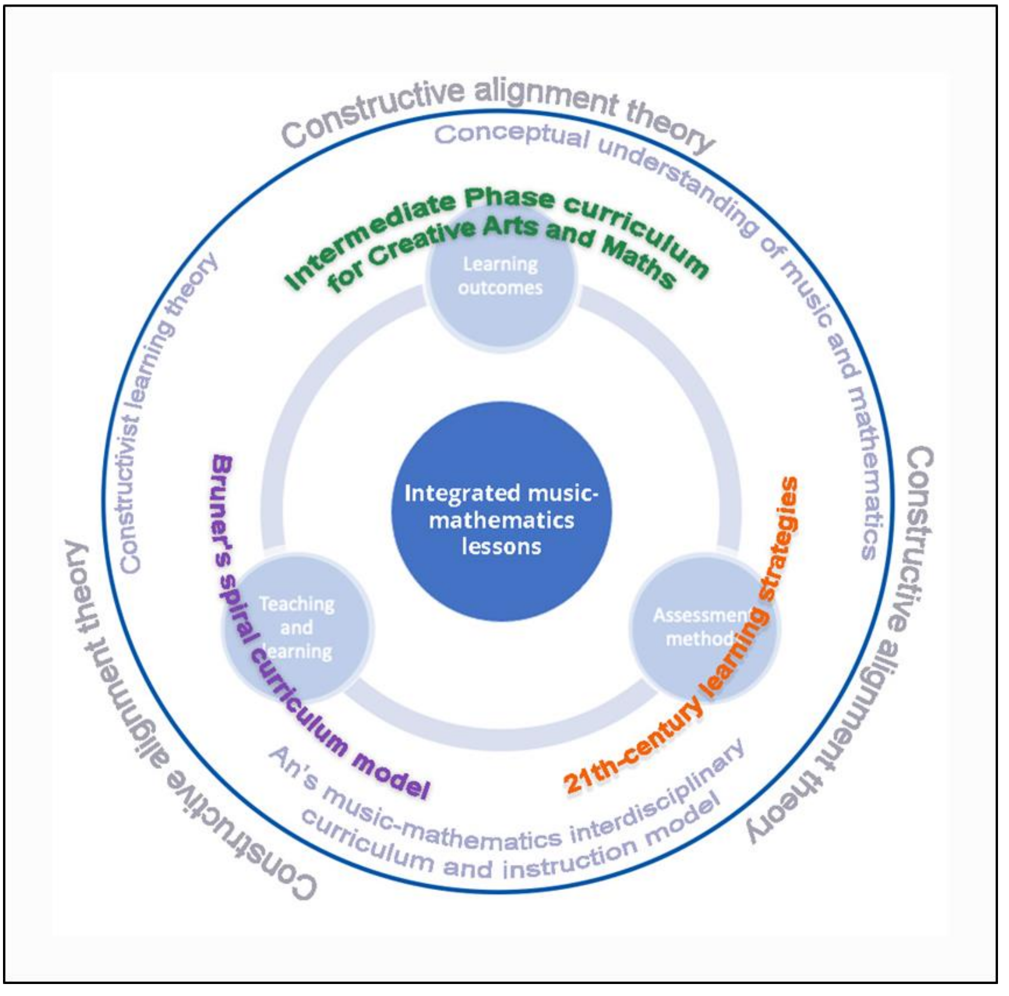
The policy documents used in this study were sourced from the publicly available online domain. They included the Annual Teaching Plans (ATP) for the Intermediate Phase (Department of Basic Education, 2022), as well as the South African Intermediate Phase curriculum for Life Skills, which incorporates Music (Department of Basic Education, 2011b), and Mathematics (Department of Basic Education, 2011c). These documents form an integral component of the Curriculum Assessment Policy Statements (CAPS), serving as the overarching policy framework for learning and teaching in South African schools. The integrated music-mathematics lessons were designed to highlight the mathematical concepts of length, time, and symmetry, as outlined in the CAPS policy document for Grade 4, Term 3. The selection of these specific concepts was not arbitrary; it adhered to the prescribed curriculum. These outcomes served as the foundation for designing the lessons, considering the cognitive abilities of the Grade 4 learners.

The researcher carefully selected teaching and learning activities that promoted the enrichment of mathematics with musical elements. While structuring the lessons, I incorporated my own creative elements into the music-mathematics lessons, ensuring alignment with the prescribed descriptions in the CAPS document. These activities aimed to empower learners through active participation in hands-on tasks and facilitated meaningful discussions. The activities were carefully designed to ignite curiosity and foster an enjoyable learning experience for Grade 4 learners. They were specifically tailored to establish connections between classroom concepts and real-life contexts, enabling learners to grasp the practical applications of their studies. Moreover, the lessons integrated 21st-century teaching and learning skills (see Section 2.4 and Table 1), equipping learners with essential competencies vital for success.

To ensure consistency between the teaching activities and the intended learning outcomes, systematic assessments were integrated into the lessons. The assessments were designed to measure the learners' understanding of music and mathematics concepts, as well as their ability in applying these concepts in practical contexts. Additionally, I adjusted the assessment methods to correspond with the developmental stage of Intermediate Phase learners, ensuring that the assessments accurately mirrored their abilities. By embracing the principles of constructive alignment, the researcher ensured that the integrated music-mathematics lessons offered meaningful and enriching learning experiences for the learners. This approach ultimately enhanced their understanding and mastery of the concepts, facilitating their overall growth and progress. The design of the integrated music-mathematics lesson plan is illustrated in Figure 2.

Figure 2

Integrated Music-Mathematics Lesson Plan Design



To create an integrated learning experience that merges music and mathematics, the implemented activities embraced 21st-century learning methods. These strategies encompassed active learning, critical thinking, collaboration, problem-solving, creativity, and reflection. By incorporating these teaching and learning approaches, integrated music-mathematics lessons were enriched, fostering a deeper level of understanding among the learners. Engaging in these activities enabled learners to develop essential skills and competencies that are valuable in the modern world.

The instruction model proposed by An et al. (2013) guided the integration of music and mathematics lessons. This model served as a framework for designing and implementing integrated music-mathematics lessons, with the intention of fostering meaningful and purposeful learning. The study aimed to integrate music and mathematics in an authentic and engaging manner, with the goal of facilitating deep and lasting learning experiences for both teachers and learners.

Furthermore, the design of the integrated lessons incorporated Bruner's (1960) spiral curriculum. This concept emphasises the interconnection between thinking and reasoning, as learners construct knowledge actively through their own experiences. The lessons were designed to build upon learners' prior experiences and understanding, enabling them to actively participate in the process of knowledge discovery.

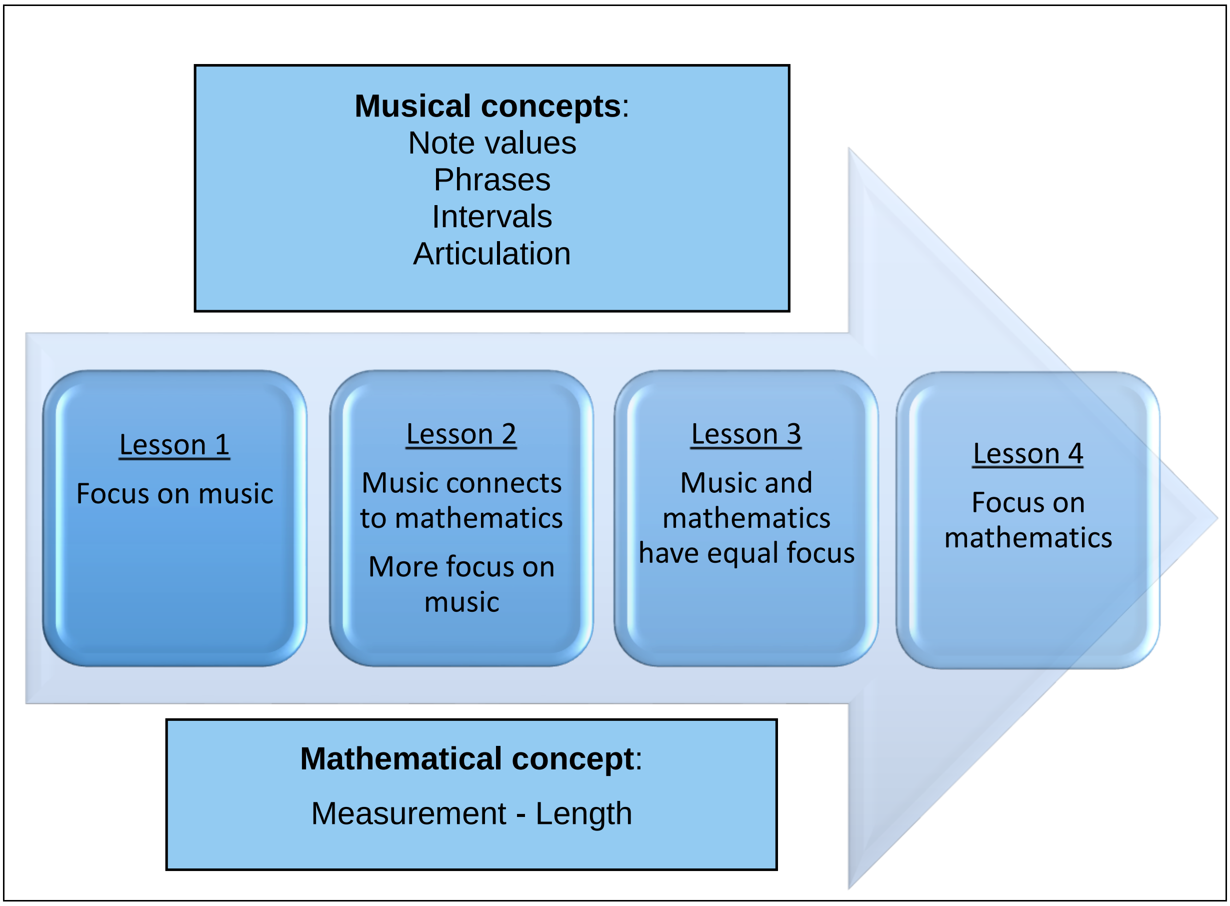
4.2 Intermediate Phase Integrated Music-Mathematics Lesson Plans

4.2.1 Mathematical Concept: Measurement

The relationship between the mathematical concept of measurement integrated with music is illustrated in the diagram below (see Figure 3).

Figure 3

Music-Mathematics Integration: Measurement



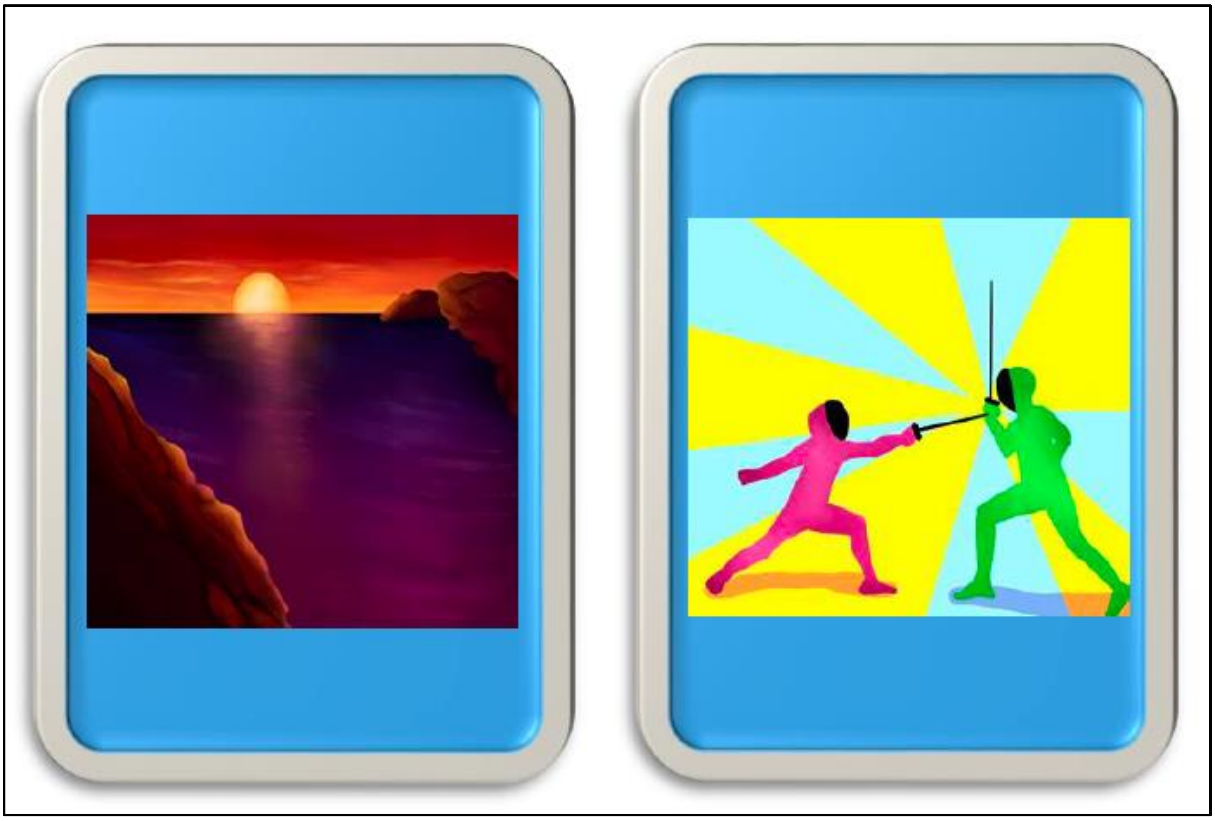
Unit of study: Measurement **Lesson: 1** **Focus of the lesson: Focus is on music**	
Materials Sheet music for the song *Happy Birthday* A recording of *Gayane Suite: Sabre Dance* by Khachaturian Posters illustrating legato and staccato. Each learner is provided with the following materials: • Two pencils • A scarf	
Prior knowledge The lesson assumes that learners have prior experience in: • Identifying and understanding how music notes are arranged on a music staff. • Identifying instruments of the symphony orchestra.	
Objectives To enhance learners' comprehension of the distinctions in length between legato and staccato notes in music, as well as the variances between low and high-pitched sounds	
Musical problems **Learners will** 1. listen to *Sabre Dance*, identify, and discuss the contrast in length, between legato and staccato notes, 2. listen to *Sabre Dance*, identify, and discuss high and low-pitch sounds, 3. improvise movements to *Sabre Dance* using two pencils and a scarf to experience the difference in length of legato and staccato notes in the music, 4. perform *Happy Birthday* using legato and staccato articulations.	**Assessment** **Learners should be able to** 1. listen to *Sabre Dance* to identify and discuss the difference between legato/staccato, articulations, and low/high pitch sounds, 2. identify and experience the difference in length between legato and staccato notes in music by improvising movements to *Sabre Dance*, 3. collaboratively decide where to incorporate legato and staccato articulations on the sheet music of *Happy Birthday*, 4. reflect on their own performance of *Happy Birthday* and identify areas for improvement, 5. reflect on the performances of other groups and provide constructive feedback.

<u>Problem-solving through active listening and improvising</u>

The learners engage in an activity where they listen to the recording of *Gayane Suite: Sabre Dance* by Khachaturian while simultaneously observing two posters that visually highlight the distinctions between legato and staccato (see Image 1). This activity helps them develop a better understanding of the differences in musical articulation and how it can be applied in the context of the piece they are listening to.

Image 1

Visual Representation of Legato and Staccato



The teacher facilitates a class discussion covering the following topics:

- Does the music sound consistent throughout the piece, or does it vary?
- What differences or contrasts can you perceive in the music? (Encourage connections to legato/staccato, soft/loud dynamics, and low/high-pitched sounds).
- Which of the two posters do you think best describes the style of the two sections in *Sabre Dance*, and why?

- Which section of the music do you think would be appropriate for incorporating scarf dancing? Can you explain your reasoning behind your choice?

The teacher puts the definition of legato and staccato to match the posters (see Image 2), reinforcing the understanding of these musical terms.

Image 2

Definition of Legato and Staccato

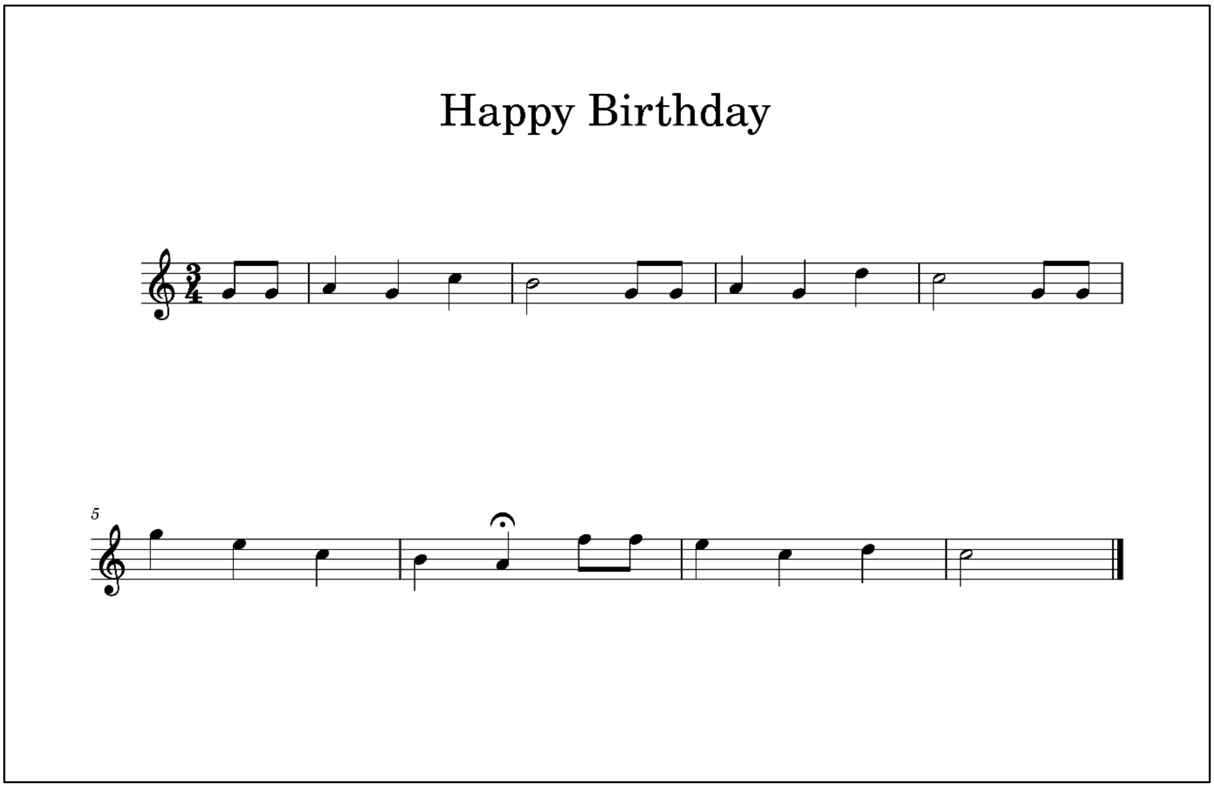
The teacher distributes two pencils and a scarf to each learner. The learners are instructed to stand up and participate in improvised movements, using the two pencils to symbolise staccato notes and the scarf to represent legato. They engage in these movements while listening to the music, allowing the music to inspire their movements and interpretations.

<u>Problem-solving through performing</u>

As part of the lesson, the class sings *Happy Birthday* together. Afterward, the teacher divides the class into small groups, with each group receiving the sheet music for *Happy Birthday* (see Image 3).

Image 3

Sheet Music of Happy Birthday



The learners will collaborate in their groups to determine suitable placements for legato and staccato notes within the song. They will mark these notes on their sheet music using personalised symbols or codes and practice singing *Happy Birthday* with the designated legato and staccato notes (see Image 4 and Image 5).

Image 4

Learner's Interpretation of Legato and Staccato (1)

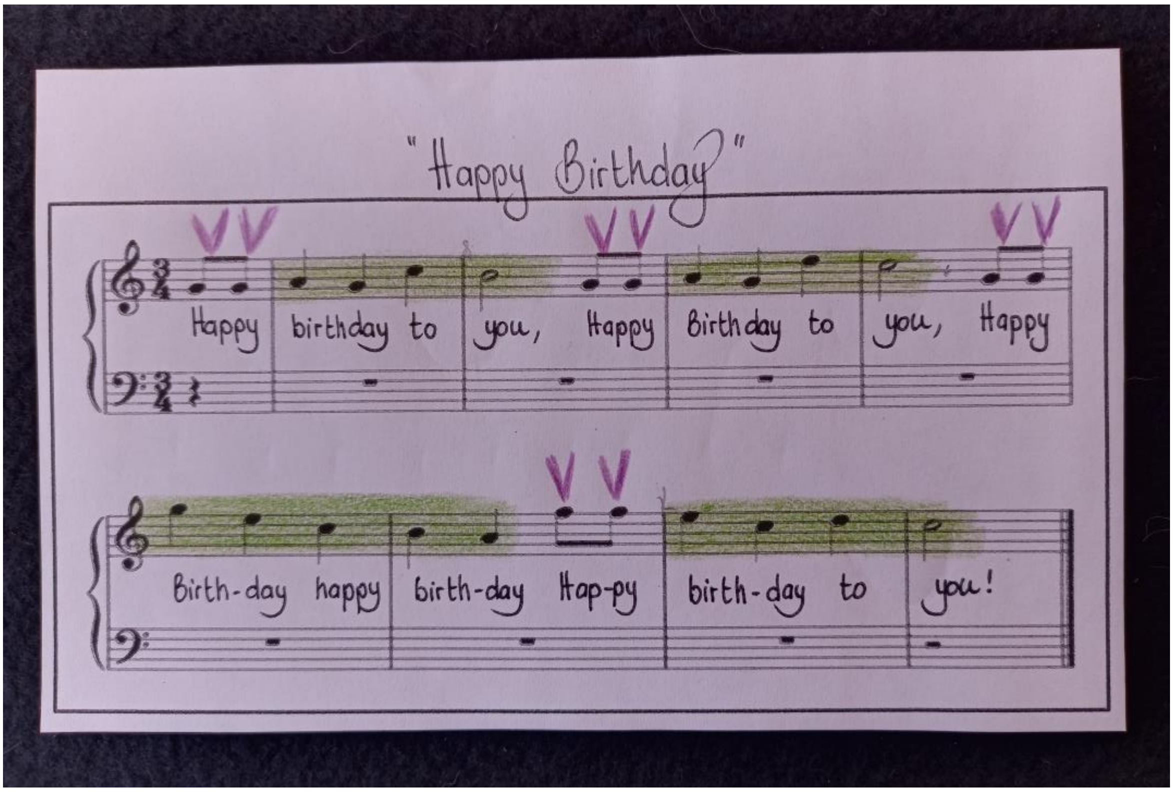


Image 5

Learner's Interpretation of Legato and Staccato (2)

Once the groups have rehearsed their versions of *Happy Birthday*, they will present their songs to the class, incorporating the indicated legato and staccato notes from their sheet music.

Following the rehearsals, the teacher will display posters that illustrate how real musicians signify legato and staccato notes on sheet music (see Image 6). These posters will provide visual examples and explanations to reinforce the understanding of legato and staccato techniques in music. The class will have the opportunity to discuss and compare their markings with the symbols and codes shown on the posters, further deepening their understanding of musical notation and interpretation.

Image 6

Legato and Staccato Symbols

Group discussion

In their groups, the learners are given a few minutes to reflect on their own performance, as well as the performances of other groups. They engage in discussions focusing on the following questions:

- Would you make any changes to your own group's performance? If so, what changes would you make and why?
- What aspects of your performance were successful? What areas could be improved upon?
- Which group's performance do you consider the most successful? What factors influenced your decision?

During the discussions, the learners share their perspectives and provide constructive feedback to each other. They consider elements such as coordination, dynamics, timing, musicality, and overall presentation. By analysing their own performance and observing other groups, they gain insights into different approaches and techniques, fostering a deeper understanding of musical interpretation and performance.

<table>
<tr><th>Unit of study: Measurement
Lesson: 2
Focus: Music connects to mathematics
More focus on music</th></tr>
<tr><td>Materials
<u>For each group:</u>
Sheet music of Sliding up and down
A card containing a problem-based question related to the lesson
Three straws of equal length to experiment with different sound pitches
<u>For each learner:</u>
A worksheet providing guidelines for designing and making a pan-flute
A worksheet for learners to create their own short composition
Six straws of equal length to create a pan flute
Sticky tape
An assignment paper
<u>In addition to the provided materials, each learner will need:</u>
Their own ruler</td></tr>
</table>

- A koki pen (marker or felt-tip pen)
- Scissors

Prior knowledge

This lesson assumes that learners have prior experience in the following areas:

• Identifying and understanding how music notes are arranged on a music staff (music).

• Identifying and understanding measurement in centimetres with a ruler (mathematics).

Objectives

- The objective of this lesson is to aid learners in understanding and identifying pitch in a music piece and to apply their knowledge of pitch by composing their own short melody,
- to assist learners in solving application problems that involve units of length, and to expand their understanding of the relationship between the various lengths of the straws and the difference in musical pitch (connecting concepts of music and mathematics).

Musical problems	**Mathematical problem**	**Assessment**
Learners will	**Learners will**	**Learners should be able to**
1. learn the song *Sliding up and down*, 2. identify and mark high and low sounds on the sheet music of *Sliding up and down*, 3. define the term *pitch,* 4. identify and discuss high and low sounds in everyday life, 5. experience and understand the relationship between the different lengths of straws and their effect on pitch, 6. compose a melody on their own pan flutes, following specific guidelines.	1. use the guidelines provided to plan and construct their own pan flute, 2. create a drawing plan of the pan flute, including the different lengths of the straws in centimetres, 3. exhibit metacognitive skills through the formulation of a strategic plan and organisation of resources to address the challenge of designing and constructing a pan flute.	1. identify high and low sounds on the sheet music of *Sliding up and down*, 2. create a list of high and low sounds in everyday life, 3. define the term *pitch* in their own words, 4. conduct an experiment, discuss the results, and answer questions related to the relationship between the length of the straws and the difference in pitch, 5. demonstrate their understanding of the concept of subtracting centimetres by measuring each straw to be 2.5 cm shorter than the others,

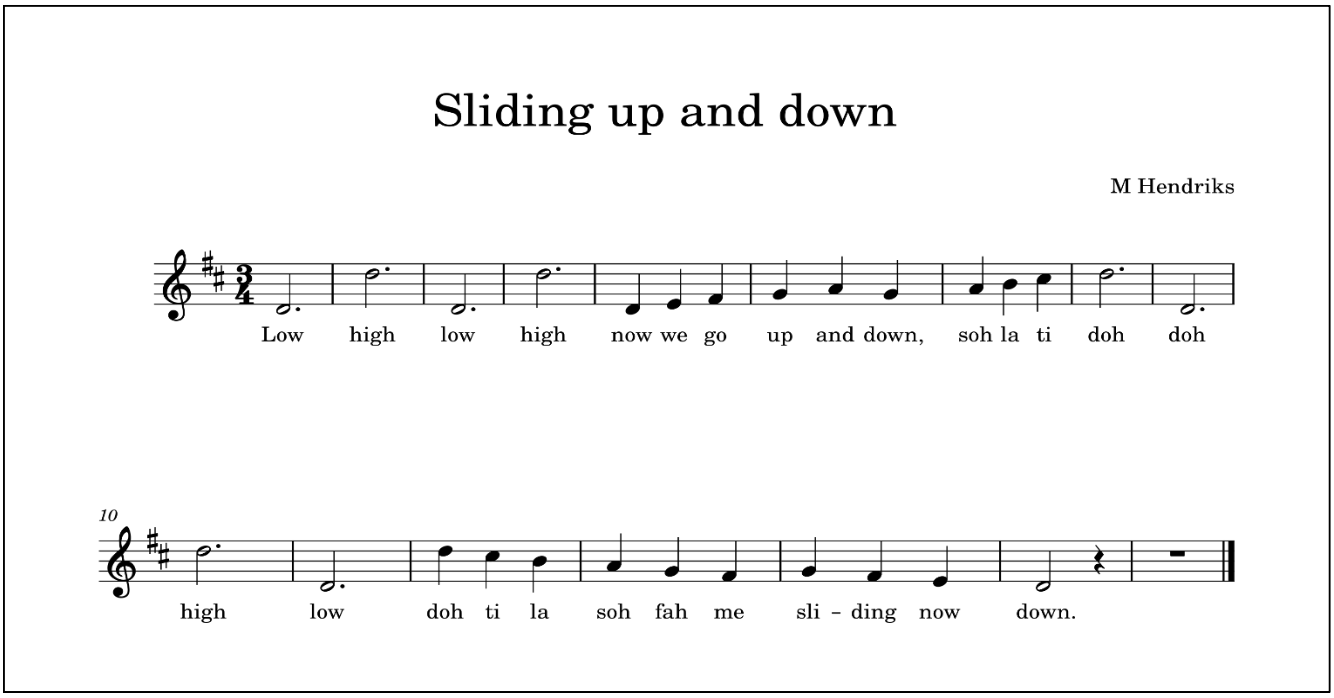
		6. demonstrate their understanding of different straw lengths by measuring them and constructing a pan flute, 7. demonstrate their understanding of the difference in pitch by composing their own melody, 8. use specific guidelines to demonstrate their understanding of musical elements by composing a melody, 9. demonstrate persistence by successfully completing the construction of a pan flute, overcoming challenges, obstacles, and setbacks along the way.

Problem-solving through singing and movement

The teacher guides the class in singing the song *Sliding Up and Down* (see Image 7). Once the song is finished, the learners disperse throughout the room and, while singing the song, actively engage in improvisation. They incorporate high and low movements, including skips and steps, and move forwards and backward in response to the music. The song is repeated multiple times to reinforce the activity and allow the learners to explore different ways of expressing the melodic motion through their movements. This activity combines music and movement, encouraging creativity and kinesthetic learning while deepening their understanding of the song's dynamics and structure.

Image 7

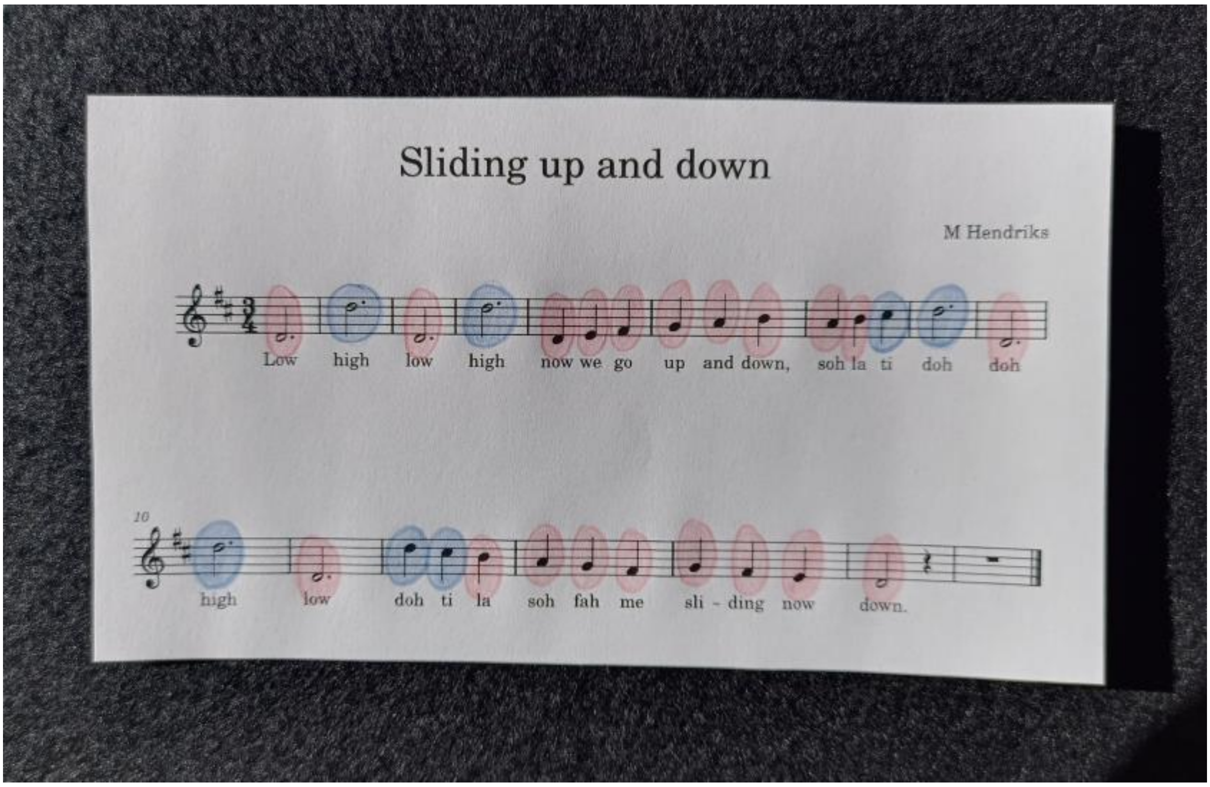
Sheet Music of Sliding Up and Down



The teacher arranges the learners into pairs and distributes the sheet music for the song *Sliding Up and Down*. Each pair also receives a blue and a red pencil. The learners sing the song twice at a slower tempo while actively listening for the high and low notes. As they sing, the learners use the blue pencil to colour or mark the high notes and the red pencil to colour or mark the low notes on their sheet music (see Image 8). This activity helps the learners visually identify and distinguish between the high and low notes in the song, reinforcing their understanding of melodic movement and improving their musical comprehension skills.

Image 8

Learner's Identification of High and Low Notes



Class discussion

- Which notes were marked with the blue pencil, and what was the reason for selecting those notes?
- Which notes were marked in red? How did you determine that those notes have a low sound?
- Let's delve into the concept of high and low sounds in our everyday environment. Can you think of any sounds that are high-pitched and low-pitched?
- What catches your attention about the melody in bars 5 to 8 and bars 12 to 15?

Problem-solving through exploring sound

Each group is provided with a card containing a problem statement (see Image 9) and three straws. The learners read and discuss the problem statement, considering the given question. Then, they proceed to cut the straws, experimenting with different lengths to produce various pitches. As they engage in this hands-on activity, the learners have discussions within their groups, sharing their observations and findings. They work collaboratively to collectively answer the question based on their experiments and the results they obtain. This activity encourages critical thinking, problem-solving, and the application of scientific principles in a practical context.

Image 9

Problem Statement: How Can the Pitch of a Sound be Manipulated Using Different Lengths of Straws?

Problem statement: How can the pitch of a sound be manipulated using different lengths of straws?	
Discuss the problem statement in your group before deciding on how to solve the problem. Write down any suggestions for solving the problem:	Our group's understanding of the problem statement:

Problem-solving through the application of new knowledge

For the next task, each learner will need the following materials: six straws, sticky tape, a ruler, a marker or felt-tip pen (koki pen), scissors, and a handout containing the assignment instructions (see Image 10). Individually, learners will design and construct their own pan flutes using the five straws, following the provided instructions. It is important to remember that each straw should be cut 2.5 cm shorter than the previous one.

Image 10

Learners' Assignment Instructions for Designing and Constructing a Pan Flute

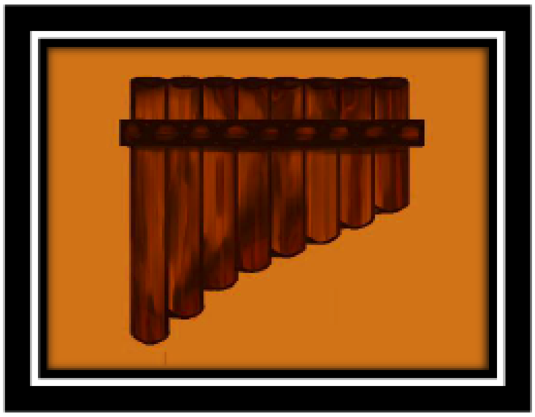
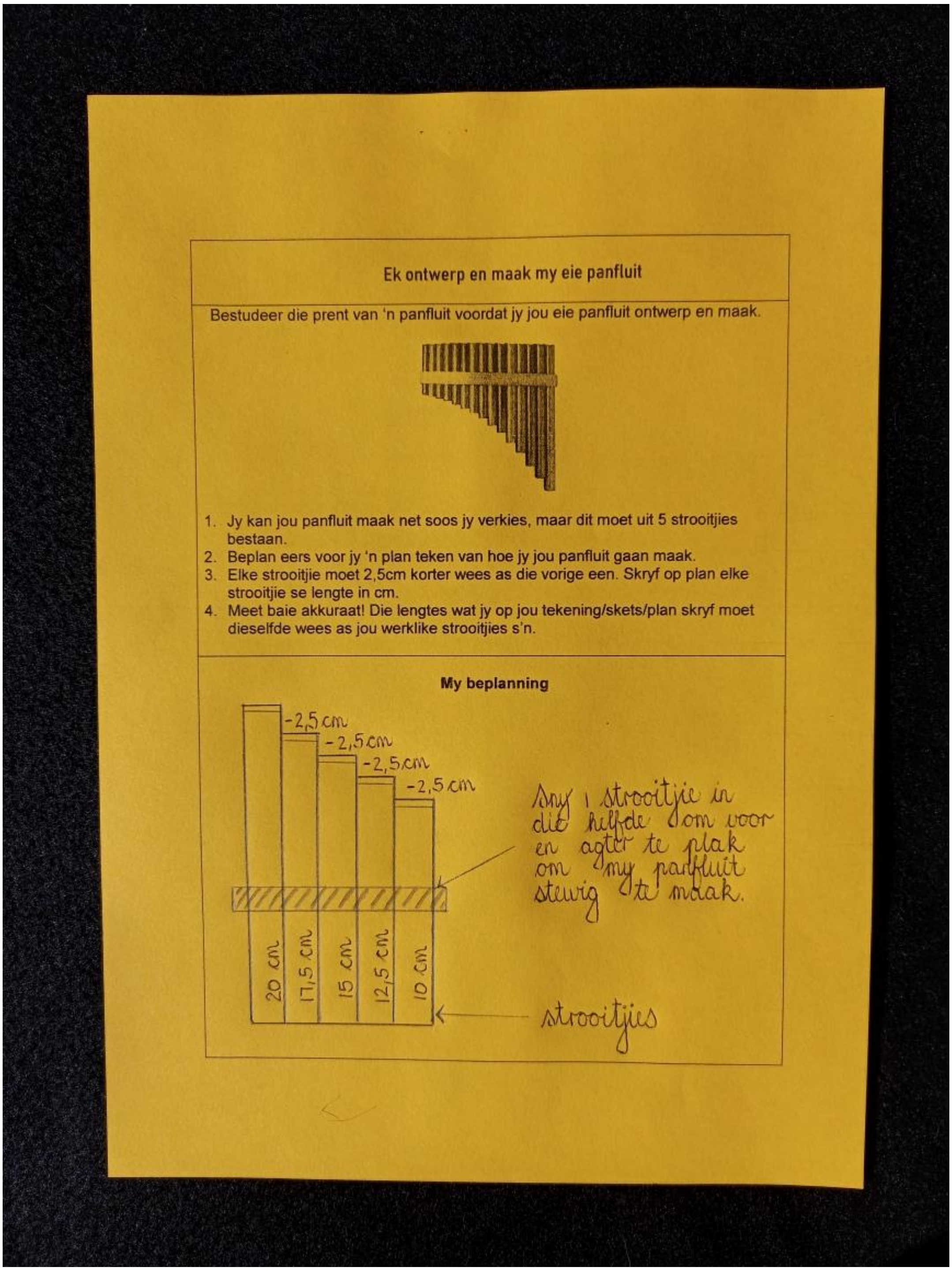
Design and construct my own pan flute	
Examine the provided image of a pan flute before proceeding to design and construct your own pan flute.  1. Ensure that your pan flute incorporates five straws, allowing for creative and unique designs. 2. Prior to creating a drawing plan for your pan flute, engage in a brainstorming session and organise your ideas effectively. 3. Remember that each straw should be 2.5 cm shorter than the previous one. Include the lengths of each straw in centimetres on your design plan. 4. Maintain precision while measuring, as the lengths indicated on your drawing plan should align with the actual lengths of the straws.	
My brainstorming ideas	**My design plan for my pan flute**

Image 11 showcases a design created by one of the learners to construct a pan flute, diligently following the provided instructions.

Image 11

Learners' Pan Flute Design


Ek ontwerp en maak my eie panfluit

Bestudeer die prent van 'n panfluit voordat jy jou eie panfluit ontwerp en maak.

1. Jy kan jou panfluit maak net soos jy verkies, maar dit moet uit 5 strooitjies bestaan.
2. Beplan eers voor jy 'n plan teken van hoe jy jou panfluit gaan maak.
3. Elke strooitjie moet 2,5cm korter wees as die vorige een. Skryf op plan elke strooitjie se lengte in cm.
4. Meet baie akkuraat! Die lengtes wat jy op jou tekening/skets/plan skryf moet dieselfde wees as jou werklike strooitjies s'n.

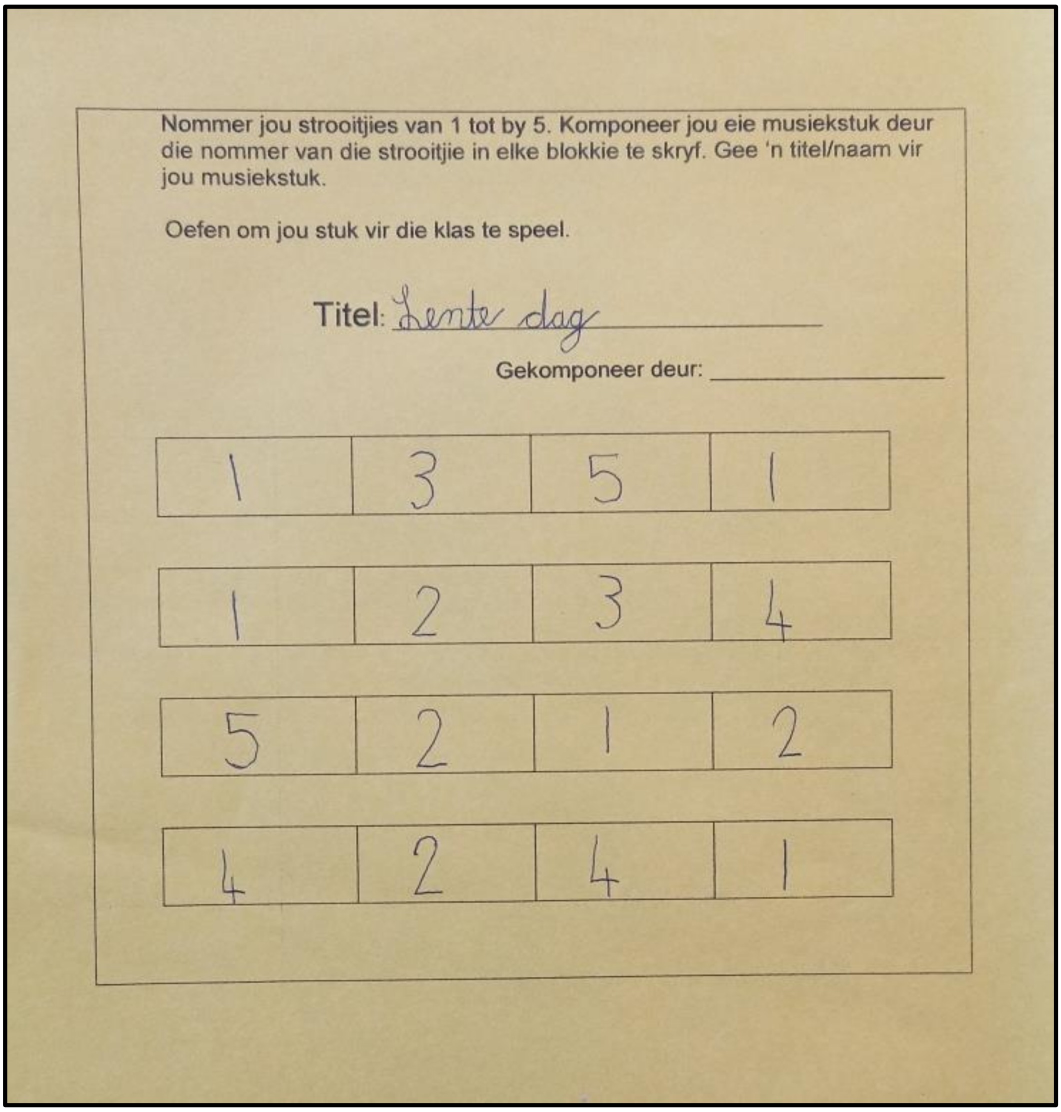
My beplanning

Problem-solving through composing

The learners number their straws from 1 to 5 with a marker. They compose their own music piece using the numbered straws. Each block represents a section of the piece, and they play the corresponding numbered straws as indicated in each block (see Image 12). Instruct the learners to give their composition a title that reflects its mood or theme. Once they have composed their piece, they practice it to prepare for performing it to the class.

Image 12

Learner’s Composition Using Their Pan Flute



Nommer jou strooitjies van 1 tot by 5. Komponeer jou eie musiekstuk deur die nommer van die strooitjie in elke blokkie te skryf. Gee 'n titel/naam vir jou musiekstuk.

Oefen om jou stuk vir die klas te speel.

Titel: Lente dag

Gekomponeer deur: ____________

1	3	5	1
1	2	3	4
5	2	1	2
4	2	4	1

Unit of study: Measurement Lesson: 3 Focus: Music and mathematics have equal focus		
Materials Each group will be provided with the following materials: The sheet music of *Happy Birthday* Rulers Pencils A variety of measuring tools		
Prior knowledge The lesson assumes that learners have the following prior knowledge: • They can identify various note values, including half notes, dotted half notes, quarter notes, and eighth notes. • They can recognise standard measuring tools and demonstrate their understanding of how to use these tools, particularly in the context of mathematics.		
Objectives • To strengthen learners' comprehension of note values and offer them hands-on practice in recognising half notes, dotted half notes, quarter notes, and eighth notes (music). • To support learners in selecting the appropriate measuring tools and applying the correct metric units to measure objects of different lengths (mathematics).		
Musical problems **Learners will**	**Mathematical problems** **Learners will**	**Assessment** **Learners should be able to**
1. identify and distinguish between the different types of music notes in *Happy Birthday*, including half notes, quarter notes, and eighth notes,	1. apply their understanding of measurement concepts to a new context, 2. collaborate to generate a list of different measuring tools that can be used to measure the length of objects, expanding their	1. demonstrate their understanding of the difference between half notes, quarter notes, and eighth notes in *Happy Birthday,* 2. explore the relationship between music and mathematical concepts,

2. identify and associate note value (length) with measurement in centimetres using icons.	knowledge of available measurement tools, 3. discuss and determine the most appropriate measuring tool(s) to measure objects of varying lengths, further developing their ability to select the appropriate tool for the task, 4. decide on the metric unit that will be used to measure objects of different lengths, reinforcing their understanding of metric units and their application in measuring objects.	3. select the appropriate measuring tool(s) for objects of varying lengths, demonstrating their ability to match the tool with the task at hand, 4. utilise the correct metric unit(s) for measuring long and short objects, further developing their understanding and application of metric units in measurement, 5. acknowledge and value the contributions of each team member during collaborative work.

Relating music note values to measurements of distance involves drawing an analogy between the temporal aspects of music and the spatial dimensions of distance.

Problem-solving through measurement

In their groups, the learners use the sheet music of *Happy Birthday*. They begin by identifying the different note values, including half notes, quarter notes, and eighth notes, presented in the song. The teacher introduces Image 13 to the learners where they can associate note value (length) with measurement in centimetres. Using the duration or length of each note as a reference, they proceed to create the first four bars of *Happy Birthday* (Image 14), using the icon representations in actual measurement (see Image 15). This activity combines musical notation recognition with measurement skills, allowing learners to explore the relationship between music and mathematical concepts.

Image 13

Guidelines and Icons for Learners in Representing the Numerical Length of Happy Birthday

Half note	Counts 2	2 cm
Quarter note	Counts 1	1 cm
Eighth note	Counts ½	½ cm or 0,5 cm

Image 14

Sheet Music of Happy Birthday for Measurement

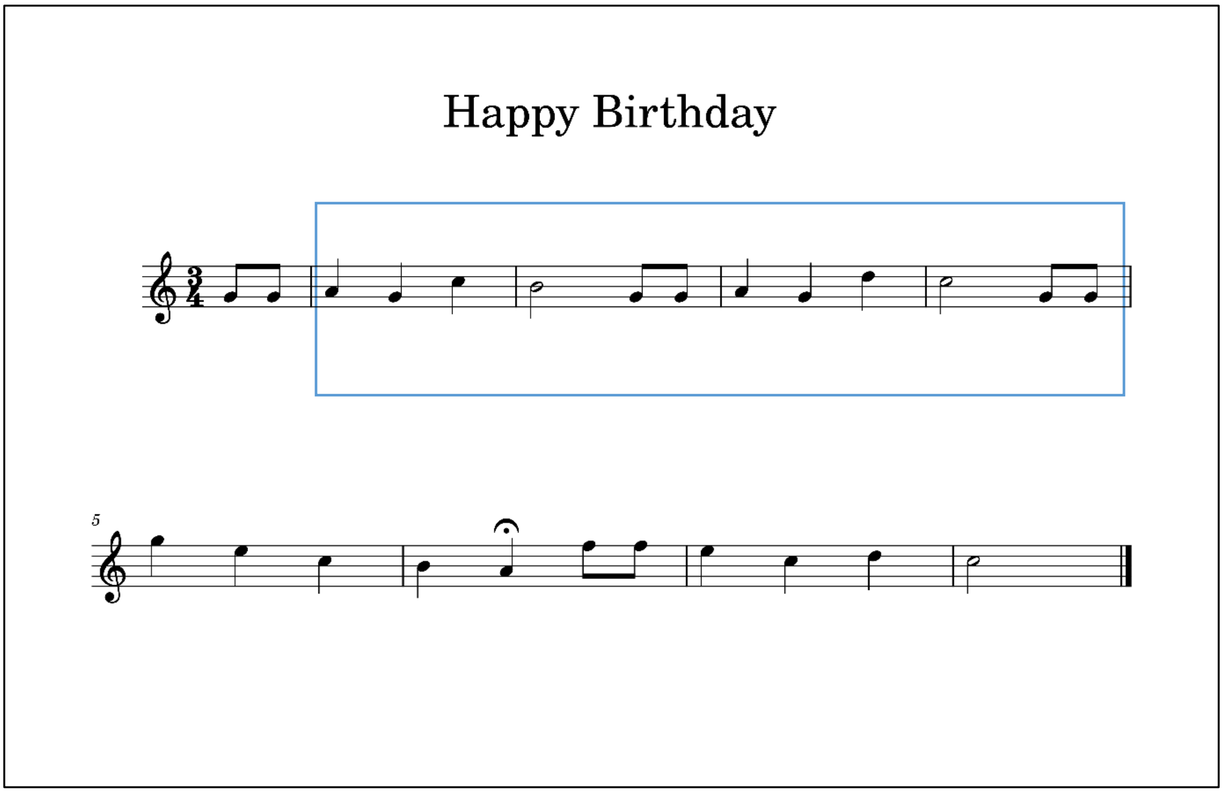
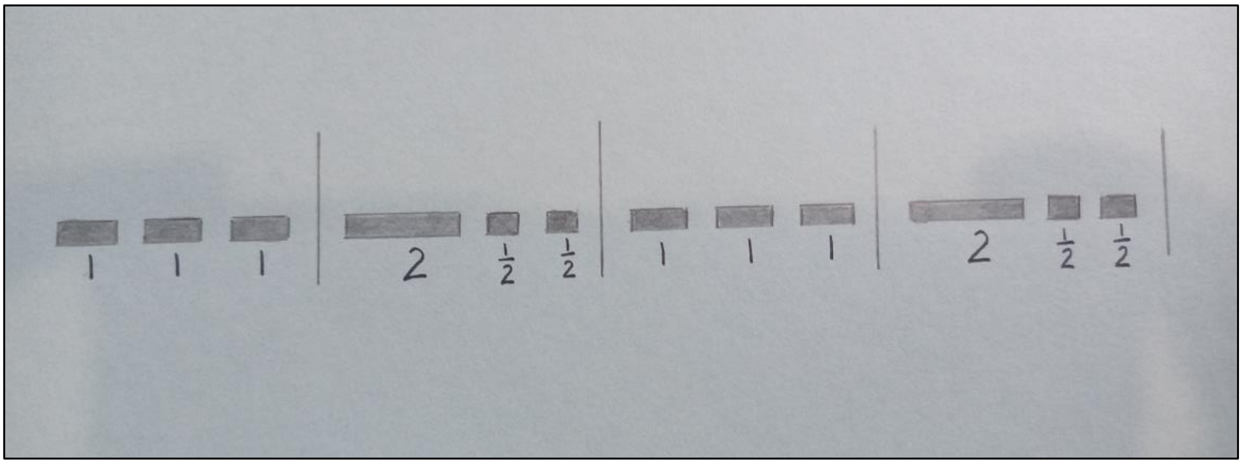


Image 15

Icon Representation of Note Values in Measurement of Distance



Problem-solving through inquiry

Class discussion

- Do we solely rely on rulers to measure objects in our daily life? What other tools can we use for measuring? In case we do not have access to a ruler or measuring tape, what other options do we have? Let's make a list of potential measuring tools.
- Based on the list, which tools are best for measuring short items, and which ones work well for measuring long items?

During the class discussion, the learners will explore alternative measuring tools beyond rulers. They will brainstorm and compile a list of potential measuring tools, considering various objects or methods they can use for measurement in their daily lives.

The teacher will divide the class into groups of four or five and distribute an assignment paper to each group (see Image 16). The assignment will involve identifying three short objects and three long objects in or around the classroom. The learners will be instructed to measure the objects using the appropriate metric unit and record the measurements, as well as the tool they used to measure, on the assignment paper. They will have 15 minutes to complete the assignment (see Image 17).

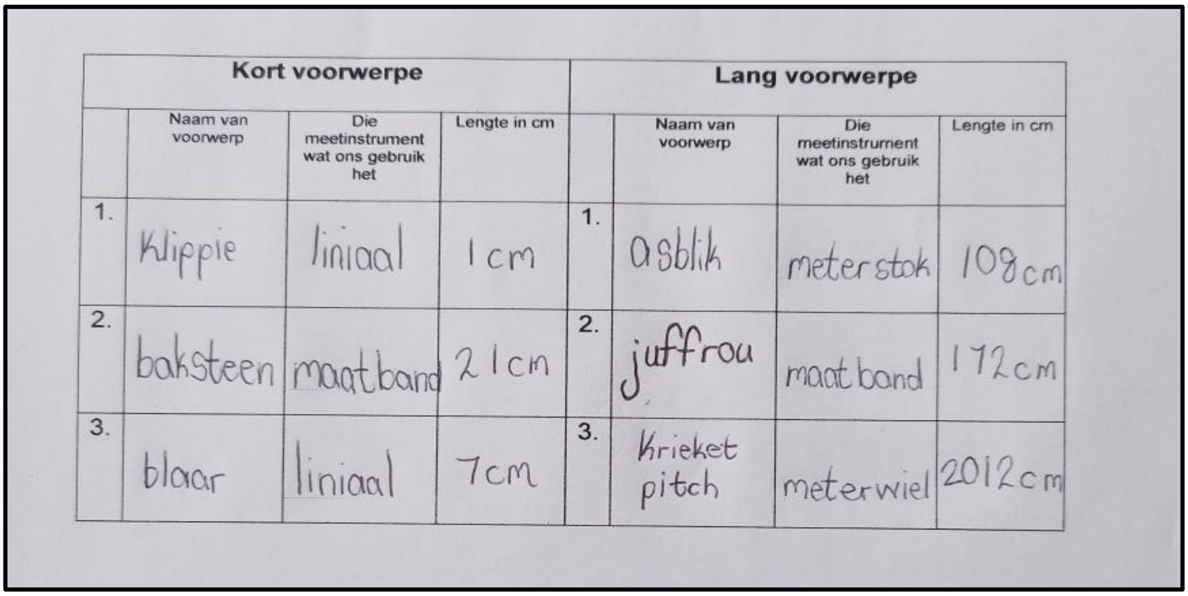
Image 16

Worksheet of Identifying and Measuring Short and Long Objects

Short objects				Long objects			
	Name of object	The measurement tool we used	Measurement		Name of object	The measurement tool we used	Measurement
1.				1.			
2.				2.			
3.				3.			

Image 17

Learner's Completed Worksheet for Identifying and Measuring Short and Long Objects



Kort voorwerpe				Lang voorwerpe			
	Naam van voorwerp	Die meetinstrument wat ons gebruik het	Lengte in cm		Naam van voorwerp	Die meetinstrument wat ons gebruik het	Lengte in cm
1.	klippie	liniaal	1 cm	1.	asblik	meterstok	108 cm
2.	baksteen	maatband	21 cm	2.	juffrou	maatband	172 cm
3.	blaar	liniaal	7 cm	3.	krieket pitch	meterwiel	2012 cm

Unit of study: Measurement **Lesson: 4** **Focus: Focus is on mathematics**	
Materials Each group will be provided with the following materials: An assignment card with the problem A large blank piece of paper Coloured pencils A variety of measurement tools	
Prior knowledge The lesson assumes: • Prior experience identifying and understanding how to measure real-life objects.	
Objectives • To assist learners in broadening their understanding of how to measure real-life objects using appropriate tools and units. • To enable learners to calculate and document the differences in length between the objects they measure, improving their math and analytical skills. • To enhance learners' critical thinking and problem-solving skills through the application of measurement concepts in a real-life context.	
Mathematical problems **Learners will** 1. read and analyse the problem as a group to gain a clear understanding of the task, 2. engage in group discussion to identify and share prior knowledge and relevant information that can help solve the problem, 3. determine any information gaps and discuss the need for additional information to solve the problem, 4. collaborate to develop and evaluate different problem-solving strategies.	**Assessment** **Learners should be able to** 1. trace the footprint of a T-Rex and the feet of each member of the group on one blank piece of paper, 2. measure each member's feet using appropriate metric tools and accurately record the measurements on the assignment paper using the correct metric unit, 3. calculate the difference in length between T-Rex's footprint and each member's feet using subtraction, 4. determine which member's footprint has the smallest difference in length compared to T-Rex's footprint.

<u>Problem-solving through discussion and measurement</u>

The learners work in the same groups as the previous lesson. Each group receives an assignment card with a problem (see Image 18), different coloured pencils, and a large piece of blank paper.

Image 18

Problem Scenario: Problem-Solving Through Discussion and Measurement

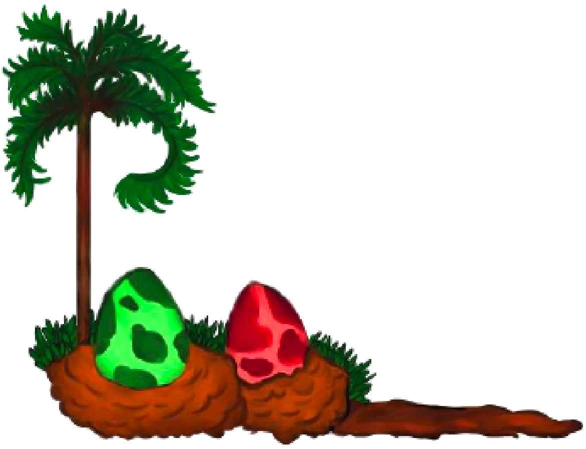
The largest dinosaur footprint ever discovered belonged to a Sauropod, a long-necked herbivore measuring 1.7 meters in length. In contrast, the T-Rex had a footprint that was 1.1 meters long and 46 centimetres wide.

To compare the length of your group members' feet to that of the T-Rex's footprint, calculate the differences in length. Use coloured pencils and a large piece of blank paper to solve the problem. Afterward, provide feedback to the class regarding the group member with the smallest difference in length.

Prior to attempting to solve the problem, instruct each group to engage in a discussion and complete the back of the assignment card (see Image 19). On the card, they identify what they already know from the problem scenario, what additional information they need to know to solve the problem, and possible strategies they can employ to solve it. This helps them organise their thoughts and approach the problem systematically.

Image 19

Problem-Solving Through Discussion and Measurement

<table>
<tr><td colspan="2">Define the problem</td></tr>
<tr><td>What kind of information from the problem scenario would be helpful to solve the problem?</td><td>What specific information is necessary to solve the problem?</td></tr>
<tr><td colspan="2">Generate possible strategies or solutions to solve the problem through brainstorming
</td></tr>
</table>

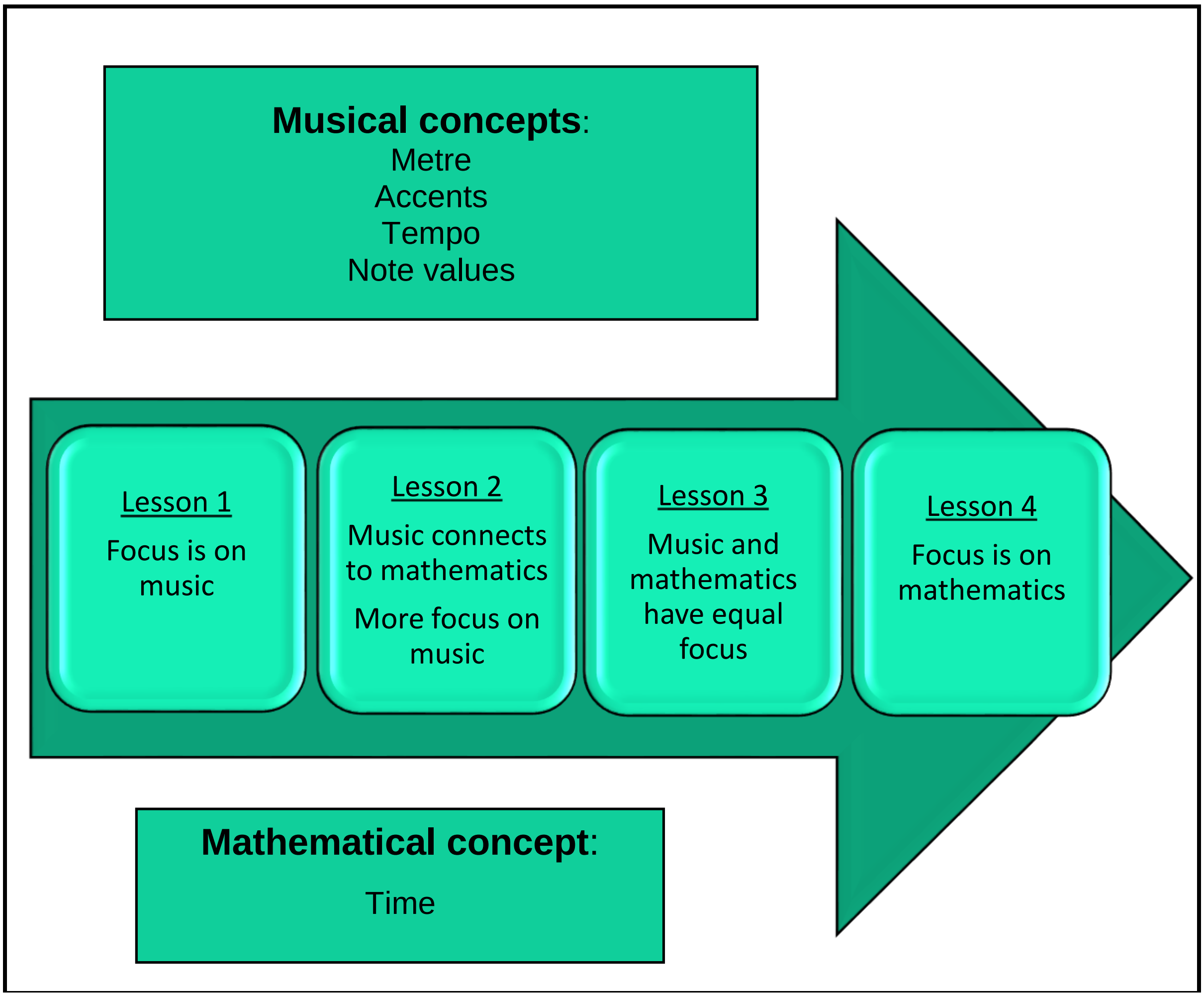
After each group has solved the problem, a representative from each group presents their problem-solving methods and conclusions to the class. This promotes communication, collaboration, and the sharing of different approaches to problem-solving.

4.2.2 Mathematical Concept: Time

The relationship between the mathematical concept of time integrated with music is illustrated in the diagram below (see Figure 4).

Figure 4

Music-Mathematics Integration: Time



<table>
<tr><th colspan="2">Lesson topic: Time
Lesson: 1
Focus of lesson: Focus is on music</th></tr>
<tr><td colspan="2">Materials
A recording of The Syncopated Clock by Leroy Anderson
The music score of The Syncopated Clock by Leroy Anderson

Each learner will be provided with the following material:
An empty can
Non-melodic percussion instruments

Each group will be provided with the following material:
A set of note cards
A rubric
Sticker dots</td></tr>
<tr><td colspan="2">Prior knowledge

The lesson assumes:
Prior experience identifying and understanding steady beat and duration in the context of a melodic line using iconic representations.</td></tr>
<tr><td colspan="2">Objectives

To enhance learners' comprehension of the correlation between a steady beat, metre (a division of strong and weak beats), and duration (rhythmic patterns) and enable learners to employ this knowledge to produce an ‘orchestral’ music composition.</td></tr>
<tr><td>Musical problems
Learners will
listen to the music of The Syncopated Clock while playing along with empty cans to keep the beat,
play the first beat of each bar with an accent and count out loud to help understand that the beat moves in fours,</td><td>Assessment
Learners should be able to
demonstrate their understanding of a steady beat by playing on the beat,
demonstrate their understanding of strong accents by playing louder on the first beat of the music,
demonstrate their understanding of simple duple meter (2/4) by counting to four and conducting the music accordingly,</td></tr>
</table>

3. demonstrate understanding of the strong first beat by using the 4-beat conducting pattern with *The Syncopated Clock*, 4. apply knowledge of steady beat, simple duple meter (2 beats in a bar), and note values to create their own 4-bar rhythm patterns in group work, 5. in their groups, perform the created two-bar rhythmic patterns using a non-melodic percussion instrument or body percussion, 6. perform their rhythmic patterns in the style of an orchestra to demonstrate their understanding of a whole musical piece, 7. enhance the style of the orchestral piece by incorporating concepts of music that demonstrate their understanding of the multidimensional qualities of music.	4. demonstrate their understanding of using different note values to create a two-bar rhythm pattern in four beats, 5. perform their rhythm patterns in groups using non-melodic percussion instruments, 6. demonstrate their understanding of the style of playing in an orchestra by choosing an instrument to represent the constant ticking of the clock and incorporating it into their performance.

<u>Problem-solving through discovering and performance</u>

<u>Activity 1:</u> *The Syncopated Clock* by Leroy Anderson.

A. The learners will tap the beat of the music using their empty cans while following the teacher's movements. The teacher will demonstrate various movements, such as tapping on the top of the can, tapping on the sides, or tapping with different parts of their hands. The learners will mimic these movements, coordinating their taps with the beat of the music. This activity helps them develop a sense of rhythm and coordination.

B. The teacher will guide the learners to feel and distinguish the strong and weak beats in the music. They will emphasise the downbeat (strong beat) by tapping their cans with more force and tap with less force on the other beats (weak beats). The learners will follow along, internalising the rhythmic structure of the music and understanding the concept of strong and weak beats.

C. The teacher will repeat the activity without the cans and guide the learners to count out loud to the beat. The teacher will provide a steady beat by clapping or using a metronome, and the learners will practice counting the beats aloud in synchronisation. This step reinforces their understanding of the steady beat and helps them develop their sense of timing and rhythm. It also allows them to transition from the physical act of tapping with cans to the mental act of counting and internalising the beat.

These activities provide a progressive approach to rhythm learning, starting with physical engagement and gradually transitioning to mental awareness of the beat. By incorporating movement, coordination, and counting, the learners develop a strong foundation in rhythm and enhance their musical abilities.

Activity 2: Reinforcing the strong and weak beats in a music piece.

Divide the class into small groups and provide each group with a copy of the first 10 bars of *The Syncopated Clock's* melody (see Image 20). The teacher plays the song at a slower tempo as the learners follow along with the music score (The researcher used the software *MuseScore 4* to adjust the speed of *The Syncopated Clock's* melody, making it slower for the activity).

Image 20

Sheet Music of The Syncopated Clock

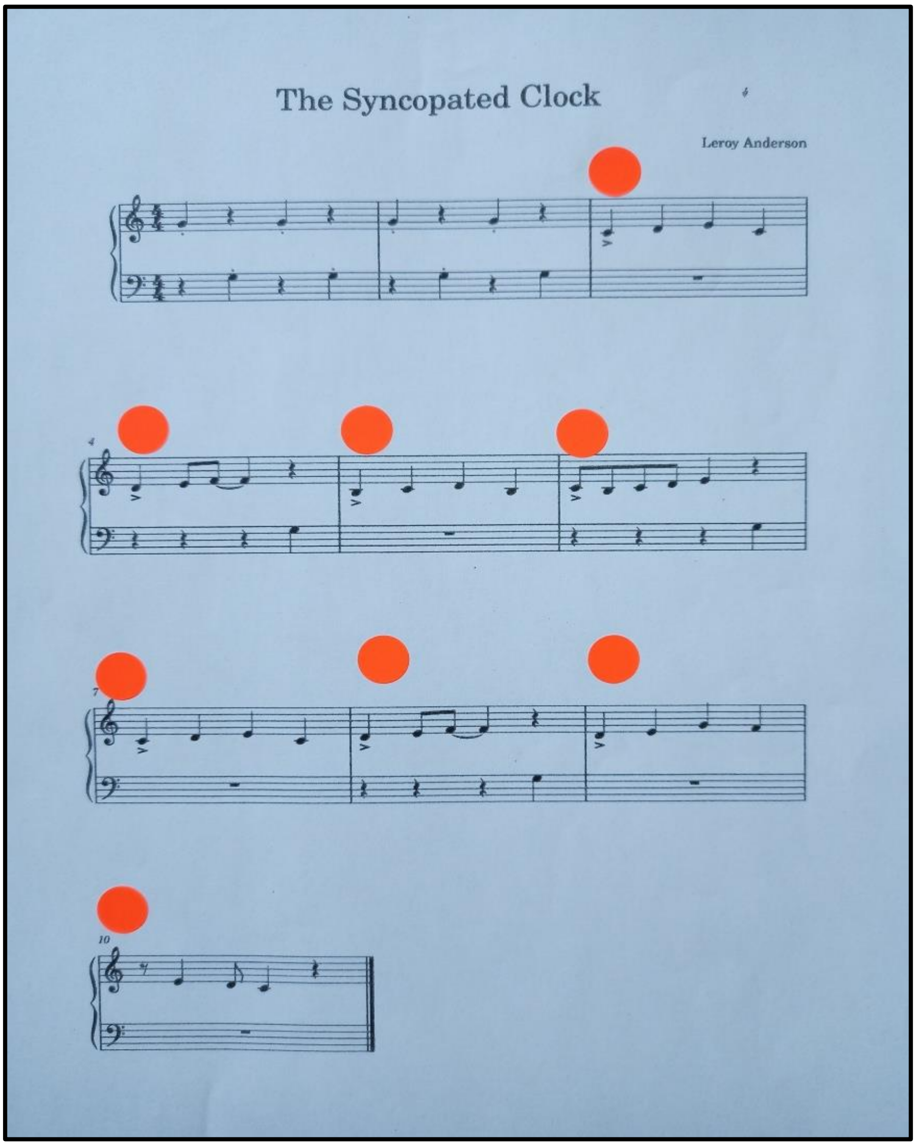
The learners' task is to demonstrate their understanding of the first beat by placing a sticker dot on the first beat of each bar (see Image 21). This activity helps them develop a clear understanding of the strong beats and reinforces their knowledge of the steady beat and meter.

The teacher walks around and observes the learners as they place the sticker dots, assessing their understanding and providing feedback or additional guidance as needed.

Once the learners have completed the task, the teacher plays the song again at a regular tempo, and the learners clap or tap along with the music. This hands-on activity helps them experience the strong and weak beats of the melody, reinforcing their understanding of the rhythm and meter.

Image 21

Learner's Identification of Strong Beats in the Music



Problem-solving by creating

Activity 3: Creating rhythmic patterns.

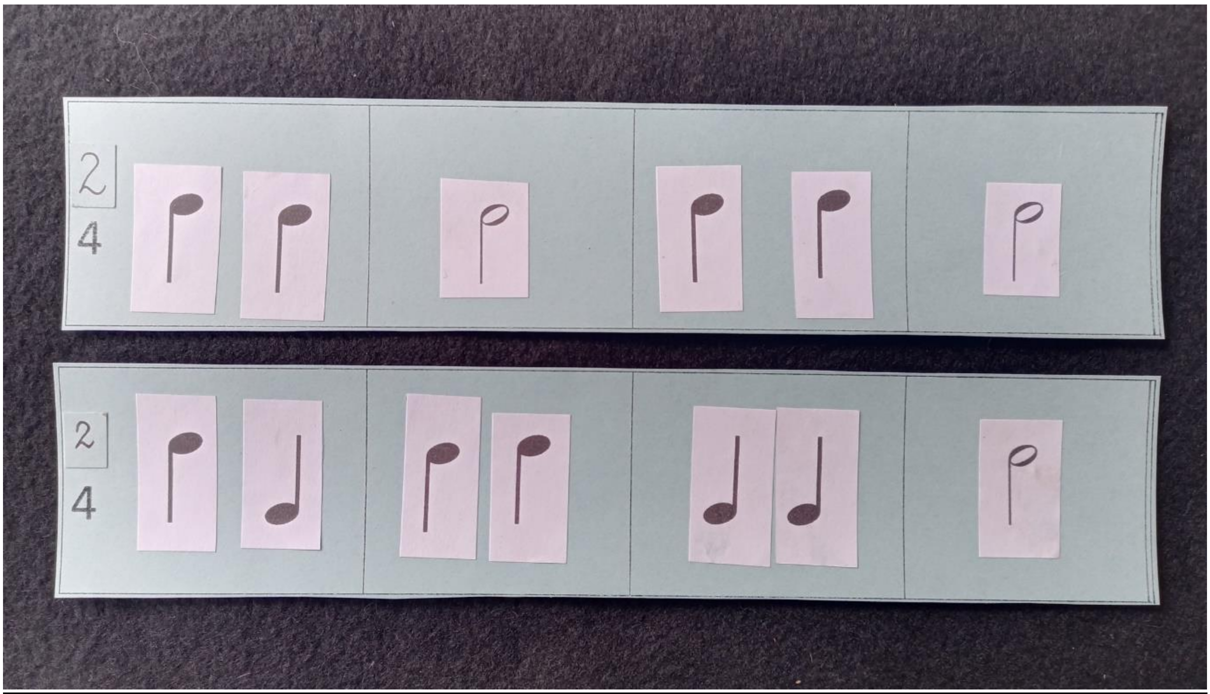
In this activity, the learners work in small groups of two or three to compose a rhythmic pattern in 2/4-time signature (see Image 22). The teacher provides a set of note cards containing quarter and half notes that the learners can use to create their patterns. A rubric is provided to guide the learners in their composition (see Image 23).

Once the learners have composed their patterns, they practice clapping them together, using pens or pencils as makeshift percussion instruments. This activity helps the learners develop their sense of rhythm and ensemble playing.

The teacher observes the groups, offers feedback, and provides guidance as necessary. When the learners complete their rhythmic patterns, they share their creations with the class and engage in a discussion about the various creative choices they made.

Image 22

Learner's Worksheet of Rhythmic Patterns in 2/4-Time Signature



Assessment

Each group evaluates their rhythmic patterns using the rubric (see Image 23) provided below:

Image 23

Rubric for Evaluating Rhythmic Patterns

	Yes	No
We used a variety of notes in our rhythm patterns.		
Each pattern consists of 2 beats.		
We could clap each rhythmic pattern using a steady beat.		
We emphasised the strong beat in each pattern.		

Problem-solving through performance

Activity 4: Clapping symphony

In this activity, the learners engage in a clapping symphony using non-melodic percussion instruments or their bodies as instruments. The teacher acts as the conductor, and the groups follow a sequential pattern to create a symphony. Here is an outline of the activity:

- Each group selects a non-melodic percussion instrument or decides to use their bodies as instruments (for example clapping, stomping, or snapping).
- Using the rhythm patterns they created in the previous activity; Group A begins by playing their rhythmic pattern while one learner plays a steady beat on a drum.
- When Group A repeats their pattern, Group B joins in with their pattern.
- As the sequence continues, Group C joins in after Group B, and this process continues until all the groups are playing together.

- Each group repeats their pattern until the whole class forms a symphony.

After completing the symphony-building process, the groups take turns performing each other's rhythmic patterns, repeating the process of building the symphony with each pattern.

Assessment

The teacher facilitates a class discussion to reflect on the group's performances. This discussion focuses on various aspects, including coordination, timing, dynamics, and overall musicality. The teacher uses the following questions to prompt reflection and gather feedback from the learners:

- How well did the groups coordinate with each other during the clapping symphony? Did you feel a sense of unity and collaboration?
- Were the timing and tempo consistent throughout the performance? How did this affect the overall musicality?
- Did the dynamics vary appropriately in different sections of the symphony? How did this contribute to the overall musical expression?
- What challenges did you encounter while playing your rhythmic patterns? How did you overcome them?
- Did you notice any improvements in your performance from the beginning to the end? What factors contributed to these improvements?
- How did it feel to perform each other's rhythmic patterns? Did you find it challenging or inspiring? Why?
- What suggestions or constructive feedback do you have for each other to enhance the overall performance?

During the class discussion, the learners reflect on the coordination, timing, dynamics, and overall musicality of the clapping symphony. They discuss the sense of unity and collaboration within the groups and the impact of consistent timing and tempo on musicality. The learners also explore how varying dynamics contribute to the expression of the music. They share their challenges while playing the rhythmic patterns and discuss strategies for overcoming them. The learners reflect on any improvements in their performance and identify contributing factors. Performing each other's rhythmic patterns is discussed in terms of the challenges and inspiration it provided. Finally, the learners offer suggestions and constructive feedback to enhance their overall performance.

<table>
<tr><th colspan="3">Lesson topic: Time
Lesson: 2
Focus: Music connects to mathematics
More focus on music</th></tr>
<tr><td colspan="3">Materials
A recording of The Little Prince - Equation by Hans Zimmer
A recording of The Syncopated Clock by Leroy Anderson

Each group will be provided with the following material:
Non-melodic percussion instruments
A stopwatch</td></tr>
<tr><td colspan="3">Prior knowledge
The lesson assumes:
Prior experience identifying and understanding the strong and weak beats in a melodic line (music).
Learners can use a stopwatch to measure time (mathematics).
Learners can calculate the length of time (mathematics).</td></tr>
<tr><td colspan="3">Objectives
The learners will reflect on the significance of tempo in music and how it can impact the mood or emotional impact of a piece. They will also recognise the importance of precise timekeeping and measurement in musical performance.</td></tr>
<tr><td>Musical problems
Learners will
1. identify and list the words related to time in The Little Prince – Equation,
2. play the first beat of each bar in The Little Prince - Equation with</td><td>Mathematical problem
Learners will
1. engage in a group discussion to identify and list words and phrases related to time,
2. explore the concepts of seconds, minutes,</td><td>Assessment
Learners should be able to
1. analyse and represent their understanding of time-related words and phrases by discussing and making a list,</td></tr>
</table>

an accent while counting out loud to help them recognise the 4/4-time signature, 3. play the beat of the music using non-melodic percussion instruments, 4. compare *The Syncopated Clock* to *The Little Prince - Equation* by analysing the musical qualities of each piece, 5. engage in a class discussion about how tempo can affect our emotions, 6. experience different tempos by clapping the rhythmic patterns they composed in Lesson 1 at both slow and fast tempos.	and hours and their practical applications in daily life, 3. discuss and calculate real-life examples of time such as the duration of a favourite TV show or the time it takes to get to school, 4. calculate the difference in time between the slow and fast versions of the rhythmic patterns they composed in Lesson 1, using a stopwatch to measure the duration of each pattern in seconds.	2. show their understanding of a steady beat by playing on the beat, 3. show their understanding of strong accents by playing louder on the first beat of the music, 4. show their understanding of four beats in the bar by counting to four and conducting the music in simple quadruple metre (4/4), 5. compare the dimensions used in *The Syncopated Clock* and *The Little Prince - Equation* by comparing musical elements, 6. show their understanding of tempo in music by playing their rhythmic patterns slow or fast, 7. show their understanding of the concepts: seconds, minutes, and hours through their discussions and answers.

<u>Problem-solving through discussion</u>

<u>Activity 1:</u> Time in my daily life

A. Learners discuss how often they hear the word ‘time’ in a day.

For example:

"It's time to wake up!"

"What time is the break?"

"Hand your assignment in on time!"

"Teacher: You're wasting time!"

"It's time to clean your room."

B. What would be the consequence if we choose to discard all watches and clocks?

<u>Problem-solving through listening and discussion</u>

<u>Activity 2:</u> *The Little Prince - Equation* by Hans Zimmer

The learners listen to *The Little Prince - Equation* while reading the lyrics projected on the screen (see Image 24). They create a list of all the words in the song that are related to the concept of *time*.

Image 24

The Little Prince – Equation by Hans Zimmer

Minus 2 by minus 3
6Y you end up with 5
X plus 3Y times 2XXY
Rewrite equation one
Maybe
In an hour
In a day
In a week
In a thousand weeks

In their groups, the learners discuss and calculate the following questions in their workbooks. The teacher walks around and assists as needed:

a. How many minutes are in an hour?

b. How many hours are in a day?

c. How many hours are in a week?

d. How many hours do you spend attending school in one week?

Assessment

The class discusses the answers to the questions while the teacher facilitates the discussion.

Problem-solving through comparing and discussion

Activity 3: Class discussion.

As a class, the learners discuss the following question:
Does the tempo of a music piece affect our mood or emotions? Provide reasons for your answers.

Problem-solving through performance

Activity 4: Experiencing fast and slow tempo.

In their groups:
One group member measures the time in seconds of their rhythmic pattern compositions (see Lesson 1 of Time) while the rest of the group plays it slowly, and again when they play it quickly, using a stopwatch.
The learners then write down the time it takes to play each composition at both tempos in their workbooks.
Next, the learners calculate the difference in time between the slow and fast versions and write the answer in seconds.
Finally, each group shares their method for measuring and calculating the difference in time and gives feedback on their results.

Lesson topic: Time Lesson: 3 Focus: Music and mathematics have equal focus		
Materials Each learner will receive the following materials: • Two paper plates • One paper brad (also known as a paper fastener)		
Prior knowledge The lesson assumes: • Prior knowledge of identifying and understanding tempo in the context of a song (music). • Prior knowledge of reading and writing analogue time (mathematics).		
Objectives 1. To enhance the learners' comprehension of tempo and steady beat and enable them to apply that knowledge to adjust the tempo of a well-known song (music). 2. To assist learners in constructing an analogue clock and displaying different times on it, improving their ability to read and write analogue time (mathematics).		
Musical problems	**Mathematical problem**	**Assessment**
Learners will	**Learners will**	**Learners should be able to**
1. modify the tempo of a song by performing it at a slower or faster pace while maintaining a steady beat, 2. maintain a steady beat while performing a song at a slower or faster tempo.	1. engage in a class discussion about the significance of clocks in our daily lives and determine their relevance in the modern era, 2. construct an analogue clock using provided materials, 3. demonstrate their understanding of reading and writing analogue time by displaying various times on their hand-made analogue clock.	1. formulate and communicate a personal opinion about the relevance of time in our daily lives based on a class discussion, 2. construct an analogue clock and demonstrate their ability to read and write analogue time by displaying various times on the clock, 3. apply their understanding of tempo by performing a song at a faster or slower pace while maintaining a steady beat, 4. demonstrate their ability to maintain a steady beat in a slower or faster tempo while performing a song.

Problem-solving through discussion

Activity 1: Class discussion on the significance of time in our daily lives.

During the class discussion, learners will explore the following:

- Do you consider time to be significant in our daily lives? Please provide reasons to support your answer.
- How is a typical weekday in a grade 4 learner's day divided? Are there different time zones for various activities?
- If clocks and timetables did not exist, how would a school day be different? Do you think it would be an advantage or a disadvantage to both learners and teachers?

During the discussion, learners share their thoughts and opinions, providing reasons and examples to support their answers. The teacher facilitates the conversation, encourages active participation, and helps guide the discussion to explore different perspectives on the importance of time and its impact on daily routines and school schedules.

Problem-solving through creativity

Activity 2: Create your own clock.

Each learner receives two paper plates and a paper brad. They use one of the paper plates to draw and cut out the two hands of a clock, with one hand longer than the other. As a class, they discuss which hand represents the minute hand and which hand represents the hour hand before writing the word "HOUR" on the hour hand and "MINUTES" on the minute hand. The learners then complete their clocks on their own, using their own creativity, with the teacher providing assistance as needed (see Image 25).

Image 25

Learners' Own Clocks

<u>Problem-solving through performance</u>

<u>Activity 3:</u> Class discussion

During the class discussion, learners will explore the following topics:

A. Can we observe the passage of time in nature?
   (The seasons change throughout the year, with variations in weather and hours of daylight. These changes are influenced by the earth's axis tilt and its orbit around the sun).
B. Using your clocks, indicate the following times:
   What time do you usually wake up in the morning?
   What time do you usually go to bed during the week?
   (The teacher walks around and assist as needed).
C. Do you think the music used to wake up in the morning is the same as the music used for sleep time? What is the reasoning behind your answer?

In their groups, learners choose a familiar song. They change the tempo of the song to make it either a wake-up song (by singing it faster) or a song suitable for bedtime (by singing it slower). If the song is lengthy, they have the option to perform only the chorus.

Each group is given eight minutes to practice the song using the new tempo. Then, they perform it to the rest of the class, making sure to keep a steady beat throughout the performance.

<table>
<tr><th colspan="2">Lesson topic: Time
Lesson: 4
Focus: Focus is on mathematics</th></tr>
<tr><td colspan="2">Materials
Each group will be provided with the following materials:
• Large white paper
• Criteria for creating a mind map (guidelines or prompts)
• A set of ten cards</td></tr>
<tr><td colspan="2">Prior knowledge
The lesson assumes:
• The learners know how to read and write time using an analogue clock,
• The learners know how to read and write time in a 12-hour format.</td></tr>
<tr><td colspan="2">Objectives
Learners will expand their understanding of analogue time using content-specific vocabulary and develop their skills in reading and writing analogue time in a 12-hour format.</td></tr>
<tr><td>Mathematical problem
Learners will
1. discuss how to tell time using different analogue clock faces,
2. create a mind map to visually represent their understanding of analogue time, using time-related vocabulary,
3. practice reading and writing analogue time using a 12-hour format,
4. demonstrate their understanding by matching time on an analogue clock to corresponding worded prompts.</td><td>Assessment
Learners should be able to
1. show their understanding of telling time on different analogue clock faces through their discussion,
2. show their understanding of the concept analogue time by creating a mind map while using time-related vocabulary,
3. show their skills in reading and writing analogue time by writing time in words and illustrating the same time on an analogue clock.</td></tr>
</table>

Problem-solving organising information

Activity 1: Class discussion.

In their respective groups, learners engage in a discussion centred around the following question:
Some analogue clock faces display only the numbers 3, 6, 9, and 12. How can you accurately read the time on such clocks? Provide examples to support your answer.

Activity 2: Create a mind map.
Each group creates a mind map to demonstrate their comprehension of analogue time. One member of each group then presents their mind map to the rest of the class. The teacher provides each group with guidelines for creating their mind map (see Image 26).

Image 26

Learners' Guidelines for Creating a Mind Map

Create a mind map about analogue time using the following guidelines

- Use a large sheet of paper to write down everything you can think of about analogue time.
- Write 'Analogue Time' in the centre of the paper.
- Write as many words or phrases as you can think of related to analogue time.
- Use colours and images to make your mind map visually appealing.
- Be creative and have fun!

<u>Problem-solving through knowledge application</u>

<u>Activity 3:</u> Read and write analogue time using the 12-hour clock time.

Each group receives a packet of 10 cards. Learners write ten different times in words on the right-hand side of each card, using the 12-hour clock format. Each group trades their cards with one of the other groups. On the left-hand side of each card, the learners match the time that is written on the cards by illustrating the same time on the analogue clock. The same two groups trade their cards back. The learners assess the illustrated times on the analogue clocks before they give feedback to the other group (see Image 27 and Image 28). The teacher walks around and guides each group.

Image 27

Learner's Illustration of Time on an Analogue Clock (1)

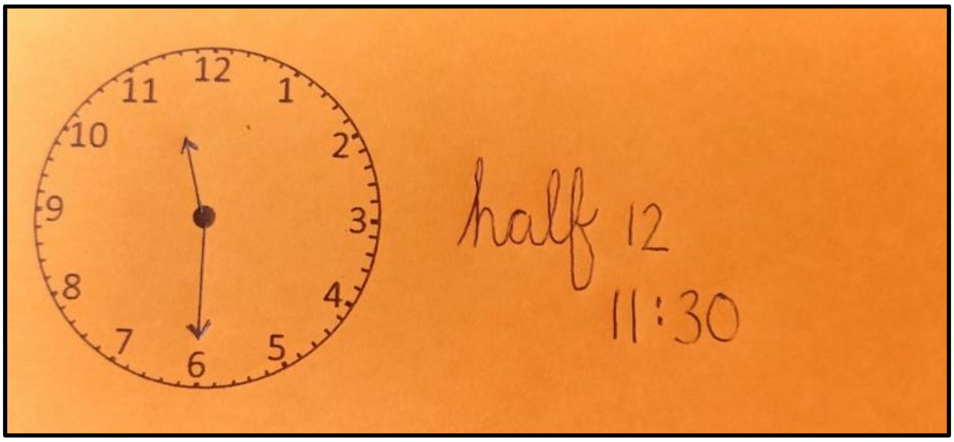
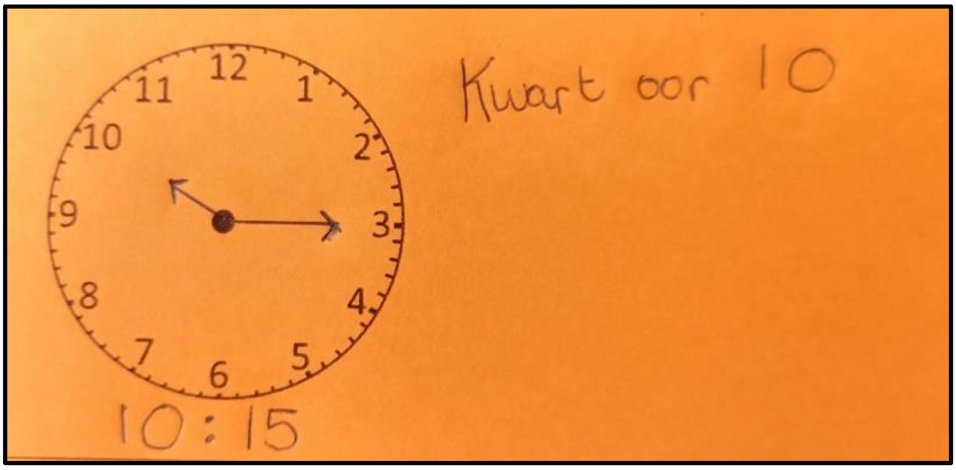


Image 28

Learner's Illustration of Time on an Analogue Clock (2)

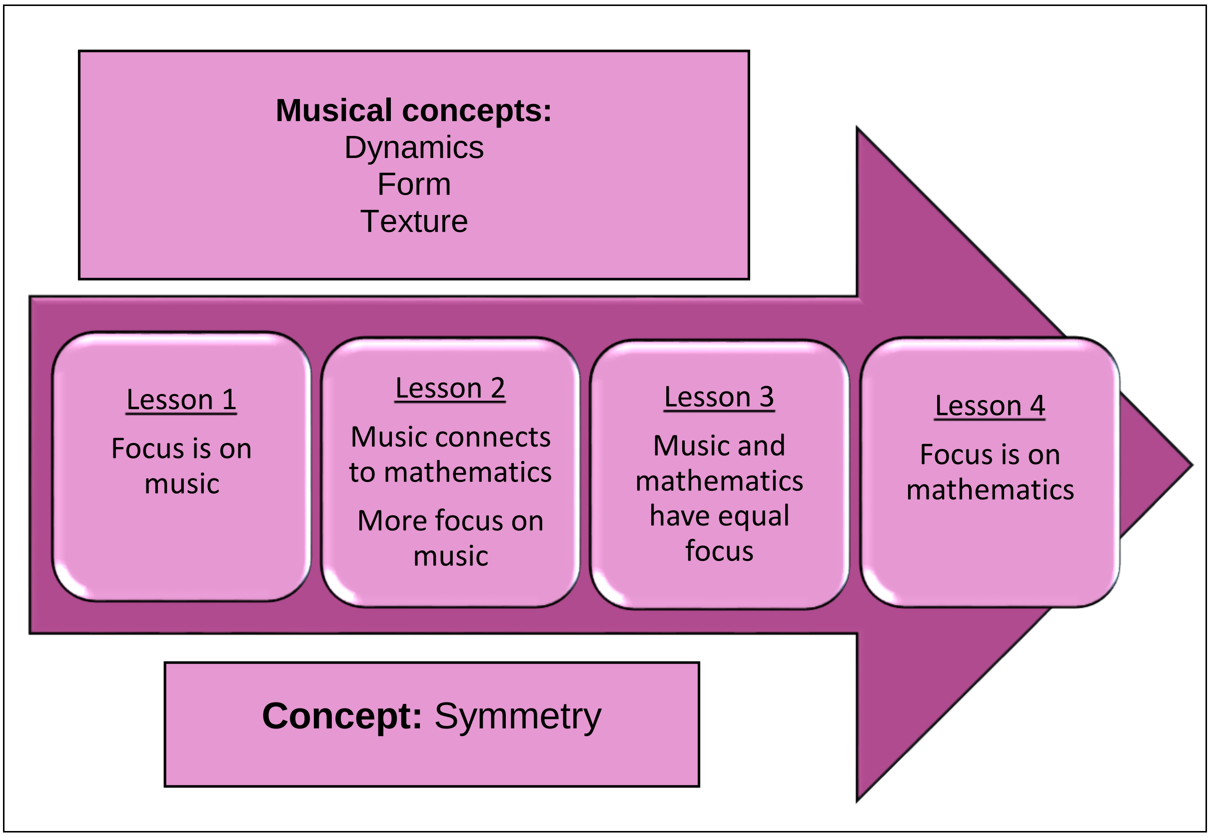


4.2.3 Mathematical Concept: Symmetry[1]

The relationship between the mathematical concept of symmetry integrated with music is illustrated in the diagram below (see Figure 5).

Figure 5

Music-Mathematics Integration: Symmetry



[1] Symmetry in mathematics refers to an image that retains its exact appearance after undergoing transformations such as rotation, reflection, or translation. A line of symmetry divides the image into two identical shapes that are mirror images of each other.
In music, symmetry can be achieved by employing contrasting and repeating melodic and rhythmic phrases.

Unit of study: Symmetry

Lesson: 1

Focus of the lesson: Focus is on music

Materials

A recording of *We will rock you* by Brain May/Queen

Each group will receive the following materials:

• Sheet music for *Twinkle Twinkle Little Star*

• An assignment page for writing their own short composition in ternary (ABA) form

Prior knowledge

The lesson assumes:

- That learners have prior experience in identifying and demonstrating their understanding of melodic direction, contour, and rhythm patterns.

Objectives

To assist learners in experiencing, understanding, and applying the concept of symmetry in music through the repetition of rhythm patterns. This activity aims to illustrate the connection between symmetry and musical structure and form.

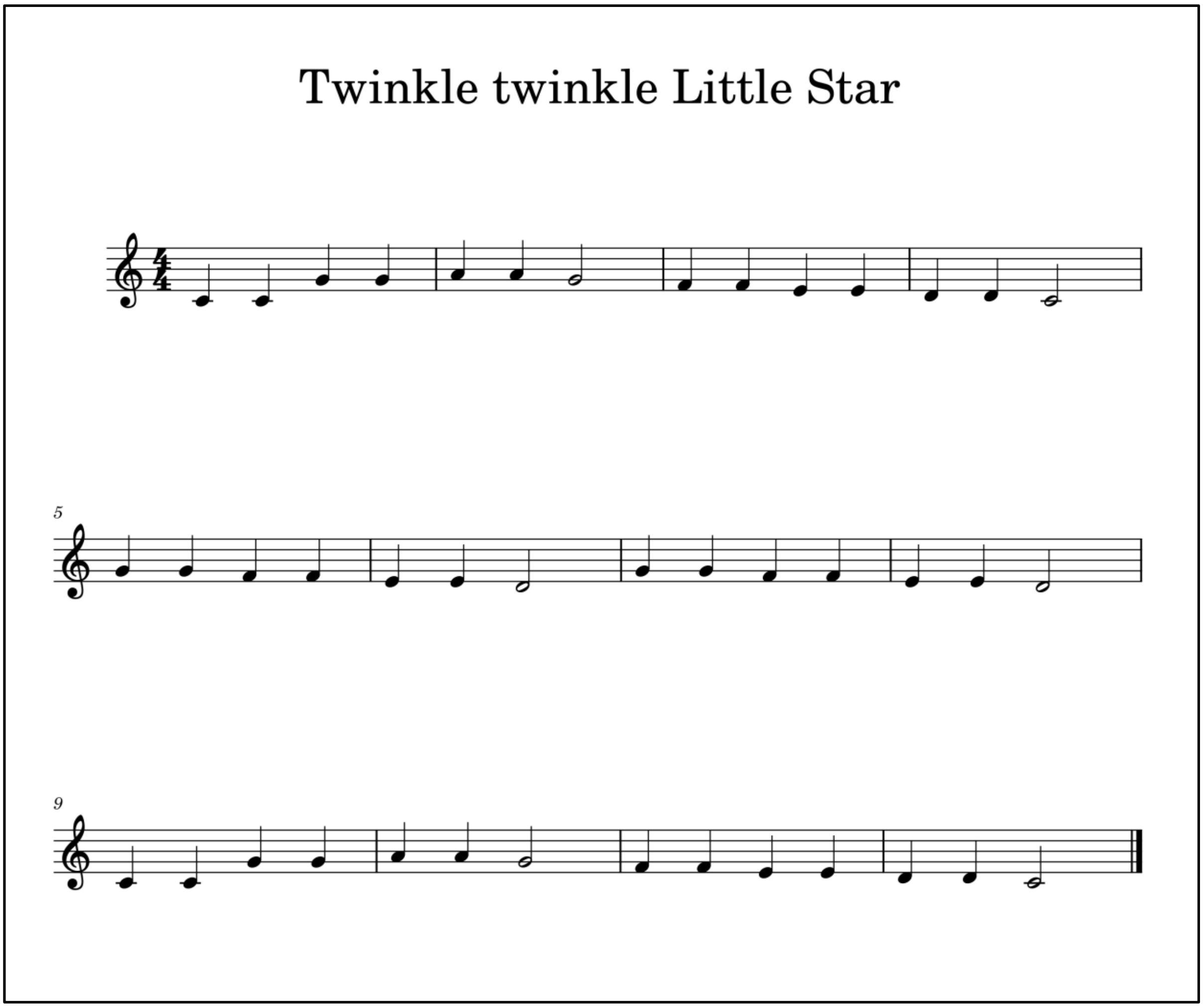
Musical problems	**Assessment**
Learners will	**Learners should be able to**
1. explore symmetry in music,	1. discuss and explore the concept of symmetry in the structure of a music piece,
2. analyse the melody and rhythm of a song or music piece and understand that these can be symmetrical,	2. demonstrate their understanding of symmetrical rhythms through active listening and analysis,
3. compose their own short rhythm demonstrating symmetry,	3. compose a short rhythm that demonstrates symmetry,
4. experience symmetry in music by clapping their newly composed ternary form rhythm.	4. evaluate each other's compositions based on the presence of symmetry.

Problem-solving through discussion and exploration

Each learner receives the sheet music of *Twinkle Twinkle Little Star* (see Image 29) prior to singing the well-known song.

Image 29

Sheet Music of Twinkle Twinkle Little Star



The learners sing the song once more while simultaneously making movements to demonstrate the melodic contour of each phrase.

Class discussion

1. Did you observe any similarities or differences in your movements when indicating the melodic contour of the phrases? Please describe your experience. (Learners connect their movements to the melodic phrases by applying the sheet music of the song to identify repetitions and contrasts in the phrases).

2. The teacher explains to the learners that the identified similar phrases are called the A-sections of the song, while the contrasting phrases are referred to as the B-section. This musical structure is known as ternary form in music.

Problem-solving through composing

The teacher divides the class into pairs and provides each pair with an assignment page. The pairs are instructed to compose their own ternary form by creating a short A-section rhythm and a contrasting B-section rhythm in 4/4 time (see Image 30 and Image 31). Each block on the page represents one beat. They will practice clapping the rhythm to the class. After each pair's performance, the class will collectively determine if their short composition exhibits symmetry.

Image 30

Learner's Worksheet of Short Rhythms in Ternary Form (1)

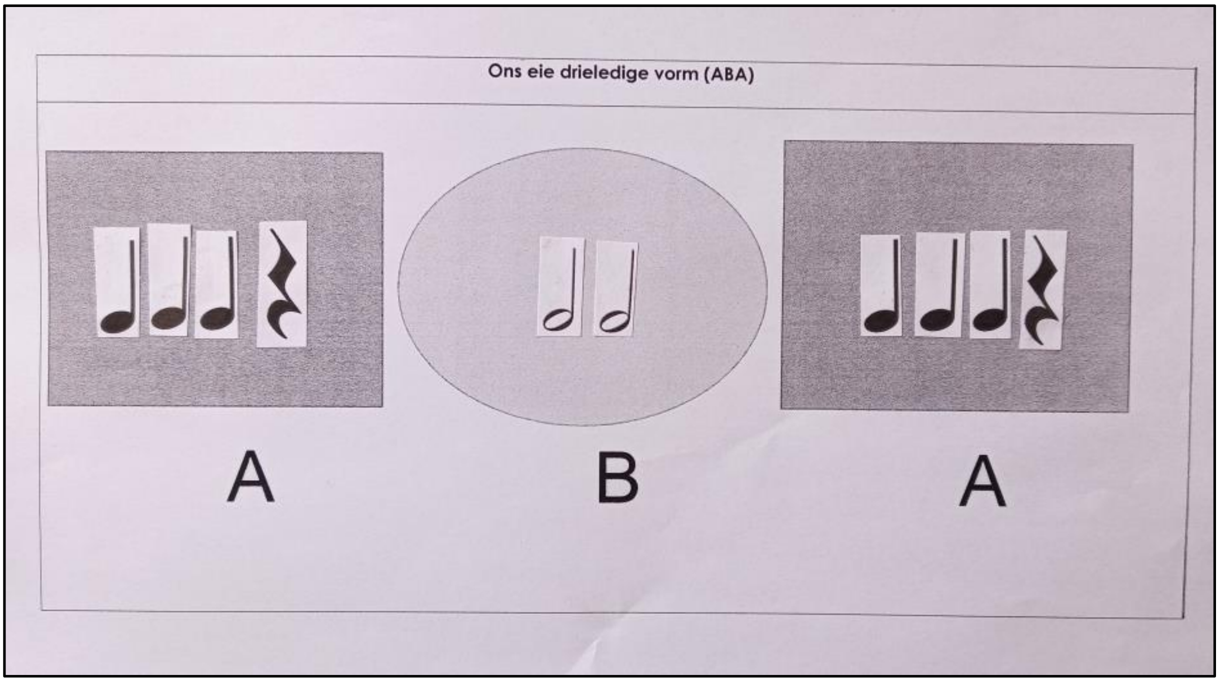
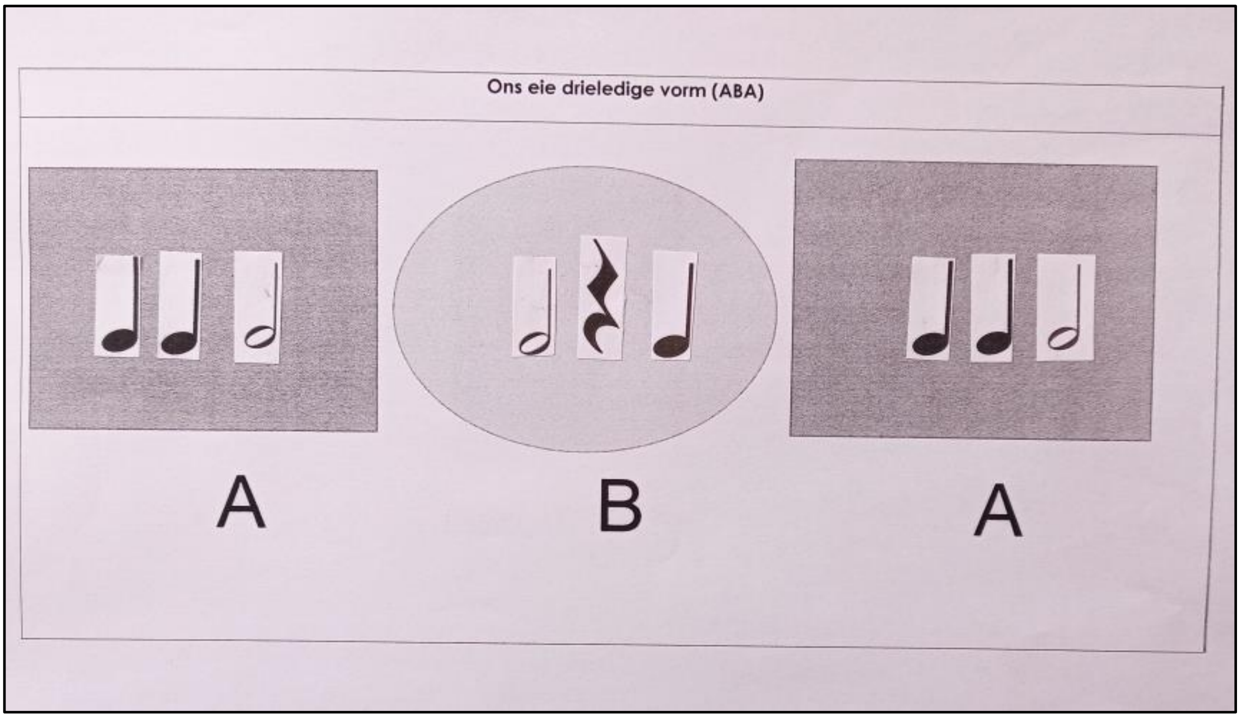


Image 31

Learner's Worksheet of Short Rhythms in Ternary Form (2)



Problem-solving through listening

The learners listen to a recording of *We Will Rock You* by Brian May/Queen. Afterward, as a class, they engage in a discussion to determine if this song exhibits symmetry. They explore the elements that contribute to its symmetry and consider how to determine if a song or piece of music is symmetrical. Following the discussion, the class listens to *We Will Rock You* again to further analyse its symmetrical aspects.

Unit of study: Symmetry Lesson: 2 Focus of the lesson: Music connects to mathematics More focus on music		
Materials The lyrics to *The Sailor's Song* Cards for each group to compose rhythms with reflection/mirror images Illustrations of symmetrical images		
Prior knowledge The lesson assumes that learners have the following prior experience: • Familiarity with note values and the ability to create rhythm patterns within a steady beat. • Some understanding of symmetry in music structure and rhythm.		
Objectives To reinforce the learners' understanding of mirror image by experiencing it physically in an action song and to apply this knowledge by composing rhythms with mirror images. To help learners investigate, experience, and identify symmetry and mirror images in our everyday lives.		
Musical problems	**Mathematical problems**	**Assessment**
Learners will	**Learners will**	**Learners should be able to**
1. learn the action song *The Sailor*, 2. experience symmetry by doing mirror image clapping movements to the beat of *The Sailor*, 3. discuss as a class if their movements were mirror images and why, 4. apply their knowledge of mirror images by composing a short	1. explore symmetry and mirror images in everyday objects and shapes, 2. define and discuss the concept of the line of symmetry, 3. investigate if the first letter of their names has one or more lines of symmetry.	1. demonstrate their understanding of incorporating rhythm and movement to maintain a steady beat, 2. perform mirror-image movements in sync with the beat of *The Sailor*, 3. apply their knowledge of mirror images by composing a short two-bar rhythm pattern. 4. create a definition for the concept of a line of symmetry,

two-bar rhythm in small groups.		5. investigate whether the first letter of their names has one or more lines of symmetry.

Problem-solving through an action song with movements

The teacher introduces the action song *The Sailor* to the class by leading them in a rhythmic chant of the first phrase while repeating the lyrics (see Image 32). The learners actively participate by following along with the teacher's lead. Once the learners become familiar with the song, the teacher divides them into pairs, and each pair faces each other. The teacher proceeds to teach the class a series of mirror-image movements, which are then synchronised with the song's rhythm and lyrics (see Image 33).

Image 32

Lyrics of A Sailor

A Sailor

A sailor went to sea, sea, sea,
To see what he could see, see, see.
But all that he could see, see, see
Was the bottom of the deep blue sea, sea, sea.

A sailor went to chop, chop, chop,
To see what he could chop, chop, chop.
But all that he could chop, chop, chop
Was the bottom of the deep blue chop, chop, chop.

A sailor went to knee, knee, knee,
To see what he could knee, knee, knee,
But all that he could knee, knee, knee,
Was the bottom of the deep blue knee, knee, knee.

A sailor went to sea, chop, knee
To see what he could sea, chop, knee
But all that he could sea, chop, knee
Was the bottom of the deep blue sea, chop, knee

Image 33

Clapping Movements of A Sailor

Lyrics	Clapping movement
A sailor went to	Clap hands criss-cross
sea, sea, sea	Hold the right hand above the right eye and salute three times
To see what he could	Clap hands criss-cross
see, see, see	Hold the right hand above the right eye and salute three times
But all that he could	Clap hands criss-cross
see, see, see	Hold the right hand above the right eye and salute three times
Was the bottom of the deep blue	Clap hands criss-cross
sea, sea, sea	Hold the right hand above the right eye and salute three times
……. Chop, chop, chop	"Chop" three times on the left arm with the right hand
……. Knee, knee, knee	Tap three times on the right knee with the right hand
……. See, chop, knee	Salute ones, "chop" ones, and tap one time on the right knee

<u>Class discussion</u>

As a class, engage in a discussion focusing on the following points:

- Did you and your partner execute the clapping movements in an identical manner?
  Allow learners to share their experiences and observations. Encourage them to compare their movements with their partners and discuss whether they were executed in an identical manner or not.
- How did your movements differ from your partner's movements?

Encourage learners to identify and discuss the differences they noticed in their movements compared to their partners. Did they have variations in speed, intensity, or rhythm? Were there any specific gestures or techniques that differed?

- What do we call this type of reflection where movements are mirrored? Guide learners to the concept of mirror image. Discuss how mirror image refers to the reflection or mirroring of movements, where one person's movements are replicated or imitated by another person in a reversed manner as if looking into a mirror.

Problem-solving through composition

Class discussion

Can rhythm have a mirror image? Yes, rhythm can have a mirror image. Just like in visual reflections, a rhythmic pattern can be reflected or mirrored to create a similar but reversed pattern.

To determine if an image is a reflection or not, we can examine if it shows symmetry across a line of reflection. In the case of rhythms, we can observe if the rhythm pattern maintains its structure but is reversed when reflected.

To explore this concept, ask one of the learners to write a one-bar rhythm in 4/4 time on the board. Then, challenge the class by asking who can create a reflection or mirror image of that rhythm in the second bar. This exercise will encourage learners to think about symmetry and rhythmic patterns, as well as engage in creative exploration of mirror images in rhythm.

Let's proceed with a discussion to determine whether the second bar's rhythm is indeed a reflection or mirror image of the first bar. Provide each pair with a card containing two blank bars. Instruct one learner in each group to write a one-bar rhythm in 4/4 time, while the other learner should create a mirror image of the rhythm in the first bar (see Image 34 and Image 35).

Afterward, ask the pairs to assess themselves and determine if the second bar is indeed a mirror image of the first. Encourage them to consider the symmetry and reversed patterns in their rhythms.

Finally, have the learners clap the short rhythm of the two bars, allowing them to experience and compare the original and mirrored rhythms in aural and physical form.

Image 34

Learners' Worksheet - Mirror Images of Rhythms (1)

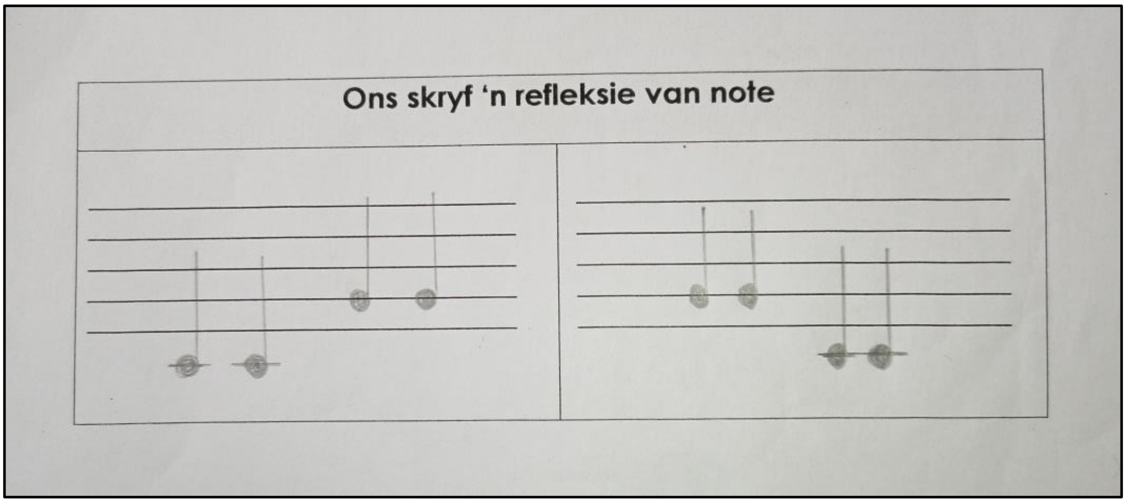
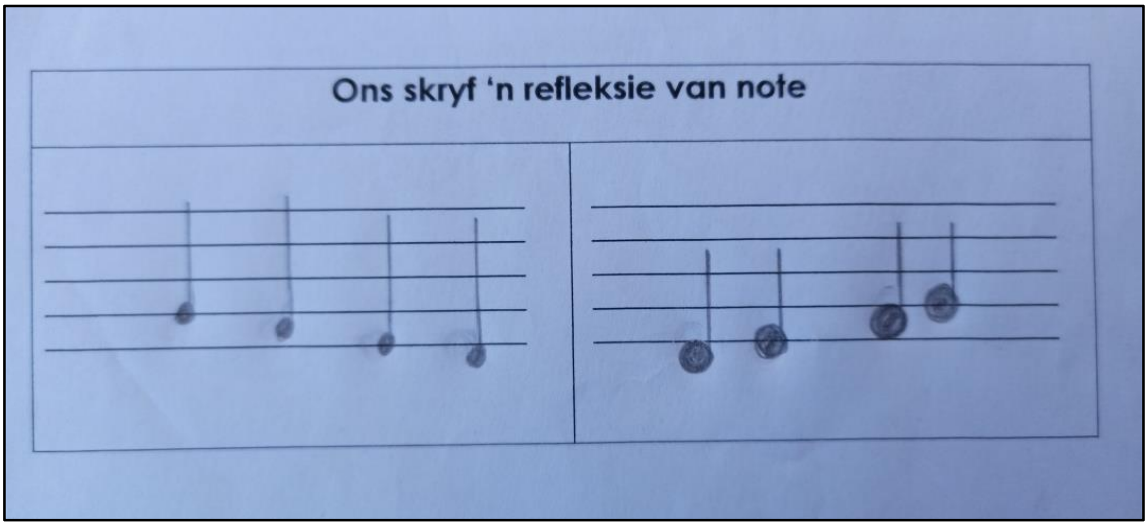


Image 35

Learners' Worksheet - Mirror Images of Rhythms (2)



Problem-solving through investigating, identifying, and experiencing

The teacher presents the following three illustrations to the learners (see Image 36, Image 37, and Image 38):

Image 36

Illustration of Symmetrical Image (1)

Image 37

Illustration of Symmetrical Image (2)

Image 38

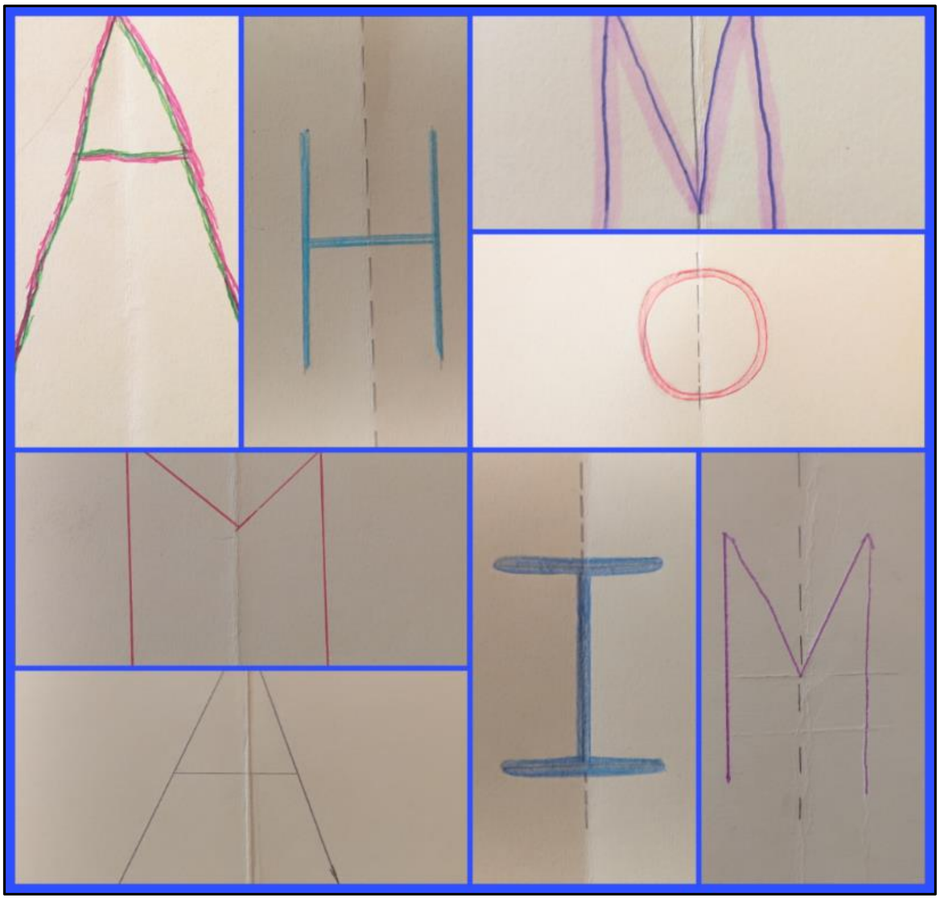
Illustration of Symmetrical Image (3)

<u>Class discussion</u>

- Is there symmetry in these illustrations?
- How did you determine if there is symmetry in each illustration?
- Can you describe the symmetry in each illustration? (Learners can discuss an imaginary line that divides an object into two similar parts).
- We call this imaginary line the line of symmetry, which divides a shape or object into identical halves.
- Let's further explore! Write the first letter of your name on your paper and investigate whether it has a line of symmetry (see Image 39). What did you notice about the letters H, I, O, or X? A shape or object can have more than one line of symmetry. Let's discuss this further, and those who discovered that the first letter of their name has multiple lines of symmetry can demonstrate to the rest of the class why this is the case.

Image 39

Learners' Representations of Line of Symmetry



Unit of study: Symmetry Lesson: 3 Focus of the lesson: Music and mathematics have equal focus		
Materials A worksheet with four music staves for each group Square sheets of paper for each learner Pencils Scissors		
Prior knowledge The lesson assumes that learners have prior experience in: • Identifying and understanding note letter names in music. • Recognising rhythmic phrases that create symmetry in music. • Identifying symmetry and the line of symmetry in mathematics.		
Objectives • To assist learners in creating short melodic phrases using mirror images in music. • To assist learners in identifying and describing the symmetry found in handmade snowflakes through mathematics.		
Musical problems	**Mathematical problems**	**Assessment**
Learners will	**Learners will**	**Learners should be able to**
1. work together as a class to investigate whether a mirror image can be written for two music notes on a staff, 2. identify the notes on the staff according to their letter names, 3. take turns in their groups to write a mirror image and form a short melodic phrase.	1. create a symmetrical snowflake out of paper by folding and cutting it, 2. identify at least one line of symmetry on their snowflake.	1. as a class, write a mirror image of two quarter notes on the staff and discuss whether the notes are symmetrical based on the characteristics of a mirror image, 2. assess their own short melodic phrases according to the characteristics of a mirror image, 3. identify the notes on the staff according to their letter names,

		4. create their own symmetrical snowflake using instructions, 5. pair up with a partner and participate in a discussion, describing their snowflake design based on its symmetrical properties.

Problem-solving through composition

Class discussion

The learners review what they have learned about symmetry in mathematics. They explain what symmetry is and provide examples of how they can recognise it. They share their understanding of symmetry in shapes or objects.

After the review, the teacher introduces a new exploration. The learners are informed that they are going to explore whether the concept of symmetry can be applied to a short melody. They are given the task of writing a mirror image of the melody. This activity encourages the learners to think creatively and consider how the principles of symmetry can be translated into the realm of music composition.

The teacher then draws a staff with two bars on the board, using a time signature of 2/4. A learner is asked to write two quarter notes on the staff, with their corresponding letter names underneath each note, in the first bar. Another learner is given the task of writing a mirror image of those two notes, including their letter names, in the second bar.

The teacher initiates a class discussion by asking questions such as:

• What are the characteristics of a mirror image?

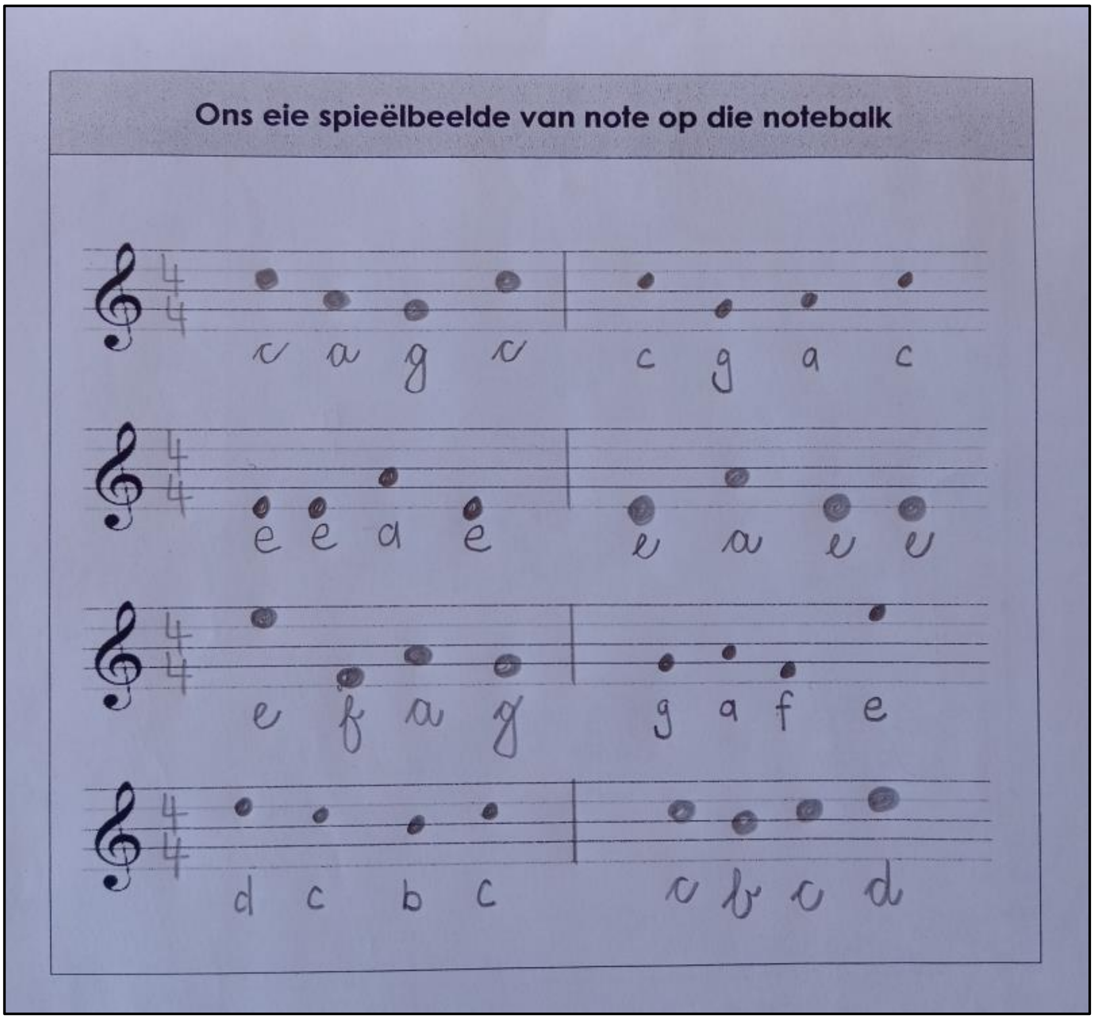
• Do these characteristics apply to the notes on the board?

The learners are then divided into groups of two and provided with an assignment page. On each page, they are instructed to draw a bar line in the middle of each staff and write the time signature 4/4 at the beginning of each staff.

In each group, one member is assigned to write four quarter notes with their corresponding letter names underneath each note in the first bar of the first staff. The second member of the group is responsible for writing a mirror image of those four notes, including their letter names, in the second bar of the first staff (see Image 40). The learners continue this process for the remaining three staves, taking turns writing the first four notes and their mirror images. Each group needs to assess themselves based on the characteristics of a mirror image and determine if their compositions meet the criteria.

Image 40

Learners' Mirror Images of Notes



Problem-solving through creativity

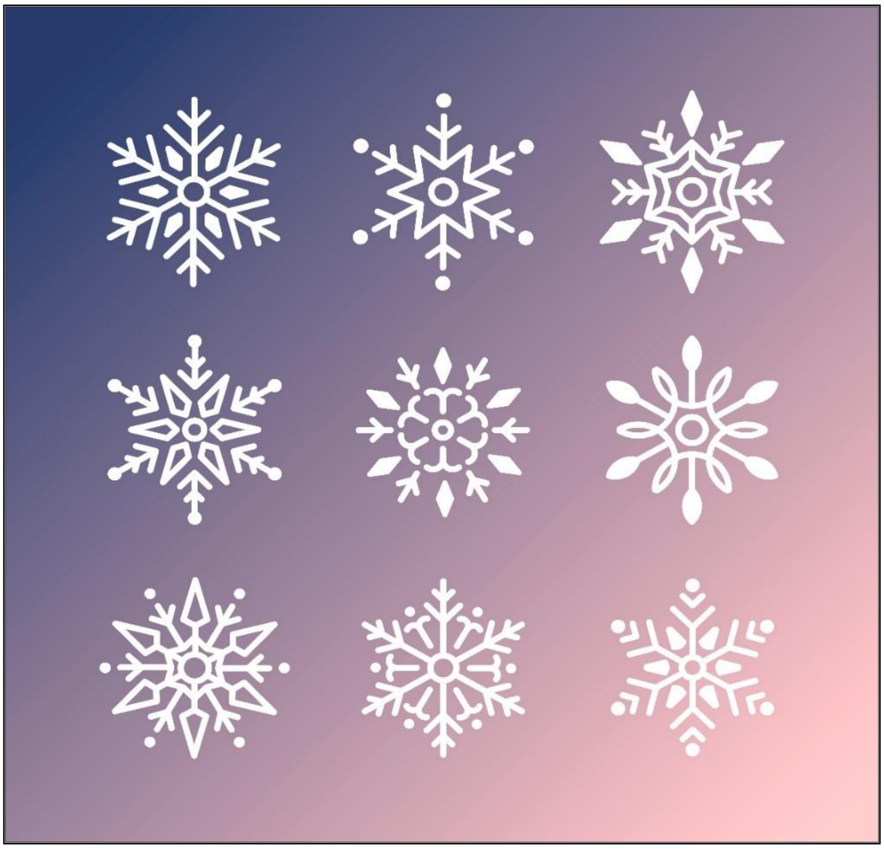
Class Discussion

The teacher displays an image of snowflakes to the learners (see Image 41). After observing the picture, the class engages in a discussion with the following prompts:

- What is depicted in the picture? (Snowflakes)
- What mathematical properties can you identify in the snowflakes? (Six sides, hexagonal shape, symmetry)

Image 41

Images of Snowflakes



To create their own symmetrical snowflakes (see Image 42), the learners will require the following materials:

- A square sheet of paper
- Pencil
- Scissors

Directions:

Step 1: Fold the paper in half diagonally to create a triangle.

Step 2: Fold the triangle in half again to make a smaller triangle.

Step 3: Fold the triangle into thirds.

Step 4: Fold the left third and the right third towards the middle.

Step 5: Cut the top of the triangle at an angle.

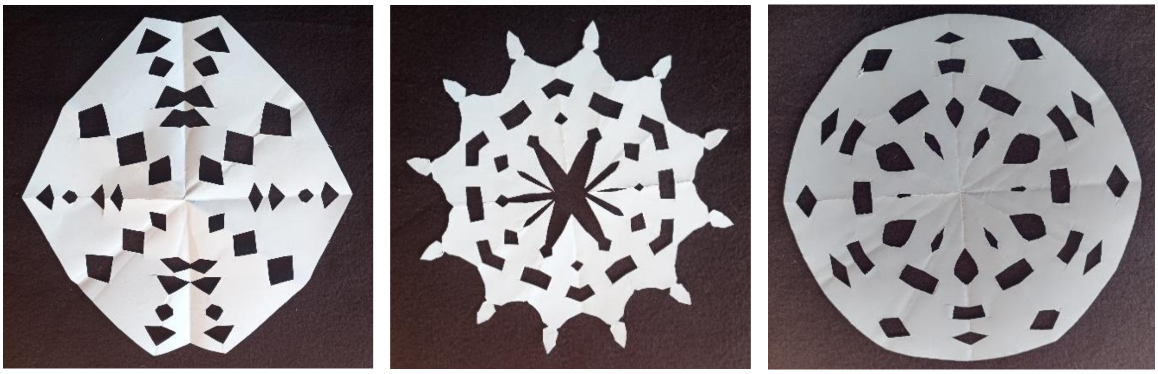
Step 6: Cut small triangles and shapes from the sides of the paper.

Step 7: Unfold your creation to reveal a symmetrical snowflake.

Step 8: Describe your snowflake by answering the following questions for the teacher:

Image 42

Learners' Creations of Symmetrical Snowflakes



After creating their individual snowflakes, the learners will pair up with a partner and engage in a discussion, addressing the following questions:

• How would you describe the overall symmetry of your snowflake?

• How many sides does your snowflake have?

• How many lines of symmetry does your snowflake possess?

• Did you encounter any challenges while making your snowflake? How did you overcome them?

• What do you find most interesting or unique about your snowflake design?

The learners should take turns sharing their responses and actively listen to their partner's answers, fostering a collaborative and engaging discussion.

<table>
<tr><th colspan="2">Unit of study: Symmetry
Lesson: 4
Focus of the lesson: Focus is on mathematics</th></tr>
<tr><td colspan="2">Materials
Each group is provided with the following materials:
• A collection of different shapes in various colours and sizes
• A paper plate</td></tr>
<tr><td colspan="2">Objective
To reinforce the concept of symmetry by guiding learners to create and describe their own symmetrical design using various shapes.</td></tr>
<tr><td>Mathematical problems
Learners will
1. use their creativity to design and create a symmetrical pattern using a variety of shapes,
2. describe their design by discussing its symmetry, lines of symmetry, and reflection properties.</td><td>Assessment
Learners should be able to
1. apply the properties of symmetry to create and describe their own symmetrical pattern using various shapes within their groups.</td></tr>
</table>

<u>Problem-solving through creativity</u>

The learners, divided into groups of two, will receive the following materials:

- A collection of different shapes in various colours and sizes.
- A paper plate.

The learners will then proceed to:

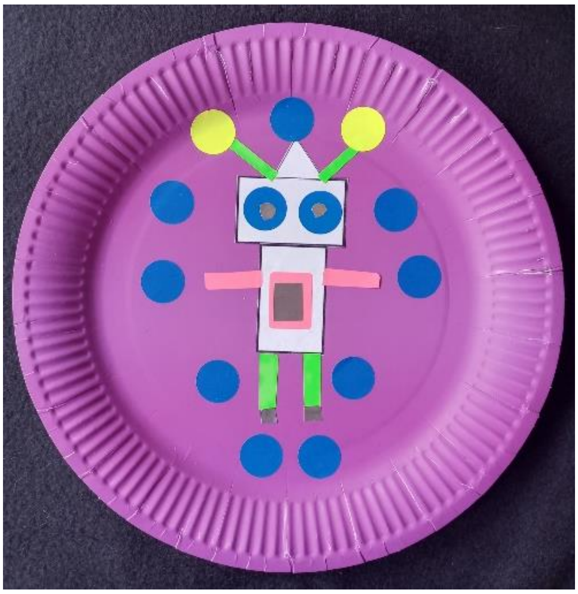
- Create a symmetrical pattern on the paper plate using the provided shapes (see Image 43).
- Describe their newly designed symmetrical shape in their own words, incorporating the concepts of symmetry and reflection.

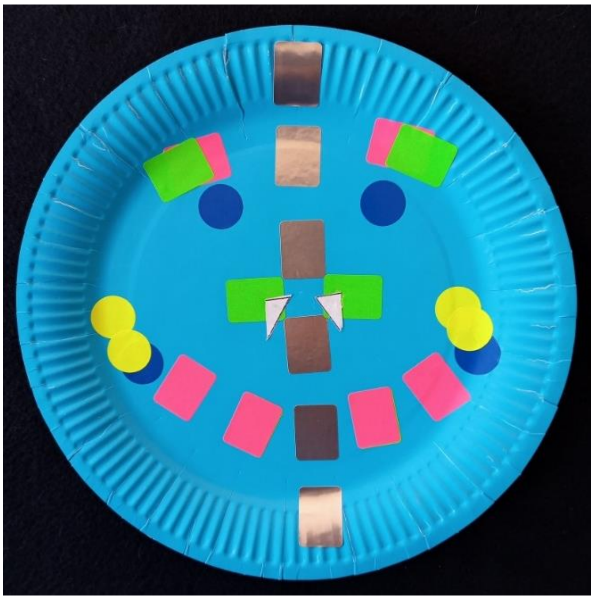
Each group will work collaboratively to arrange the shapes on the paper plate, ensuring that the pattern exhibits symmetry. They will discuss and articulate their understanding of symmetry and reflection as they describe their design.

During the activity, the teacher will circulate among the groups, providing guidance and support as needed.

Image 43

Learners' Symmetrical Patterns Using a Variety of Shapes





4.3 Conclusion

These integrated music-mathematics lesson plans were thoughtfully put together. Each element of the lesson plans was intentionally designed to create a connected teaching and learning experience. This approach went beyond fulfilling academic requirements; it aimed to foster a deep understanding of the significance of both subjects. Consequently, it facilitated a comprehensive exploration of how music can enhance mathematics, enriching the teaching and learning experience as a whole.

Chapter 4 provided a comprehensive overview of the integrated music-mathematics lessons that constituted a fundamental component of this study. Moving forward, Chapter 5 will focus on outlining the process of qualitative data analysis and presenting the themes and categories that emerged from the data collected by the researcher. This chapter will delve into the rich insights and patterns identified through the analysis, shedding light on the experiences and perspectives of the participating generalist teachers in the Intermediate Phase. By examining the themes and categories that emerged from the data, the chapter aims to provide a deeper understanding of the integration of music and mathematics in the teaching and learning process.

Chapter 5: Data Analysis

5.1 Introduction

In this chapter, the process of qualitative data analysis is outlined, and the themes and categories that emerged from the collected data are presented. To gather comprehensive and relevant data, a combination of research methods was employed (Busetto et al., 2020). These methods included document analysis, participant observations, semi-structured interviews, and the use of field notes. Following data collection, the recorded information was transcribed, organised, and collated for analysis. The chosen analytical approach was thematic analysis (Lochmiller, 2021), which allowed for the identification and exploration of key themes and categories within the data (Vaismoradi & Snelgrove, 2019). Through this analysis, the research questions of the study were answered.

The analysis comprehended a systematic examination of the data, including coding, categorisation, and identification of recurring patterns and themes. The resulting themes and categories offered valuable insights into the experiences, perceptions, and challenges encountered by the participants as they integrated music and mathematics in their teaching practices. The comprehensive presentation of these themes and categories enhanced the depth and richness of understanding of the research topic and contributed to the broader knowledge within the field.

A semi-structured individual interview (Appendix C, Schedule 1) was conducted with each of the participating generalist teachers. After analysing pedagogical principles and teaching strategies from existing literature and South African Department of Education policy documents, the researcher designed the integrated music-mathematics lessons. These integrated lessons are highlighted in Chapter 4.

Following the individual observation of the integrated music-mathematics lessons each participant had a one-on-one session with the researcher. The purpose of these sessions was to offer guidance on effectively incorporating music into mathematics lessons. This assistance was tailored to the observations made by the participating teachers during the lessons. To facilitate data analysis, the interviews were recorded in audio format and transcribed verbatim.

Subsequently, each participating teacher delivered the integrated music-mathematics lessons to their respective Grade 4 classes. The researcher conducted individual observations of each participant, carefully recording field notes. Following the participants' presentation of the integrated music-mathematics lessons and their assessment of their learners' comprehension during these instructional sessions, the researcher conducted semi-structured individual interviews with each participant involved (Appendix D, Schedule 2).

5.2 Respondent Profile

Understanding the background and qualifications of the participants is vital for interpreting the findings of the study (Antony & Elangkumaran, 2020). It's worth noting that while all participants possessed teaching experience in the Intermediate Phase, none of them held prior formal music qualifications. However, one participant did have piano and flute training during their childhood. This suggests that the participants may have had varying levels of comfort and confidence in integrating music with mathematics. Furthermore, their individual experiences and perspectives may have influenced their approach and attitudes toward the integrated lessons. As such, it is important to consider these factors when interpreting the data and drawing conclusions from the study.

5.3 Discussion of Themes

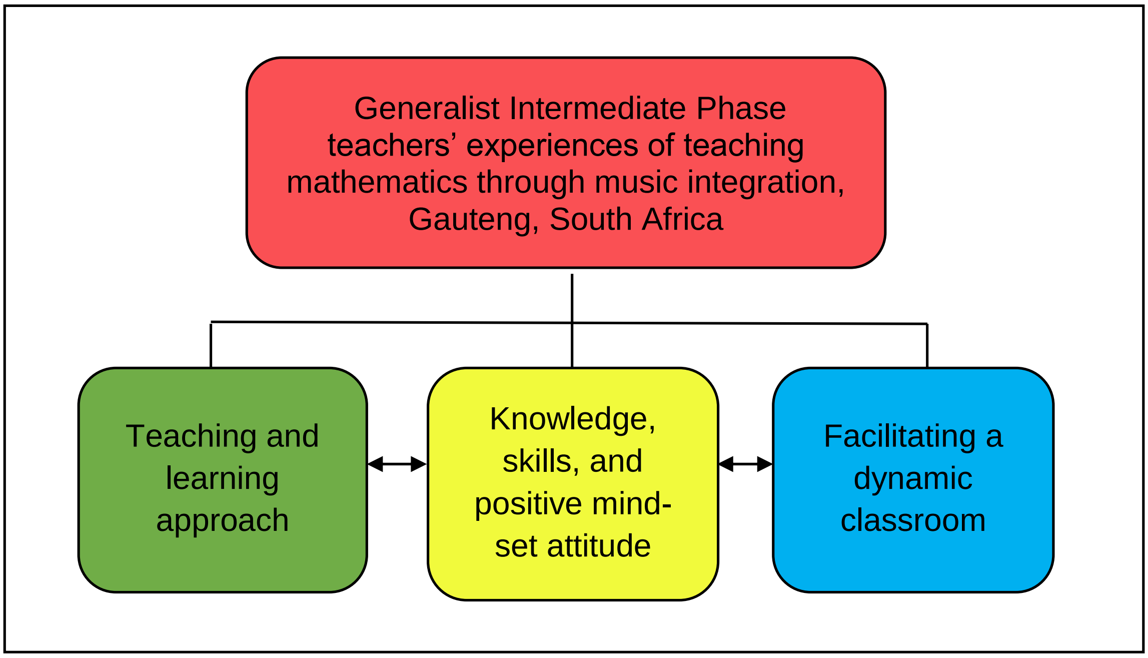
The analysis aimed to explore how generalist teachers in the Intermediate Phase perceived the enhancement of mathematics through music in their teaching and learning practices. The data was methodically gathered and systematically analysed to extract valuable insights and interpretations in an organised manner.

Three interconnected themes emerged from this study (Figure 6):

1. Teaching and learning approach
2. Knowledge, skills, and positive mind-set attitude
3. Facilitating a dynamic classroom

Figure 6

Interconnected Themes

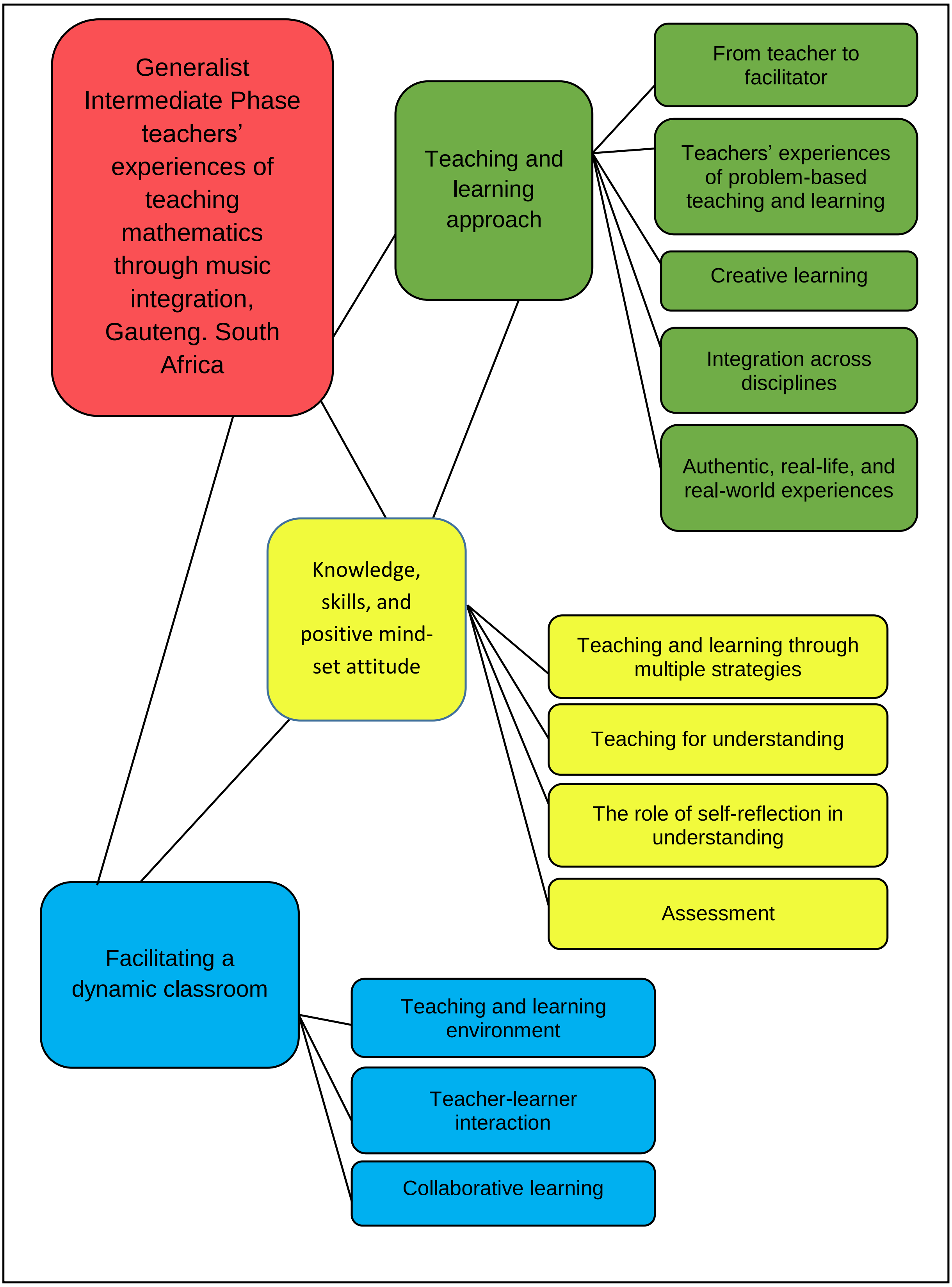


The interrelated themes and categories (see Figure 7), underscore the main research question:

How do generalist teachers in the Intermediate Phase experience the enhancement of mathematics through music teaching and learning?

Figure 7

Interconnected Themes and Categories

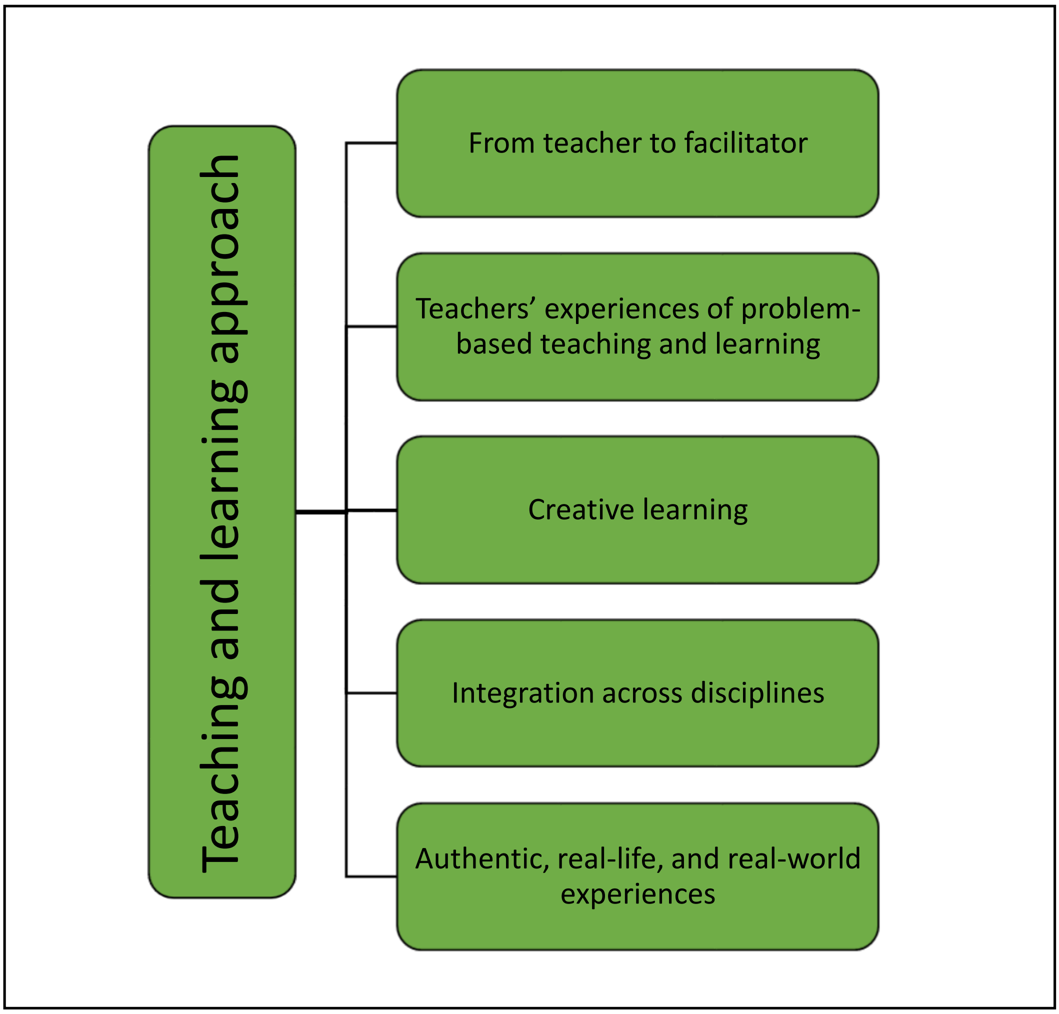


5.3.1 Teaching and Learning Approach

The integrated music-mathematics lessons included multiple teaching and learning approaches, such as problem-based learning, creative learning, and learner-centred methodology. In this chapter, the researcher analyses the participants' experiences with these approaches (see Figure 8).

Figure 8

Teaching and Learning Approach



5.3.1.1 From Teacher to Facilitator. During the semi-structured interviews conducted in Phase 1 prior to the participants delivering the integrated music-mathematics lessons, the researcher prompted the participating generalist teachers to elaborate on their roles within the mathematics classroom. They were asked to indicate whether they presented the information to the learners or facilitated learning. Teachers Naylene and Divan answered that they "introduced" the learning content to the learners, while teacher Amy replied that she "explained" to the learners what they had to do in the activities.

The other participating teachers also indicated that they held authority in the classroom. All the participants stated that they facilitated learning, but they acted as the primary sources of knowledge, assigning worksheets as the main activity for the learners to complete. In the semi-structured interviews, every participating teacher referred to their role in directing learning. Teacher Sebastiaan stated that he sometimes introduced a new topic by asking questions to test the learners' prior knowledge. Subsequently, he would typically initiate the lesson by delivering all the learning materials to the learners, who would passively absorb the knowledge he presented.

During the implementation phase (Phase 2), the participating teachers observed the integrated music-mathematics lessons that the researcher gave to their Grade 4 classes. Afterward, when the researcher met with each teacher individually, the researcher received a variety of reactions from the participating teachers who were not used to implementing a learner-centred approach. Most of them were excited and enthusiastic to try this new approach, while teacher Anke was initially sceptical and expressed concerns that it could have a negative effect on discipline in the class. However, she saw the implementation of a learner-centred approach as a challenge and agreed to participate.

After the participants observed the integrated lessons, they expressed the need to adjust their teaching style. They recognised the importance of relinquishing control and enabling learners to take ownership of their learning to align with a learner-centred approach.

Although the transition from being the primary information giver to a facilitator of learner-centred learning was a positive experience for all teachers, it was not without challenges. Teacher Marlise found it challenging to refrain from always directing her learners, while teacher Divan struggled with letting go of the need to tell his learners what to do, which he was accustomed to doing. Trusting their learners to solve problems independently proved to be a hurdle for most participants. Initially, teacher Anke found the difference in her role intimidating as she was accustomed to being in control of all teaching and learning. Eventually, she acknowledged that the learner-centred method produced better outcomes than a traditional teaching and learning approach.

After presenting the integrated music-mathematics lessons, the teachers discovered that they still play a critical role in the learning process. Teacher Divan recognised the importance of teamwork between the teacher and learners. He explained: “As a teammate, I must facilitate active learning experiences to engage the learners in the process. The more support and encouragement I provide, the more my learners will thrive as part of my team”. The participant teachers conveyed that assuming the role of facilitator rather than a teacher in the music-mathematics integrated lessons had a favourable influence on their teaching. They were enthusiastic about continuing to integrate music activities into their upcoming lessons.

5.3.1.2 Teachers' Experiences of Problem-Based Teaching and Learning. During the semi-structured interviews (Phase 1), the participating teachers reported that they had received conventional training, and problem-based learning was not a component of their teacher education programs. As a result, some participants expressed uncertainty and concern about this approach. Teachers Sebastian and teacher Amy feared that problem-based learning would be time-consuming and that they would not have enough time to cover the curriculum content. Teacher Sebastian was uneasy about how this approach might impact the quality of his teaching, as the focus of problem-based learning is on the learners rather than on the teacher as the primary source of knowledge. In contrast, teacher Marlise stated that she never give her learners the time or space to explore their own learning, as she believe they might use an incorrect method. Therefore, she only teach the methods and procedures to her learners that she deem appropriate. Meanwhile, teachers Divan, Anke, and Sebastian expressed scepticism about the Grade 4 learners' ability to find solutions to new problems.

Despite not being trained in problem-based learning, the participating teachers expressed to the researcher their eagerness and willingness to explore new and innovative methods that could potentially optimise teaching and learning. First, the participants observed the researcher individually while she gave integrated music-mathematics lessons to one of their Grade 4 classes. Following this, the researcher met with each participant individually to provide guidance on how they could guide their learners to explore mathematical concepts through meaningful and engaging music activities.

The participating teachers were observed by the researcher during the integrated music-mathematics lessons. They provided guidance to their small groups by offering suggestions for problem-solving without revealing too much information or giving away answers. Initially, a challenge for the participants was not giving their learners enough time to think, discuss, and analyse potential solutions. The participants were impatient but soon realised that the learners needed time to generate innovative solutions to the problems. Teacher Anke recounted an experience with a group in her class who initially faced difficulty with a problem. She asked the group thought-provoking questions that encouraged and guided them to think of alternative ways to approach the problem. After some time to analyse and consider possible solutions, the learners developed creative and interesting answers. This accomplishment left her with a sense of satisfaction as an educator.

The integrated music-mathematics lessons included a variety of problem-based activities such as problem-solving through listening and improvising, performing, singing, exploring with sound, constructing, and composing, discovering, performing, and creating. The researcher observed that the participants readily embraced problem-solving as a teaching and learning approach. For instance, teachers Anke and Sebastian easily adapted their approach to the problem-solving task through active listening and improvising, and they guided their learners with ease by asking open-ended questions. It was also encouraging to observe how Teacher Anke guided her learners through a problem-solving assignment, requiring them to identify and implement legato and staccato techniques in a music piece. Most surprising was the enthusiastic way in which teacher Divan taught his learners to sing the song *Sliding up and down* as part of a problem-solving task through singing. With the help of the song’s music score on a transparent sheet, he repeated the song a few times while the learners followed until they could sing the song with confidence. What was most noteworthy about teacher Divan's approach was how he made singing the song *Sliding up and down* a fun and enjoyable problem-solving task for the learners.

The participants facilitated and interacted with the learners by providing suggestions, but not answers, to the problems. By asking questions such as *why*, *how*, *what if*, and *what*, the teachers triggered the learners' independent thinking. Teacher Anke contributed that the more she complimented the group's determination or encouraged the learners to find multiple answers to the problem, the better their responses were.

During the lesson where the learners had to measure the length of straws 2,5 cm longer or shorter than the others, the researcher observed that the learners struggled significantly. Only a few learners were able to measure the straws correctly. However, when the teachers gave the learners time to think about the problem and evaluate different solutions, more of them were able to measure the straws correctly. The researcher concluded that it is vital for teachers to allow learners enough time to evaluate various problem-solving solutions. In some cases, the process of solving a problem can be more significant than the answer itself.

The participants noted that the learners had a deeper understanding of the subject matter after participating in the problem-based activities. According to teachers Divan and Marlise, the learners applied their prior knowledge to solve new problems, leading to a level of understanding that would not have been possible with traditional teaching methods. Teacher Anke expressed satisfaction in seeing the learners apply their knowledge to solve real-world mathematical problems, which are a part of our daily lives. Teacher Naylene, another participant in the study, observed that the problem-solving tasks provided a chance for learners to reflect on their existing knowledge and apply it to solve novel problems. She found that this process helped her learners develop a deeper understanding of the material and increased their confidence in their ability to tackle challenging tasks.

After the integrated music-mathematics lessons, the participants provided feedback on their experience with the problem-based learning approach. The interviews and observations conducted with each participant revealed their delight in the approach. The participating teachers described their teaching experience using adjectives such as “meaningful”, “exceeded my expectations”, and “enjoyable”.

Teacher Sebastian responded to his initial concern that problem-based learning could affect the quality of his teaching. According to him, the problem-based approach enhanced teaching and learning as he was able to bring out the best in his learners and enable them to think creatively. Teacher Marlise conveyed her pleasant surprise as her learners demonstrated capabilities beyond what she had imagined. Each group in her class used a different, yet useful approach to identify the problem before discussing and debating possible solutions. Teachers Divan, Anke, and Sebastian all agreed that they had underestimated the learners in their classes, as these learners were more than capable of providing solutions to new problems. The teachers who participated in this study were astonished as they did not expect their learners to adjust so easily to problem-based learning. One of the participants noted that the problems presented to the learners were relevant to their world, which made the approach enjoyable for them. Another teacher agreed, stating that learners enjoy a challenge.

All the participants responded positively towards the implementation of problem-based teaching and learning. Teachers Marlise and Amy mentioned that the problem-based tasks provided their learners with opportunities to expand their knowledge and develop valuable skills. According to teacher Anke, problem-based learning benefited the learners as they were actively engaged with real-world problems. Despite initial doubts about problem-based teaching and learning, teacher Sebastian noted: “It was inspiring to witness how the learners were capable of expressing their opinions and learning independently”. The participating teachers expressed their enthusiasm for problem-based teaching and learning, citing its ability to expand learners' knowledge and actively develop valuable skills.

5.3.1.3 Creative Learning. All the participating teachers remarked that prior to presenting the research lessons, they had not incorporated creative activities into their learners' assignments. Teacher Anke admitted that she had never considered mathematics in a creative way before. Similarly, teacher Divan noted that his learners had never engaged in creative activities during class. Therefore, the participants were enthusiastic when they described the excitement the learners felt when they engaged in various creative activities involving music and mathematics.

The learners devised unconventional methods to solve problems and demonstrated creative ways in applying mathematical concepts. These instances of creative thinking were noticeable to the participants, who expressed joy in witnessing their learners’ positive and innovative problem-solving approaches.

According to teacher Amy, the creative tasks fostered positive attitudes among the learners, building confidence and interest in completing the work. She emphasised the significance of engaging and inspirational activities, noting that learners tend to thrive when their imaginations are challenged, as these tasks inspire them to think independently and develop their critical thinking skills. Moreover, teacher Amy held the belief that the diverse and creative methods used by learners to connect mathematical and musical concepts contributed to a deeper comprehension of these ideas. Teacher Marlise also realised that she had not fully embraced creative methods of teaching and learning. She noted that the integrated music-mathematics lessons showed that learners should be exposed to more creative tasks. In her opinion, the integration of the two subjects in a series of lessons encouraged creativity. She highlighted that the concepts presented in both subjects stimulate creativity in the learners, requiring them to approach learning problems from a fresh perspective and see them in a new light.

Teacher Divan supported the previous comments, acknowledging that he never would have thought that a creative assignment would have such a positive impact on his learners' understanding of the learning content. He discussed the connections his learners made between music and mathematics which improved their understanding of the concepts by allowing them to experience the relationships between the two subjects. He observed that because the learners had to be open-minded to explore new possibilities, they had to think deeper, thereby improving their understanding.

The researcher observed that when teachers encouraged creative and independent thinking and created an environment where learners were not afraid to think independently, learners were more inventive in the integrated music-mathematics lessons.

5.3.1.4 Integration Across Disciplines. As part of the semi-structured interviews (Phase 2), the researcher asked the participants about their perceptions of the integration of music and mathematics. According to the participants, engaging learners through activities such as singing and moving to the rhythm was a new approach to teaching and learning. Teacher Marlise revealed that she never knew music and mathematics could be integrated, while teacher Anke found it very interesting that music could be integrated with mathematical concepts such as symmetry, length, and time. Although teachers Divan and Sebastian occasionally use background music to create a calm and relaxing class atmosphere, the other teachers do not use any form of music in their classes.

However, most of the teachers who participated in this study showed eagerness to investigate an approach to teaching and learning that gives priority to the holistic development of learners, which includes their cognitive, physical, and emotional aspects. According to the participants, creating a positive and supportive atmosphere is crucial for fostering a love for learning.

The findings highlight the participants’ experience of the integrated music-mathematics lessons as relevant. Teacher Sebastian confirmed that various aspects of music and mathematics were combined in a meaningful way. Teacher Divan shared that before the integrated music-mathematics lessons, he did not have the opportunity to connect with his learners on an emotional level. However, with the new integrated approach, he was able to establish deeper connections with his learners and create a more meaningful learning experience for them.

Both teachers Anke and Amy commented on the rich content of the integrated music-mathematics lessons. They observed a transfer from surface learning to deep understanding among the learners as they had opportunities to perceive innovative relationships between the concepts. Teacher Amy also observed a higher level of critical thinking and understanding among her learners, as they were taught the concepts from different perspectives. Similarly, teacher Marlise noted that the combination of music and mathematics enhanced the learning experiences, allowing learners to make meaningful connections by exploring concepts in different ways.

These activities, as pointed out by teacher Anke, focused on the whole learner. She explained that the integration of active and varied musical activities helped make learning mathematics a more concrete experience for learners who may struggle with understanding abstract and difficult mathematical concepts.

While the teachers involved were receptive to incorporating music to enrich mathematics, two participants encountered difficulties. One of them initially struggled with confidence in teaching the musical aspect. Facing nervousness and hesitancy at first, this participating teacher found it challenging to initiate the lesson. To offer support, I stood up from the back of the classroom, offering assistance with the projector slides. This intervention proved instrumental in improving the participant's confidence to teach the integrated music-mathematics lessons. Another challenge was that the generalist teachers were not always familiar with the correct subject-specific language. Despite the integrated music-mathematics lessons avoiding complex musical concepts and being crafted to be taught by any generalist teacher, this reality can have implications for the effectiveness of teaching and learning.

The participants agreed that the integration of music and mathematics was a powerful motivator for the learners. It created a positive learning environment that engaged not only their cognitive abilities but also their physical and mental faculties. The participating teachers observed that the integration of music and mathematics resulted in increased learner engagement and enjoyment of the concepts being taught in a unique and interesting manner.

Teacher Divan mentioned that the integration of music and mathematics has provided him with a new and interesting way to teach his lessons, making the lessons more relevant and engaging for his learners. By incorporating different teaching techniques, he can make his teaching more varied, exciting, and enjoyable, which ultimately leads to better learning outcomes for his learners. The participants agreed that the integration of music and mathematics in education has highlighted the importance of a holistic approach to teaching and learning, where the cognitive, physical, and emotional needs of learners are taken into consideration for a more meaningful and engaging learning experience.

5.3.1.5 Authentic, Real-Life, and Real-World Learning Experiences. The participants expressed enthusiasm for the integrated music-mathematics lessons, which offered their learners practical learning experiences rooted in real-life situations. Rather than relying on traditional lecture-style teaching methods, the teachers actively engaged the learners and encouraged them to become dynamic participants in the learning process by incorporating relevant examples and tasks that connected to their personal experiences.

Teacher Divan emphasised that an authentic approach enhanced the learners' engagement in activities, which in turn improved their learning. He explained that the integrated music-mathematics lessons were rooted in real-life circumstances and experiences, which helped make mathematical concepts more concrete. Teacher Divan further noted that the learners acquired valuable and practical skills through these lessons. Teacher Amy echoed his sentiments, adding that learners gained a deeper understanding of concepts by articulating their ideas and actively participating in class. She observed that when learners can relate their learning to their daily lives, it greatly enhances the quality of teaching and learning.

Teacher Marlise opined that the learners are more likely to retain the concepts they learn through authentic teaching and learning approaches, which include real-life and real-world examples. She explained that when learners can observe the practical application of new knowledge in real-life situations, it becomes easier for them to establish connections with their prior understanding, which in turn enhances their ability to remember and recall the information in the future.

Teacher Sebastian observed that the authentic teaching and learning approach had a positive impact on the classroom dynamic, as learners formed a community through their shared learning experience, by observing and listening to each other. Similarly, teacher Naylene believed that an authentic method positively influenced the learners' motivation, citing the learners' high level of interest in the subject matter. She also noted that during the integrated lessons, she received more feedback from the learners compared to traditional lessons, as the learners were able to relate to the content more easily.

Teacher Anke observed that the authentic teaching and learning approach empowered her learners, and she deemed it an essential method to continue using because it taught the learners important skills for solving real-world tasks. She explained that although some learners initially found the assignments challenging, with encouragement, guidance, and collaboration within the group, the learners were able to use their skills and knowledge to successfully complete the tasks.

The teachers who took part in the research discovered that integrating real-life and real-world experiences into their lessons greatly improved their learners' understanding. They shared that this approach not only heightened learner engagement and motivation but also promoted a deeper comprehension of the concepts and facilitated meaningful connections between the two subject areas.

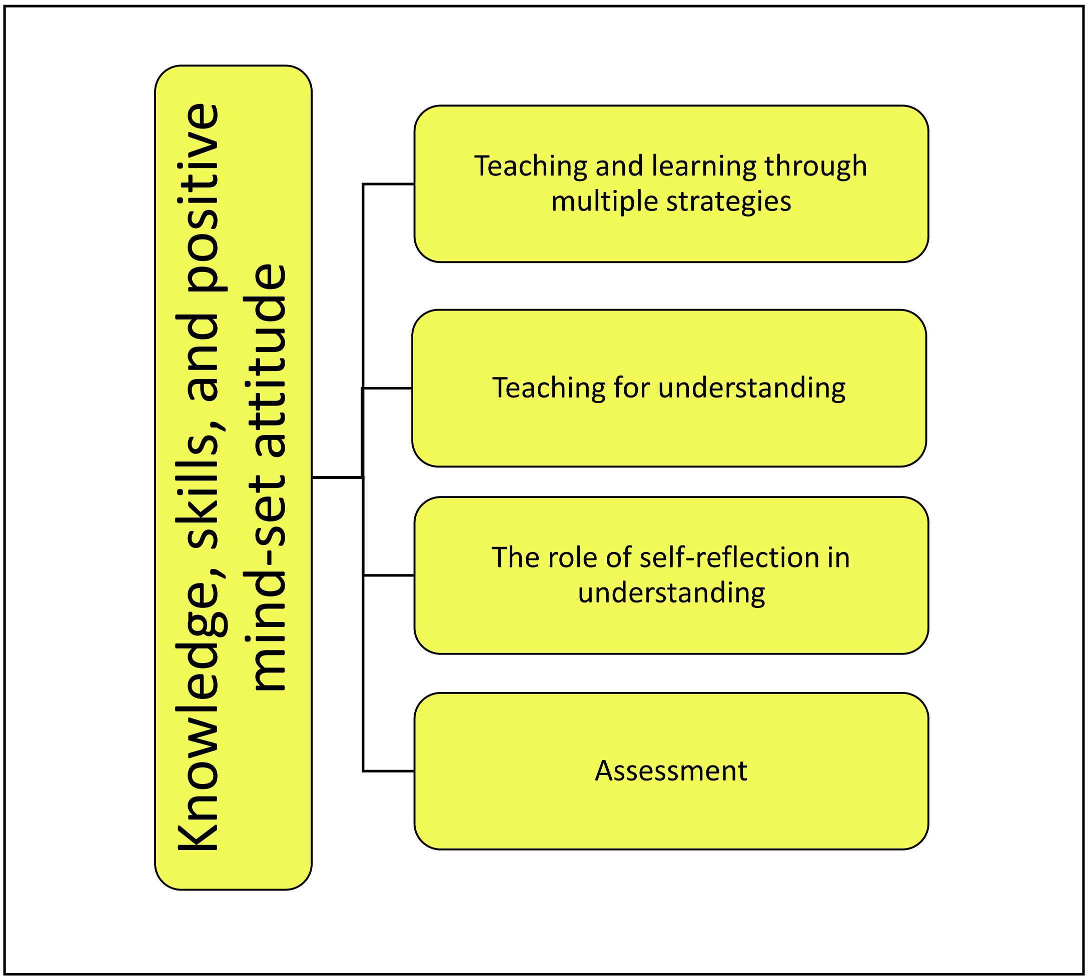
5.3.2 Knowledge, Skills, and Positive Mind-Set Attitude

The data analysis process enabled the researcher to evaluate how the participants experienced different teaching and learning processes to guide learners in obtaining knowledge, skills, and developing a positive mind-set attitude (see

Figure 9). The participating teachers implemented a variety of learning activities during the integrated music-mathematics lessons. As part of the data analysis, the researcher examined the participants' beliefs regarding whether the active application of learners' knowledge, skills, and positive mind-set attitudes made a significant difference in their understanding of the concepts. Furthermore, the participating teachers gave their opinions on the role of self-reflection in understanding. Lastly, the participants' experiences of active assessment tasks will be discussed.

Figure 9

Knowledge, Skills, and Positive Mind-Set Attitude



5.3.2.1 Teaching and Learning Through Multiple Strategies. As part of the integrated music and mathematics lessons, learners had multiple opportunities to demonstrate their understanding of a particular concept in various contexts. They were required to apply their knowledge and transfer it to new situations. The participating teachers observed the learners as they engaged, participated, and applied their knowledge through practical activities.

All the participants acknowledged the importance of creative thinking skills in various activities. Teacher Sebastian stated: "It was fascinating to see how each group approached the same task with their distinct strategies and abilities. No two groups completed the assignment in the same way". Teacher Divan also noted that the diversity of learning opportunities enabled the learners to develop their own perspectives, thereby promoting independent thinking. According to teacher Naylene: "The greater the variety of approaches they use, the more beneficial for learning”. Teacher Anke commented that the learners had a good time, which underscores the importance of making learning enjoyable for students. Furthermore, teacher Marlise highlighted: "A subject can be approached from a variety of angles, and it's essential to recognise this”.

According to teacher Amy, the integrated music-mathematics lessons brought a new dimension to the class by stimulating learners' innovative thinking skills through different learning strategies. The assignments empowered the learners to analyse, reason, and make decisions, providing multiple opportunities for growth. Teacher Sebastian agreed, saying that the learners were engaged in a more interesting and effective learning experience beyond just writing and listening. By incorporating musical elements, such as rhythm and melody, learners were able to actively participate in the lessons through singing, clapping, and playing musical instruments. This not only made the learning experience more interesting but also helped learners to better internalise and retain mathematical concepts. Additionally, the use of various teaching and learning strategies, such as group work, problem-solving, and creative projects, further enhanced learner engagement and made the lessons more effective in achieving conceptual understanding. During a discussion before the integrated music-mathematics lessons, teacher Divan expressed concern that using too many materials and strategies in his teaching would confuse learners. However, after the lessons, he admitted that the variety of activities had brought a new dimension to the class.

During the integrated music-mathematics lessons, teacher Divan noted that the learners remained focused on the task at hand, thanks to their enjoyment of the music activities. Teacher Anke appreciated the fact that the learners were actively engaged in constructing knowledge using multiple senses, including sight, sound, and movement.

Teacher Marlise observed that the learners showed great enthusiasm during the integrated music-mathematics lessons, finding the variety of challenges both enjoyable and constructive. Teacher Naylene added that even learners who struggled with mathematical thinking were able to engage in critical and analytical thinking through the music-mathematics integration. By making concepts more tangible and less abstract, the activities provided a more enjoyable way of exploring mathematical concepts.

According to teacher Amy, the variety of learning opportunities provided during the integrated music-mathematics lessons created meaning for the learners by making tasks relevant to their world. She suggested that teachers create more opportunities for learners to revisit concepts. Teacher Divan agreed, saying that providing a variety of opportunities can help learners master a concept by requiring them to apply their knowledge in different ways. During the semi-structured interviews and discussions, all six participants noted that the learners' understanding of the concepts was enhanced when they could explore their own methods and procedures using various approaches and methods.

During the semi-structured interviews (Phase 1), conducted prior to the integrated music-mathematics lessons, the participants noted that learners often forget what they have learned. However, the participating teachers agreed that the variety of activities used in the integrated lessons had a positive impact on the retention and recall of the content learned, despite the short duration of the study. Teacher Naylene agreed that applying various activities enhanced the learners' understanding of the concepts learned. She noted that the activities were not only effective but also fun, which helped the learners learn more effectively.

The researcher found from the semi-structured interviews (Phase 2) that the participants did not typically use a diverse range of teaching and learning strategies in their own lessons. However, they adapted to teaching and learning through various active activities during the integrated music-mathematics lessons. Teachers Amy, Naylene, and Marlise supported movement and improvisation activities with enthusiasm. Despite lacking previous musical experience, teacher Divan competently assisted learners in understanding how musical notes are arranged on a staff. The researcher was surprised by the participants’ ability to guide the learners in experimenting with different lengths and pitches and easily assist them in exploring sound.

Some of the participants expressed their desire to continue using different learning approaches. Teacher Amy stated that she plans to incorporate varied approaches in her future lessons, while teacher Sebastian acknowledged the need to use a variety of teaching and learning methods more frequently.

5.3.2.2 Teaching for Understanding. The participants all agreed that transferring learners' understanding of concepts from short-term to long-term memory is typically challenging. Teacher Marlise highlighted the importance of revisiting concepts frequently to ensure long-term understanding among learners. This sentiment was echoed by teacher Naylene, who suggested that concepts should be reinforced through a variety of approaches to enhance learners' understanding. The integrated music-mathematics lessons provided the participating teachers with an opportunity to explore and experiment with various approaches, ultimately leading to a better understanding of the concepts taught among the learners.

The participants were inspired to see the potential increase in the learners' understanding during the integrated music-mathematics lessons. According to all the participating teachers, actively applying the learners' knowledge made a significant difference in their understanding of the concepts. Teachers Anke and Marlise confirmed that the learners were engaged enough to transfer the information into long-term memory after the series of integrated music-mathematics lessons. Teacher Sebastian commented that he observed an improvement in his learners' understanding, as they were able to apply their knowledge flexibly to new music-mathematics tasks compared to when they practiced the work through written exercises. Teachers Amy and Anke noted that the learners were able to extend their understanding beyond mathematics by applying their knowledge of time, length, and symmetry to active music activities. They observed that the learners were able to establish their own perspective by considering the concept from different points of view. Similarly, teacher Divan recognised that the learners were able to deepen their understanding of the concepts by revisiting them using multiple strategies.

Teacher Marlise noted that learners were able to construct their own understanding through active discussions. She appreciated their engagement, as they had to explain the outcomes of their assignments. Through these discussions, Marlise observed that the learners were more invested in their own learning and could explain and reason about the concepts in their own words. She also noted that learners felt a sense of ownership and control over their learning, making it more meaningful for them. Additionally, Marlise observed that learners were able to transfer their knowledge without being told what to do by the teacher.

Teacher Sebastian highlighted the benefits of class and group discussions and how it enhanced understanding among the learners. The learners were able to express their own ideas, demonstrating their independence. According to teacher Sebastian, these debates encouraged the learners to think deeply, analyse, explain, evaluate, reason, and compare their ideas, which in turn led to an increase in their understanding. He added that the integrated music-mathematics lessons provided the learners with an opportunity to explore and experiment with various approaches, ultimately leading to a better understanding of the concepts taught through higher-order learning activities. He was confident that the learners' understanding had grown.

According to teacher Anke, asking higher-order questions encouraged her learners to engage in more critical thinking, leading to a deeper understanding of the concepts. She emphasised that these types of questions promoted insight compared to surface-level questions, which only tested the learners' memory. The learners were required to pay attention and think deeply before answering, resulting in an enhancement of their understanding.

Teacher Divan acknowledged that pre-planning higher-order questions is an essential part of the integrated music-mathematics lessons to encourage learners' thinking and reasoning. However, the researcher observed that the participating teachers often did not allow enough time for the learners to think of their answers before responding. When the participants did increase the time allowed for the learners to process the questions, the learners were able to provide more thoughtful and enhanced answers.

Feedback from the participants emphasises the importance of revisiting concepts frequently using a variety of approaches to enhance the retention of learned material. According to the participating teachers involved in the study, learners' understanding of the concepts improved by actively applying their knowledge and skills.

5.3.2.3 The Role of Self-Reflection in Understanding. Self-reflection is an important skill that can improve academic performance (Chen & Chen, 2022). During the semi-structured interviews (Phase 1), when asked how often their learners have the chance to reflect on their mathematical understanding, four out of the six participating teachers reported that they do not provide such opportunities. One of the participants, teacher Naylene, expressed that grade four learners might not be ready to use the skill of reflection effectively.

The integrated music-mathematics lessons offered several opportunities for the teachers to encourage learners' reflection on their own learning. These opportunities included self-reflection through questions, discussions with the class and in groups, as well as self-reflection using rubrics.

The researcher noticed that teachers Divan, Naylene and Anke preferred the question strategy to encourage learners' self-reflection. The participants asked the learners relevant questions about their own performance, as well as that of their fellow learners to encourage self-reflections. Teacher Marlise responded that these questions encouraged the groups to think about the quality of their performances and how their performances related to those of the other groups. By reviewing their own performances, based on the provided criteria given at the beginning of the assignment, the learners took ownership of their own learning by engaging with, and analysing their work, according to teacher Amy. Teacher Naylene agreed that by appraising their own and each other's work, the learners had to think deeper about their tasks and performances as well as the work of their peers to evaluate it effectively. She also noticed that reflection permitted the learners to take a step back to make sense of their performances by examining *what* they accomplished and *how* they can improve in the future.

The researcher noticed that the type of questions asked by the participants played a crucial role. The participating teachers who used the pre-planned reflective questions that were aligned with the task's objectives were more effective in supporting the learners to those who formulated their own questions on the spot without prior planning. Furthermore, the researcher observed that to facilitate self-reflection among learners, the reflective questions posed by participants must be tailored to the cognitive level of the learner, incorporating one or two questions that encourage deeper thinking. Finally, the researcher noted that the participants must allocate adequate time for learners to reflect on their work.

Teacher Marlise believed that the learners engaged in self-reflection within a secure and non-threatening classroom environment, as the reflective questions posed did not have a definite, correct answer. She noted that the learners were comfortable exploring their learning processes, acknowledging both strengths and weaknesses in a realistic manner. Furthermore, the learners displayed a strong commitment to adapt and improve their approaches for future tasks.

The integrated music-mathematics lessons also incorporated self-reflection through discussions. The researcher observed how the participating teachers initiated class discussions by asking open-ended questions that prompted learners to reflect on the concepts they have learned. Teacher Sebastian remarked that this approach fostered active thinking and engagement among learners during the discussion.

According to Teacher Naylene, the dialogue between learners helped them to reflect on their own knowledge and attitude. Through interacting with each other, learners became more attentive and conscious of their own errors and those of their peers. The learners expressed their commitment to being more attentive in the future and avoiding similar errors. Teacher Naylene concluded that meaningful self-reflection gave learners the necessary tools to improve as they had the opportunity to reflect on their own strengths and weaknesses. Teachers Amy and Divan concurred that reflective discussions encouraged learners to share their opinions and perspectives, thereby empowering them to improve their learning.

As part of the integrated music-mathematics lessons, learners reflected on their task performances using a rubric. Teacher Sebastian noted that through these self-reflective rubrics, learners were able to evaluate their progress in the learning process and identify areas for improvement. He expressed a positive attitude towards self-reflection, acknowledging that it could encourage learners to enhance their future assignments, resulting in better academic outcomes. Teacher Anke also noted that rubrics can prepare learners for future practices by providing comprehensive feedback. She underlined that combining a rubric and a checklist is suitable for Grade 4 learners as this approach assisted learners in comprehending the requirements of the task and empowered them to take ownership of their learning process. Although initially sceptical about self-reflection, teacher Naylene discovered that by providing rubrics and checklists, Grade 4 learners found it easy to engage in the process.

The feedback given by participating teachers regarding the learners' performance and tasks had a significant impact on the cultivation of self-reflection. When participant teachers responded with generic phrases like "good" or "well done," their feedback failed to encourage further growth. However, when participants provided meaningful feedback, such as "you used intriguing and imaginative symbols to differentiate between legato and staccato in your melody," it motivated the learners to engage in self-reflection. The researcher noted that teachers' provision of constructive feedback is essential for promoting self-reflection among learners.

5.3.2.4 Assessment. Throughout the integrated music-mathematics lessons, the Grade 4 teachers witnessed their learners demonstrating active application of their knowledge, abilities, and attitudes to new situations with a high level of attentiveness. These active assessment tasks were conducted in various ways, focusing on fostering creativity and innovation among the learners.

During the semi-structured interviews (Phase 4), the participants accentuated that the active assessment tasks were vastly different from the traditional, conservative tests or exam questions they commonly use. Teachers Anke and Marlise both commented on the variety of active assessment tasks, noting that they assessed much more than a typical test. Teacher Anke explained that traditional tests mainly assess what a learner has memorised, while active assessment tasks also assess skills, values, and attitudes that are typically difficult to evaluate in mathematics. Teacher Sebastian also shared this sentiment, stating that attitudes are challenging to assess using traditional testing methods.

Two of the participants, teachers Amy and Divan, appreciated the active assessment tasks that required higher-order thinking. According to teacher Amy: “It was refreshing to see how creatively the learners were involved in the assessment tasks, as they were encouraged to come up with original ideas and take risks”. Teacher Divan shared a similar sentiment: “Problem-solving was not previously used in our classes as part of assessments. An answer was either right or wrong, with no room for inventiveness. The learners enjoyed using their knowledge and creativity to solve real-world problems”.

As opposed to traditional assessments, the participating teachers found the integrated music-mathematics assessment tasks to be more learner-friendly. Teachers Naylene and Amy specifically referred to the stress-free classroom atmosphere that was observed while the learners were engaged in these assessment tasks. Teacher Naylene mentioned:

> The learners demonstrated a positive and relaxed attitude during the integrated music-mathematics assessment tasks, which boosted their confidence in learning. As a result, I am confident that this approach will lead to improved academic performance. Additionally, active assessment tasks that incorporate creativity and problem-solving will provide a more engaging and enjoyable learning experience for learners, which will also contribute to higher academic performance.

In addition, teacher Amy complied that the active assessment tasks increased the learner’s motivation and interest. She explained: “I had the opportunity to praise and encourage the learners while they were working on the assessment tasks. This inspired them to perform at their best”.

Teacher Divan acknowledged that the learners did more than simply provide correct answers. He welcomed their ability to analyse and understand the essential concepts to justify their answers. Similarly, teacher Amy spoke positively about the active role of the learners during the assessment. She stated that the assessment tasks were a more effective measure of the learners' understanding of the concepts than a test. Teacher Amy also observed that traditional tests often only measure a learner's ability to recall facts, whereas the active assessment tasks evaluated their combined skills and performances. Likewise, teacher Sebastian viewed these assessment tasks as a vital and integral part of classroom activities, enabling learners to showcase what they have learned.

The researcher observed that the assessment tasks were more beneficial than a traditional test or exam at the end of a lesson series. The tasks were more efficient and meaningful for the learners, and teachers could provide immediate feedback. According to teacher Amy, her learners were motivated to improve their performance because they could discuss the strengths and weaknesses of their assignments in a positive manner. This made the learners feel more invested in their own learning process.

Teacher Divan expressed his appreciation for the discussions he had with his learners, as they helped him understand what they had grasped and what they still needed to learn. He added that the discussions were not only beneficial to the learners but also to him as their teacher.

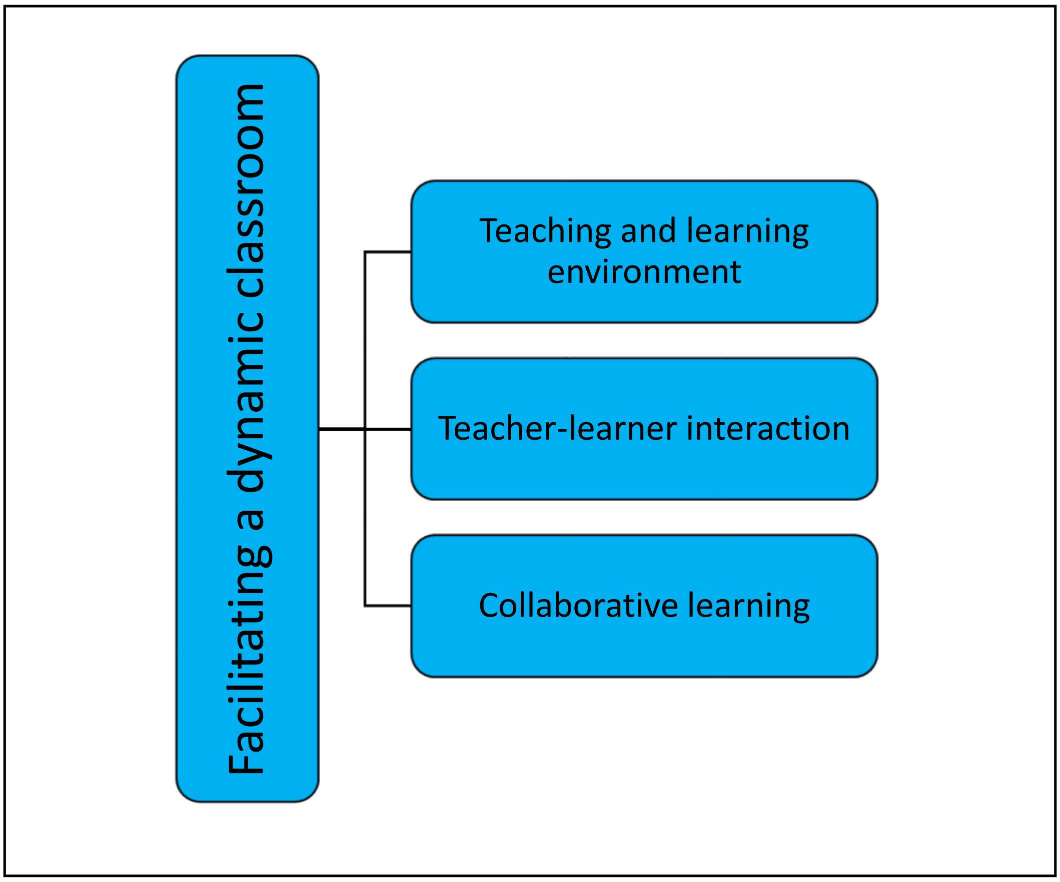
Teacher Naylene expressed her surprise at the variety of active techniques available to teachers for collecting information about their learners' knowledge. She noted: “The assessment tasks were a fundamental part of the learning process. The learners were active participants in the task, rather than just following instructions”. Teacher Anke found the active assessment tasks valuable as they supported different learning styles. She believed that the various assessment strategies could enhance learners' academic performance by accommodating their individual needs and strengths.

5.3.3 Facilitating a Dynamic Classroom

The participants in this study experienced how the implementation of teaching and learning strategies, such as real-life learning, independent thinking, learning through discussions, and small-group collaboration, can create a positive learning space (see Figure 10). As a result, the participants’ experience highlights the importance of creating a supportive and dynamic learning classroom that caters to the diverse needs and preferences of learners.

Figure 10

Facilitating a Dynamic Classroom



5.3.3.1 Teaching and Learning Environment. The participating teachers cultivated a positive and productive learning environment during the integrated music-mathematics lessons. They achieved this by implementing a range of strategies that fostered a dynamic classroom atmosphere.

The physical arrangement of each class deviated from the traditional classroom setup, where the teacher occupies the front while learners are arranged in rows facing forward. Instead, the learners were frequently organised into small teams, displaying flexibility in their grouping arrangements, whether within the classroom or outdoors. The formation of groups in the classroom was not dictated by the teachers; instead, learners naturally gravitated towards their peers based on their proximity. This arrangement proved to be highly effective as it fostered a sense of collaboration and teamwork among the learners. Teacher Naylene specifically highlighted the appropriateness of this seating arrangement, recognising its resemblance to real-life teamwork dynamics. Moreover, the opportunity to engage in lessons in an outdoor setting added an element of excitement and sparked creativity among the learners.

The participants encountered a transformative learning environment for the first time. Teacher Amy expressed her contentment, stating: "I embraced a novel teaching approach that demonstrated greater effectiveness in fostering learner comprehension and active engagement". Teacher Divan contemplated the past lessons, where the primary emphasis revolved around determining right and wrong answers. However, in the integrated music-mathematics lessons, the focus shifted towards the exploration of diverse strategies, and multiple perspectives that ultimately yielded the same correct answers. He discerned the advantages of approaching tasks with originality and ingenuity.

Teacher Marlise eagerly embraced the transformative learning environment and openly acknowledged that she had never experienced such an immersive and interactive teaching style before. She recognised the shift in her own approach and expressed her enthusiasm for the new opportunities it presented. Initially, venturing beyond her established routine induced a sense of nervousness, but she swiftly grasped the significance of embracing diverse strategies and methodologies. She recognised the immense advantages reaped by her learners through this approach, as they were able to absorb knowledge in a more effective and impactful manner.

The participants were in complete agreement regarding the empowering nature of the new learning environment, which encouraged learners to embrace risk-taking, explore diverse solutions, and express themselves without the burden of judgment or fear of making mistakes. Teacher Marlise captured the essence of the supportive learning environment by emphasising that when learners feel safe and nurtured, they can confidently express themselves without the fear of failure. The dedicated efforts of the participating teachers in creating such a supportive environment yielded significant improvements in learning outcomes and overall growth among the learners. Their commitment to fostering an optimal learning experience was evident in the positive outcomes observed.

5.3.3.2 Teacher-Learner Interaction. The implementation of active teaching and learning methods in the integrated music-mathematics lessons positively influenced the interaction between teachers and learners. The participants embraced this new mode of interaction with their learners, as expressed by teacher Divan: "I have never before had the opportunity to engage in such meaningful and interactive interactions with my learners. The level of engagement and connection I experienced with them was truly unique and unprecedented”. Similarly, teacher Anke highlighted the development of a stronger interpersonal relationship between herself and the learners compared to the traditional classroom setting. She emphasised the challenge of effectively engaging with all learners in a traditional classroom setup. However, by adopting a learner-centred approach, she discovered the opportunity to personally interact with each learner at least once during every lesson. Teacher Sebastian also recognised the advantages of heightened interaction, acknowledging that he now had the opportunity to identify and address learners' challenges more effectively. The improved teacher-learner interaction within the integrated music-mathematics lessons brought a heightened sense of fulfilment to the teachers.

The researcher observed a notable spirit of collaboration and receptiveness among both teachers and learners. Whenever a learner needed support, the participating teachers were readily accessible and maintained a close, personal connection with the learners.

The positive teacher-learner relationship had a significant impact on learners' behaviour. There was a sense of mutual respect and understanding between both parties, which fostered a conducive and harmonious learning environment. Whenever a learner required assistance with a task, the teachers approached the situation with friendliness and care, ensuring that the learner felt supported and encouraged throughout the learning process. They offered help in a compassionate and nurturing manner, creating a safe space for learners to seek guidance without hesitation. The participants' adept adjustment to the individual needs of each learner fostered a setting where every learner felt valued and fully engaged. This flexibility in teaching approach resulted in a positive teacher-learner relationship, with mutual respect and understanding. As a result, disruptive or off-task behaviour was rare, and the classroom was more focused and productive.

5.3.3.3 Collaborative Learning. The interviewed participants shared their past negative experiences with collaborative learning, particularly in relation to group work. Initially, they expressed reservations about implementing group activities. However, during the integrated music-mathematics lessons, the participants expressed positive feedback about the use of group work as a teaching and learning strategy. The collected data indicated that group work provide learners with the opportunity to interact with their learning and collaborate towards a common goal.

After the integrated music-mathematics lessons, teachers Anke and Sebastian expressed their views on the effectiveness of collaborative learning in enhancing learners' creativity and problem-solving skills. Teacher Anke observed that group work allowed the learners to gain a better understanding of concepts through critical discussions and creative problem-solving, and they were motivated by each other's opinions. Likewise, teacher Sebastian commented that group work enabled learners to explore different strategies to find the best solutions for problem-solving tasks, thus enhancing their learning.

Teacher Amy observed a healthy sense of competition among the groups during the integrated music-mathematics lessons. Teacher Divan also acknowledged this and noted that the learners worked harder when they were working in groups as opposed to working individually.

The researcher noticed that the use of small groups facilitated better control for the participants. It became simpler to monitor and guide their progress, ensuring that all learners remained focused and actively involved in the learning activities. With the reduced number of learners in each group, the participating teachers could provide individualised attention and support, addressing the specific needs of each learner more effectively. This enhanced level of control enabled a more structured and engaged learning experience for everyone involved.

The success of collaborative learning during the integrated music-mathematics lessons was attributed to several factors, according to the researcher. Firstly, the manageable number of groups ensured effective monitoring by the participating teachers and promoted involvement by every learner in the group. Secondly, the participants actively facilitated and guided group interactions, while also relinquishing some responsibility to the learners. Thirdly, the participating teachers gave clear instructions that allowed the groups to work independently on problem-solving tasks. Finally, the tasks were given a time limit, which encouraged the groups to work quickly and effectively, thereby reducing disruptive behaviour.

5.4 Conclusion

This chapter has presented the themes and categories that emerged from the research, specifically focusing on the experiences of the participating teachers as they integrated music and mathematics into their teaching and learning approaches. The analysis of the collected data generated valuable insights regarding the challenges, perceptions, and benefits associated with the integration of music and mathematics. In the subsequent chapter, the researcher will present the findings of the study, offering a detailed account of the outcomes.

Chapter 6: Discussion

6.1 Introduction

Chapter 6 presents the findings of the study. The research aimed to investigate the experiences of generalist teachers, who had no prior experience in teaching music, regarding the implementation of integrated learning approaches and assessment strategies that connect concepts and learning experiences in both music and mathematics. With constructive alignment as a guiding framework, the researcher designed teaching and learning activities that facilitated the optimisation of mathematical learning through musical enrichment. The participants presented these lessons to their respective classes and shared their experiences regarding the reinforcement of mathematics with the aid of music. These contributions were subsequently analysed, resulting in the discovery of findings and the emergence of thematic patterns. Chapter 6 is a synthesis of the literature study, the analysed data and the emergent themes that developed in the findings.

6.2 Thematic Discussion

The analysis of the collected data revealed three interconnected themes: teaching and learning approach, knowledge, skills, and positive mind-set attitudes, as well as facilitating a dynamic classroom (see Figure 11). These interconnected themes improved the comprehension of how generalist teachers in the Intermediate Phase elevate mathematics through the incorporation of music.

Figure 11

Interrelated Themes

Additionally, these themes gave rise to several categories, which were discussed in detail in Chapter 5.

6.3 Teaching and Learning Approach

The transition from teacher to facilitator, aimed at providing effective education, has presented both challenges and opportunities for the participants. Participating teachers accentuated the potential of problem-based learning to foster a deeper understanding of the subject matter among learners. Embracing a creative learning approach, the participants provided authentic opportunities for learners to explore and apply concepts. The integrated music-mathematics lessons equipped the participants with practical strategies to integrate creative approaches into their teaching practices. Integrating purposeful tasks with real-world applications effectively cultivated learners' active engagement and intrinsic motivation. Findings of this study reveal that the multifaceted benefits of the observed pedagogical approaches, particularly the enhancement of mathematics through music, hold the potential to transform educational practices.

6.3.1 From Teacher to Facilitator

The role of teachers in learner-centred and active learning methodologies are transforming into that of facilitators who guide the learning and discovery process in learners (Capogna, 2017; Goodyear & Dudley, 2015; Jagtap, 2016). Alongside the acknowledgment of the need to relinquish control, the participants of this study embraced their role as facilitators in the learning process. They comprehended the significance of cultivating collaboration between facilitators and learners to enhance active learning and engagement. This notion corresponds with the perspectives of Lunenburg & Ornstein (2012) and Singh & Yaduvanshi (2015), who assert that the teacher's facilitative role nurtures a supportive and nurturing learning environment. Within this setting, learners are motivated to delve into exploration, inquiry, and connections grounded in their personal experiences (see Section 2.5.1). The participants observed the positive impact of assuming the facilitator role in integrated music-mathematics lessons and expressed enthusiasm for incorporating music activities into future lessons.

The research findings demonstrate the participants' successful adaptation to the role of facilitators, despite their initial uncertainties regarding effective facilitation. This is consistent with a study conducted by Gillies and Boyle (2010) on a group of teachers who also exhibited the ability to adapt to the facilitator role, despite their initial reservations concerning effective facilitation strategies.

The integrated music-mathematics lessons, supported by relevant teaching and learning material, facilitated the teachers' transition. Through active participation in the study and implementing integrated music-mathematics lessons, the teachers gained invaluable insights, enhancing their understanding of effective facilitation techniques. This is in line with Keiler's (2018) emphasis on the necessity for effective strategies to support teachers in adopting a learner-centred approach to teaching and learning.

The participants acknowledged the importance of promoting active engagement among learners in the classroom and offering assistance, advice, and direction when necessary. This comply with Yousafzai's (2020) findings that active involvement in the learning process helps learners cultivate a more profound grasp of the material and interact with it in a more substantial manner, consequently enhancing their motivation to sustain their learning trajectory (see Section 2.4). Kloosterman and Taylor’s (2012) findings also support the promotion of active learning engagement and emphasise the importance of cultivating teamwork between facilitators and learners to enhance active learning and engagement. Observing the positive impact of assuming the facilitator role during integrated music-mathematics lessons, the participants expressed enthusiasm for incorporating music activities into future lessons.

Despite encountering initial challenges, such as relinquishing constant control over learners and entrusting them to independently solve problems, the participants embraced their role as facilitators, resulting in positive results, including heightened critical thinking abilities, increased creativity, and enhanced learner engagement. This observation finds support in the study conducted by Lei et al. (2018), where similar positive outcomes contributed to attaining academic success.

Maher and Seach (2016) in conjunction with Merriam et al. (2007) highlighted in their respective studies the significance of establishing a supportive and engaging environment. Similarly, the participants of this study recognised the role played by teachers in guiding, supporting, and empowering learners, which greatly contributed to cultivating effective teaching and learning within a learner-centred setting, resulting in enhanced engagement. The teacher participants also acknowledged the significance of creating a supportive and engaging environment through the application of scaffolding and direct instruction when necessary, finding a balance between fostering independence and providing structure in the learning process. This approach allowed learners to thrive and develop their skills while still benefiting from the necessary guidance and support.

6.3.2 Problem-Based Learning

Problem-based learning (PBL) is an instructional method that places the learner at the centre, applying real-world scenarios to cultivate practical problem-solving skills (Kraft-Terry & Wiebe, 2022; Sebatana & Dudu, 2022). It aims to develop an analytical approach in learners and encourage a strong sense of ownership over their own learning (Lapek, 2018; Wiggins, 2016). The research findings demonstrate the participants' clear understanding of their roles as facilitators, particularly highlighting the impact of problem-based learning in integrated music-mathematics lessons. By incorporating problem-based learning into the teaching and learning approach, the participants experienced its potential to nurture a deep understanding of the subject matter among learners. This observation conforms with Ali’s (2019) affirmation, highlighting problem-based learning as an effective framework for learners to develop problem-solving abilities and gain a deeper comprehension of the learning material.

The participants in the current study noted an increase in learner confidence. This positive attitude towards learning is consistent with the research conducted by Orji and Ogbuanya (2020), which highlighted how problem-based learning taps into learners' intrinsic motivation by allowing them to explore topics of interest and curiosity. Moreover, the participating teachers noticed a significant reduction in learners' fear of making mistakes. Learners in this study exhibited enhanced risk-taking tendencies and greater self-confidence. This finding is in harmony with the research conducted by Smith et al. (2022), who similarly concluded that problem-based learning cultivates a learning environment where failure is embraced as a natural part of the learning process. Deno (2005) and Lodge et al., (2018) also advocate that when learners encounter challenges or setbacks in problem-solving, they are encouraged to learn from these experiences and explore alternative solutions, which significantly contributes to their personal growth and self-assurance (Yew & Goh, 2016).

In this study, the participants observed that learners displayed an improved application of their prior knowledge to solve new problems, surpassing the level of understanding achieved through traditional teaching methods. By incorporating music into the learning process, learners were further motivated to draw upon their existing knowledge, engaging in reflection and creative application to address novel challenges. This experience resonates with the research by Capraro and Jones (2013), which states that problem-based learning promotes interdisciplinary teaching and learning, facilitating the integration of various subject areas (see Section 2.5.1.2).

The positive experiences shared by both participating teachers and learners highlight the significance of problem-based teaching and learning. Not only does it enhance learners' understanding, but it also cultivates essential skills, all the while fostering active engagement with real-world issues. The participants' experiences comply with Cain and Cocco's (2013) emphasis on the contextual nature of learning, involving learners in hands-on exploration of authentic and meaningful problems that mirror the challenges encountered (see Section 2.5.1.2). Lapek (2018), also affirm that problem-based learning is a learner-centred instructional approach that applies real-world scenarios to nurture problem-solving skills in practical situations. The enthusiasm expressed by the participants further underscores the potential of problem-based teaching and learning as an effective approach to enhance teaching and learning models in the Intermediate phase.

6.3.3 Creative Learning

Creative learning in education refers to an innovative and dynamic teaching and learning approach that prioritises the nurturing of learners' creativity, imagination, and original thinking (Collard & Looney, 2014; Harris & De Bruin, 2017; Kettler et al., 2021). Initially, the participants held the belief that mathematics was not a creative subject, perceiving it as a rigid and formulaic discipline governed solely by rules and calculations. However, this notion contradicts the perspective presented by Cremin and Barnes (2018), who contend that creativity is not confined to specific subjects. As the learners immersed themselves in creative problem-solving tasks, they underwent a significant transformation in their perception of the role and importance of creativity. They discovered intricate patterns, symmetries, and captivating relationships within mathematical concepts that ignited their curiosity and imagination. This notion resonates with Moate and Cox (2015), who suggest that rather than just transmitting information, teachers should pose challenges and stimulate curiosity, creating an environment that nurtures active engagement and independent thinking (see Section 2.5.1).

In this study, the integration of creative music tasks served as a catalyst for promoting divergent thinking among learners. Through these tasks, learners were motivated to explore a variety of solutions and viewpoints, fostering creativity in both problem-solving and decision-making processes. This harmonise with the perspective of Fox and Surtees (2010), as discussed in Section 2.6, which highlights how active participation in music-making activities not only boosts attention but also nurtures creativity and encourages persistence in mathematical tasks. Lewis and Lovatt’s (2013) research also demonstrated that music fosters creative thinking abilities. Through the learners’ active engagement in the integrated music-mathematics lessons, they not only developed a comprehensive awareness of the intricate facets of creativity but also gained a significant understanding of music’s potential in enriching the educational journey. With their newly acquired knowledge and understanding, the participants were well-prepared to integrate inventive and imaginative teaching methodologies into their instructional practices. As a result, their learners enjoyed dynamic and enriching learning experiences, similar to the findings reported in the study conducted by Fan and Cai (2022).

The participating teachers expressed that the inclusion of creative tasks actively encouraged learners to explore the intricate interrelationships between music and mathematics, resulting in higher levels of thinking and comprehension. This finding synchronise with Hallam's (2010) research, which also demonstrated that learners' understanding was enhanced through active engagement with music. Armed with a keen awareness of the significant impact of creativity in education, the participants embraced the integration of music and mathematics into their teaching practices.

The current study illustrates that fostering creativity is deeply dependent on the learning environment. This finding resonates with Crossman's (2013) study, which revealed that to promote creative thinking and learning, teachers must confront the challenge of cultivating a safe and secure environment through the design of learner-centred activities, while actively encouraging freedom, exploration, and inquiry among learners. The present study further highlights the significance of teachers nurturing a belief in their learners' own creative potential. The study's participants recognised the significance of offering praise to learners for their efforts and celebrating their creative contributions, irrespective of the outcome. As discussed in Section 2.4, Nakano and Wechsler (2018) emphasise that creativity is a skill that demands cultivation, necessitating teachers to foster, enrich, and prioritise creativity in the classroom to empower learners. These affirmations played a pivotal role in fostering learners' self-confidence and intrinsic motivation, leading to a greater willingness to actively embrace creative thinking and expression. Reid and Petocz (2004), further underscore the transformative impact of positive reinforcement on learners' creative development and active engagement in the learning process.

This study underscores the indispensable role of teacher’s own creative capacities in effectively fostering creativity in learners. Venter and Viljoen, (2020) and Zulkifli et al. (2022) indicate that by serving as role models and exhibiting creative behaviours, teachers wield a substantial influence in cultivating creativity within the classroom (see Section 2.4). To implement creativity in practice, the participating teachers in this study recognised the necessity of expanding their comprehension of creativity and embracing various creative approaches, enabling them to adeptly integrate creative teaching methods into their instructional practices. Cremin and Barnes (2018), also accentuated the importance for teachers to broaden their understanding of creativity and creative practices to effectively teach and foster creativity among learners.

Initially, the participating teachers held the belief that incorporating creativity into the curriculum would consume too much time, despite it being explicitly stated as a vital aspect of teaching and learning in both music and mathematics (Department of Basic Education, 2011a). However, they discovered that by effectively planning creative tasks, these creative elements seamlessly integrated into the lessons, dispelling the notion that creativity should be treated as a separate entity.

In the current study, it was demonstrated that investing in creativity yielded time-saving benefits, as learners developed a deeper comprehension of the subject matter, which resulted in a reduced need for repetitive information. Samson's (2015) study also highlighted the advantages of incorporating creative problem-solving tasks into the learning process, ultimately enhancing learners' understanding of the material.

6.3.4 Integration Across Disciplines

The process of integrating across disciplines in education goes beyond teaching subjects in isolation (Aguilera & Ortiz-Revilla, 2021; Belbase et al., 2021; Conde et al., 2021). Instead, it seeks to create meaningful connections between different academic areas, encouraging teaching for deep and comprehensive knowledge (Vasquez et al., 2013). The collected data illustrated that integrating music into mathematics lessons enhanced learners' grasp of concepts, critical thinking, and problem-solving skills. Wiggins (2001), as highlighted in Section 2.6 of this study, concurred by stressing that the combination of music and mathematics strengthens learners' comprehension of mathematical concepts while nurturing their problem-solving skills and critical thinking abilities. This resonance finds further support in the studies conducted by Lovemore et al. (2021) and Walsh and Coleman (2023). The interdisciplinary approach applied in this study had a positive impact on both the participants' instruction and the learners' attitude towards learning. It encouraged learners to actively engage with captivating concepts, resulting in an enrichment of knowledge and skills, which aligns with the findings of Jones (2009) and Stavrou et al. (2011).

The participants recognised that the integration of diverse and interactive musical activities offered a transformative learning experience for learners who initially struggled with abstract mathematical concepts. By immersing themselves in the captivating realm of music, participants observed that learners could effectively bridge the gap between the abstract nature of mathematics and their own comprehension. Music facilitated a deepening of learners' conceptual understanding of mathematics, a vital facet for excelling in the classroom (Mills, 2019), as elaborated upon in Section 2.4.3. This finding further correlates with the study conducted by Martínez-Jiménez et al. (2019) on the advantages of combining both subjects, which was applied by students pursuing a degree in primary education. The incorporation of music as a tool in this research enabled learners to visualise and experience mathematical concepts in a tangible and relatable manner, thereby unlocking their potential to grasp complex ideas and apply them with confidence. This integration not only facilitated a concrete understanding of mathematics but also instilled a sense of empowerment and accessibility, breaking down barriers that impeded learners' progress in the subject. Trinick et al. (2016) similarly found that integrating music and mathematics supports and enhances deep understanding of concepts among learners.

Learning mathematics can tap into various emotions and connections. The joy of solving a challenging problem can be a real emotional high. Yet, frustration is real when a learner struggles with a problem. There's also a sense of accomplishment and confidence that can come from mastering mathematical concepts. When the learners saw how math applies to real-life situations, it created a deeper emotional connection, making it more meaningful. Combining music and mathematics enhanced the emotional experience of learning (Luczak, 2021).

The teachers who participated in the study valued these integrated lessons, as they allowed learners to construct meaning through active participation in music and mathematics activities. Chrysostomou (2004) also acknowledged the impact of music in facilitating meaningful connections between both music and mathematics concepts. The incorporation of music and mathematics granted learners in this study the chance to delve into the interplay between these subjects. This shift facilitated a transition from surface-level learning to a more profound comprehension and enhanced critical thinking. As outlined in Section 2.6, embracing an integrated teaching and learning approach presents a range of benefits. These include an enhanced understanding of mathematical principles, elevated academic achievement in mathematics (Bairy, 2019; Lim et al., 2017), a stimulating and investigative learning environment (Scott, 2006), and a more profound and meaningful learning journey (Trinick et al., 2016).

The interdisciplinary approach in this study made it possible to incorporate diverse content and instructional methods, effectively enhancing learner engagement, enjoyment, and comprehensive development by addressing their cognitive, physical, and emotional requirements. Belbase et al. (2021) and Russell and Zembylas (2007) provide support for these findings, highlighting the value of integration in creating comprehensive, engaging, and holistic learning experiences for learners.

The participating teachers observed that the integration of music and mathematics sparked learners' curiosity and encouraged them to explore new ideas and approaches. Omigie and Ricci (2022) agree in their study that integrating music is an effective teaching method to enhance curiosity. Participating teachers also concur that through the integration of music into mathematical activities and vice versa, learners managed to establish meaningful connections between the two subjects and cultivate a more encompassing outlook on how they intersect within real-world contexts. As noted in Section 2.6, an integrated curriculum empowers learners to apply their acquired knowledge in practical situations, fostering a positive learning attitude and heightened engagement (Adams, 2007; Lujan & DiCarlo, 2017). Deonath and Jaggernauth (2021) also support this finding in their study, highlighting that the integration of music and mathematics generated interest among learners to connect learning to real-world situations. In this recent study, the integration of music and mathematics cultivated an appreciation for the aesthetic aspects and intrinsic elegance of both disciplines, thereby enhancing learners' overall enjoyment and engagement in the learning process.

6.3.5 Authentic, Real-Life, and Real-World Experiences

Authentic, real-life, and real-world experiences in education connect classroom learning with practical situations, enabling learners to apply knowledge to real-life scenarios and understand subject relevance beyond the classroom (Payne, 2022; Stanley, 2021; White, 2021). In this study, the participants' ability to foster practical application and transferable skills among learners emerged as a vital factor that significantly enhanced the teaching and learning experience, similar to the findings of Gainsburg (2008) and Tran and Nguyen (2020). The integration of music and mathematics underscored the significance of tailored learning, wherein learners were encouraged to apply their classroom knowledge to authentic contexts. The research conducted by Mebert et al. (2020), also highlighted the positive impact of integrating music and mathematics in creating meaningful learning experiences.

The impact of the authentic approach on the participating teachers' and learners’ enthusiasm and engagement was significant. Learners actively connected what they learned in the classroom to practical situations, resulting in a heightened level of engagement. Benson-O'Connor et al. (2019) and Mebert et al. (2020) conducted studies applying authentic learning experiences to connect learners' lives to the world around them, and both studies reported positive outcomes.

In this study, the participants not only recognised the significant role that authentic interaction played in engaging learners but also highlighted its contribution to fostering a more profound grasp of the subject matter and inspiring learners to apply their gained knowledge in meaningful contexts. This concept corresponds with the views expressed by Bransford et al. (2000) and Rillero (2016), who emphasise that for learners to optimise their potential for learning, they should aim for a comprehensive understanding of the study materials and the ability to apply that knowledge beyond the classroom setting (see Section 2.4). Similarly, Cheng et al. (2019) reported substantial positive changes resulting from authentic learning experiences, as they were found to enhance learners' cognitive advancement, collaborative efficacy, and problem-solving proficiency. These findings further validate the idea that engaging learners in authentic interactions not only deepens their understanding but also equips them with valuable skills that extend beyond the boundaries of traditional learning environments.

The benefits of active real-world application were clearly demonstrated through the heightened interest and dedication of learners in the learning process within this recent study. Enghag et al. (2007), as explained in Section 2.4, elaborate that bridging the gap between classroom instruction and real-life experiences results in the learning material becoming more engaging, interesting, and meaningful for learners. Quigley and Herro (2019) provide further support to these observations, as their research discovered that real-life and real-world application through an interdisciplinary approach can positively influence learners' perception of reality, fostering a more interconnected and deep understanding of the subject matter.

Based on the participants' experiences in this study, it is evident that the integration of real-life and real-world experiences into music-mathematics lessons offers significant benefits. By incorporating music and mathematics concepts as part of their instructional practices, the participating teachers observed remarkable improvement in the learners' ability to make meaningful associations between music and mathematics, resulting in a holistic approach to learning, in line with the research of Carter et al. (2021) and An and Tillman (2015). Through the integration of music and mathematics, the participants observed how learners acknowledged the relevance and practicality of their education. This, in turn, led to an enhanced understanding of the subject matter and an increased motivation to engage with the content. As confirmed by Hajian (2019), learners who genuinely comprehend possess the capability to adeptly transfer and apply concepts to real-life situations (see Section 2.4.1). The emphasis on practical application and transferability of skills allowed the participants of this research to witness first-hand how learners developed the necessary competencies to navigate real-world challenges and contribute meaningfully to various situations or environments. These valuable experiences underscore the critical importance of establishing strong links between theoretical knowledge and practical experiences (Morley & Jamil, 2021).

The dynamic involvement observed by both the researcher and participants led to the learners establishing personal connections between themselves, the knowledge being imparted, their peers, and the real world. As a result, the educational environment in this study became vibrant and dynamic, fostering a deep sense of meaning and engagement among the learners. Herrington et al. (2014) also documented that authentic learning significantly enhances the real-world classroom environment, resulting in a comprehensive level of teaching and learning.

Through the integration of purposeful tasks and assignments with real-world applications, the participants fostered active engagement among learners in activities that extended their intrinsic motivation. This resonates with the discussion in Section 2.2 where Hailikari et al. (2021) assert that employing a constructive alignment approach directs attention to learners' active engagement and the deliberate construction of knowledge. As highlighted by Fredricks and McColskey (2012), internal motivational factors driven by individual factors rather than external incentives can fuel learners to demonstrate unwavering determination, exceptional proficiency, and steadfast commitment to their educational endeavours. The data collected from this research, along with the findings of Da (2023), Lowell and Yang (2022), and Wiggins and McTighe (2011), supports the notion that fostering a strong sense of competence and independence, and promoting connections within the learning environment, positively influences learners' overall learning experiences, leading to increased motivation and resilience in their educational pursuits.

6.4 Knowledge, Skills, and Positive Mind-Set Attitude

In the context of the research, the participants' commitment to continuous improvement and growth, coupled with their dedication to nurturing knowledge, skills, and a positive mind-set attitude, formed the foundation for the discussion on effective teaching practices. In addition, the participants' insights and reflections on the integration of music and mathematics provided valuable contributions to the broader discourse on integrating music and mathematics in the Intermediate Phase.

6.4.1 Teaching and Learning Through Multiple Strategies

Teaching and learning through multiple strategies represent an instructional methodology that applies diverse methods, techniques, and resources to accommodate a wide array of learning styles and preferences (Cipriano, 2023; Tishkovskaya & Lancaster, 2012; Westwood, 2008). Identifying the importance of refining their teaching strategies, the participants in this study proactively pursued ways to enhance their instructional methods and approaches. Gravett and Petersen (2022) investigated the active engagement of teachers in professional development opportunities, where they reflected on their teaching practices and equipped themselves with the most effective tools to facilitate their learners' pursuit of knowledge and foster their overall success. The present study reflects similar findings, indicating that participants' commitment to continuous improvement not only enhanced their teaching abilities but also demonstrated their commitment to creating an optimal learning environment for their learners.

By embracing a variety of instructional approaches, the participants demonstrated their deep understanding of the interconnectedness between knowledge, skills, and a positive mindset attitude in fostering effective teaching and learning practices. Similarly, as mentioned in Section 2.4.3, teachers play a pivotal role in guiding learners towards a strong conceptual understanding through a variation of well-designed learning activities (Yuliandari & Anggraini, 2021). DeLuca and Lam (2014) and Fizza and Rashid (2023) concur with this finding, highlighting that a teacher's pedagogical expertise is vital for successful teaching and learning, as they must possess the ability to intuitively know how to optimise their learners' capabilities through a variety of strategies.

With a proactive approach, the participating teachers implemented creative strategies to motivate and encourage their learners, consistently addressing their changing needs and adapting to the ever-changing educational environment. Mallillin (2021) also discovered that teachers' pedagogical approaches to empower the classroom environment are vital for the organisation and comprehension of the learning domain. The dedication to ongoing improvement directly influenced the enhanced quality of the participants' instruction. The teachers who participated in this study showcased a comprehensive understanding of the significance of active and intellectual engagement. This perspective coincides with the viewpoints of Willingham (2021) and Sanger (2020), who emphasise the importance of employing diverse strategies to foster effective learning outcomes. This notion is further supported by Section 2.4.2, which delves into the necessity of a diverse range of activities for learners to cultivate a profound understanding of music (Gruhn, 2005). Similarly, Section 2.4.3 underscores that employing various learning strategies allows learners to analyse complex mathematical concepts, thereby facilitating conceptual understanding in mathematics (Fitzgerald & Palincsar, 2019).

Mahama et al. (2023) propose that through the integration of sensory appeals, including captivating visuals, engaging auditory stimuli, and interactive kinaesthetic activities, teachers accurately tap into learners' natural curiosity and effectively stimulate their desire to explore and delve deeper into the subject matter. This perspective corresponds with the argument presented in Section 2.4.2 that, given that music encompasses all the mentioned sensory elements, it serves as an approach through which multifaceted experiences and a variety of music-related activities can enhance knowledge.

The teacher participants in the current study discovered that this strategic incorporation of sensory elements not only captured learners' attention but also fostered an immersive and multisensory learning experience, thereby enhancing their motivation, engagement, and overall comprehension of the content.

Through the integration of music and mathematics, the participating teachers observed that the implementation of diverse learning strategies invigorated innovative thinking skills and encouraged conceptual understanding among the learners, similar than the findings of Lim et al. (2017) and Zhou and Kim (2010). The participants observed how learners became more adept at exploring information, making connections, and engaging in higher-order cognitive processes. This observation underscored the learners' active application of knowledge, skill development, and cultivation of a positive mind-set attitude towards learning, attributed to the implementation of teaching and learning through multiple strategies in this study. In similar studies, positive outcomes were observed when teachers employed effective measures and approaches to expose learners to various settings and interpretations, leading to deep conceptual understanding among learners (Adam et al., 2022; Jawad et al., 2021; Lumpkin et al., 2015).

6.4.2 Teaching for Understanding

Teaching for understanding is an instructional approach that prioritises not only knowledge acquisition but also the development of a profound and meaningful comprehension of the subject matter (Joynes et al., 2019; McTighe & Silver, 2020; Stern et al., 2017). The participants' experiences in adopting this approach had a notable impact on their teaching practices and beliefs. They recognised the importance of cultivating deep knowledge and fostering an extensive comprehension of the subject matter in their learners, as supported by the research of Handayani et al. (2019) and Ku and Ho (2010).

By implementing teaching strategies focused on enhancing comprehension and critical thinking, the participants witnessed significant advancements in their learners' knowledge and skills. These learners demonstrated a heightened proficiency in comprehending concepts and applying them in relevant real-life scenarios. This correlation resonates with the findings of Hajian (2019) and Wiggins and McTighe (2011), suggesting that learners who possess conceptual understanding demonstrate the competence to transfer and apply concepts to real-life situations, as illustrated in Section 2.4.1.

The participating teachers underscored the transition from a conventional approach centred on memorisation and rote learning of content to one that prioritises conceptual understanding, a finding parallel to the research of Sarrazin (2016). This transformative process for deep learning necessitates active engagement with learning material, extending beyond procedural knowledge. This is consistent with the perspectives of Bransford et al. (2000) and Rillero (2016), who stress that learners should aim to achieve a comprehensive understanding of study materials and possess the capability to apply that knowledge beyond the classroom setting to enhance their learning potential (see Section 2.4).

By providing opportunities for problem-solving and real-world connections, the participating teachers discovered that their learners could cultivate a deeper level of understanding that extended beyond mere factual recall. This research finding is substantiated by Brady et al. (2015), emphasising the significance of presenting high-order learning possibilities to learners, which helps them comprehend and enrich their understanding, ultimately enhancing their problem-solving capabilities.

Engaging their learners in meaningful discussions and collaborative activities played an important role in promoting understanding in this study. This experience from the participants accords with the discussion presented in Section 2.4, highlighting the significance of learners engaging in conversations and collaborative activities that foster deeper understanding and knowledge construction (Linton et al., 2014). Active discussions and interactions enhance learner engagement, facilitate the acquisition of new knowledge (Feroz et al., 2021), and provide teachers with valuable insights to assess learners' comprehension (Resnick et al., 2018).

Supena et al. (2021) conducted studies that unveiled how active participation among learners fosters improved conceptual understanding, subsequently leading to enhanced learning and heightened focus. In this study, the participants observed how interactive participation encouraged their learners to engage in critical thinking, analyse information, and establish connections across diverse contexts. These interactions nurtured a heightened level of engagement and enabled learners to construct their understanding through active participation and reflection, an idea reinforced by the studies of Wilson (2022) and Alvarez-Bell et al. (2017) that advocate for engagement in deep learning. These findings comply with Section 2.4, which delves into the positive impact of active engagement on enhancing knowledge retention and motivation (Watkins & Mazur, 2013), as well as participating in a cooperative and innovative learning environment (Hightower et al., 2011).

The participating teachers noticed that teaching for understanding sparked curiosity and motivation among learners. By accentuating the *why* and *how* of the subject matter, they witnessed a shift in their learners' attitudes toward learning, as they became more invested in the process and eager to explore and discover new knowledge. The emphasis on understanding the underlying principles and connections behind the content instilled a sense of purpose and relevance, making the learning experience closely connected to the real-world, tailored to address learners' needs, resulting in meaningful and lasting learning outcomes (Bao & Koenig, 2019; Coyle & Meyer, 2021; Huberman et al., 2014).

6.4.3 The Role of Self-Reflection in Strengthening Knowledge, Skills, and Positive Mind-Set Attitude

Self-reflection is an active approach for learners to pause and contemplate on the learning that has occurred, employing various strategies to monitor and reflect on their progress, which leads to the development (Branch & Paranjape, 2002; Davies et al., 2013; Raemdonck et al., 2008). The empirical findings of this study, supported by Nurpratiwi et al. (2022), firmly establish the vital role of deliberate planning and facilitation in cultivating effective self-reflection in the realm of teaching and learning. The participants in this research assumed a central role in providing learners with transformative experiences, equipping them with essential competencies to effectively navigate challenges and actively engage in introspective pursuits. Notably, the integrated music-mathematics lessons emerged as a rich context for fostering self-reflection, offering numerous opportunities for asking thought-provoking questions (Chin & Osborne, 2008), discussions (Thomas, 2023), and the application of self-reflective rubrics (Vasileiadou & Karadimitriou, 2021). Through these experiences, the participating teachers observed how learners not only deepened their understanding of the subject matter but also sharpened their capabilities and fostered an empowered attitude. This first-hand observation reinforced the intrinsic connection between knowledge, skills, and a positive mind-set attitude within the teaching and learning process.

The participants' experiences highlighted the effectiveness of asking higher-order questions to foster self-reflection and stimulate critical thinking among learners. As emphasised in Section 2.5.1.2, teachers are encouraged to facilitate self-reflection throughout the problem-based learning process (Krause & Stark, 2010), guiding learners to assess their own progress and understanding (Van der Vleuten & Schuwirth, 2019; West et al., 2013). By actively evaluating their performance against established criteria, learners developed a sense of ownership in their educational journey and engaged in comprehensive analyses of their work. Tofade et al. (2013) strongly underscore the significance of posing higher-order questions that prompt learners to investigate and assess their understanding and knowledge.

The participating teachers recognised the importance of peer interactions in fostering self-reflection. Actively engaging in dialogue and discussions heightened learners' attentiveness and awareness of both their own mistakes and those made by their peers. The above-mentioned outcome support Moss and Brookhart’s (2019) view that meaningful self-reflection empowers learners to take charge of their progress, enhance their understanding, and advance in their educational journey.

The value of self-reflective rubrics in assessing learners' progress and motivating them to enhance their future assignments was acknowledged. Self-reflection played a facilitating role in providing comprehensive feedback, thereby preparing learners for future practices. Andrade and Valtcheva (2009) affirms the significance and value of feedback, particularly in the form of rubrics, as it grants learners the opportunity to revise their work. The study further highlighted the effectiveness of combining rubrics with checklists (Andrade, 2019), particularly for grade four learners, as it supported their understanding of task expectations and empowered their learning journey.

The study highlights the significance of constructive alignment in the design of integrated music-mathematics lessons, which established an environment conducive to promoting self-reflection. The participating teachers observed significant academic growth resulting from learners' active engagement in self-reflection. The study conducted by Miller and Konstantinou (2021) supports the notion that authentic self-reflection is a vital skill for learners to develop, as it has the potential to enhance their academic performances.

6.4.4 Assessment

Evaluating learners' educational achievements in a meaningful and comprehensive manner is a fundamental aspect of the learning process (Brown, 2019; Leenknecht et al., 2021). In this context, the participants of the study displayed a clear understanding of the intrinsic connection between knowledge, skills, and a positive mind-set attitude, identifying its importance in the assessment process.

The participants further acknowledged the significance of assessing learners' analytical skills, understanding of key concepts, and ability to justify their answers, instead of solely accentuating the correctness of responses. This approach to assessment enabled learners in this research to demonstrate a deeper level of comprehension and engage in critical thinking, surpassing the superficial memorisation of facts. Rothman (2018) concurs that teachers need to develop innovative assessment tools to measure learners' broader competencies.

The active assessment tasks presented participants with opportunities to offer praise and encouragement to learners, which is often restricted in traditional classroom settings. Al-Ghamdi (2017) affirms that praise and effective feedback are significant tools that teachers should apply to enhance learning. The participating teachers noted that learners were motivated to enhance their performance as they actively participated in constructive classroom conversations about the strengths and weaknesses of their assignments in a positive and supportive atmosphere. These discussions, as highlighted by Resnick et al. (2018) in Section 2.4, offer valuable insights for teachers to evaluate learners' comprehension and progress. This collaborative approach fostered a sense of ownership and investment in their own learning process. Section 2.4 emphasises the significance of learners' active engagement in the dynamic learning process, a point highlighted by Sanger (2020) and accentuated as an integral aspect of assessment.

The participating teachers in this study underscored the significant role of delivering timely feedback to guide instruction and support learner development, supported by the research of Carless (2022). The participants identified the essential role of constructive feedback in assisting learners in improving their understanding and skills. By providing productive feedback, participating teachers were able to effectively guide learners toward meaningful learning experiences and cultivate a culture of continuous growth. Adarkwah (2021) agree that feedback, regardless of its format, should be clear, provided in a timely manner, given frequently, encouraging, and valuable.

In demonstrating a clear appreciation for the value of conceptual understanding in the assessment process, the participants actively accentuated the intrinsic connection between knowledge, skills, and a positive min-set attitude. They acknowledged the importance of integrating a diverse range of active assessment tasks within the integrated music-mathematics lessons to assess learners' understanding, skills, and a constructive and growth-oriented mind-set across multiple domains. Through the implementation of a diverse array of assessment tasks, the participating teachers proficiently assessed a wider spectrum of learning outcomes, consequently elevating the validity and reliability of the assessment process. This corresponds with the findings of Blaha et al. (2022), which indicate that understanding surpasses mere information acquisition and encompasses the successful application in various contexts (see Section 2.4.1). Hämäläinen et al. (2021), Horst and Prendergast (2020), and Wei et al. (2021) also recommend that teachers should design assessment opportunities for learners to showcase the full extent of their cognitive knowledge, capabilities, attitudes, and skills.

6.5 Facilitating a Dynamic Classroom

Creating a dynamic classroom environment is vital for promoting active engagement and collaborative learning among learners. The participating teachers implemented various elements and strategies that fostered a dynamic classroom, resulting in a positive impact on learners' educational experiences and outcomes.

6.5.1 Teaching and Learning Environment

The participating teachers applied a range of strategies to cultivate a dynamic and engaging classroom atmosphere while fostering conceptual understanding in music and mathematics. This facilitative role of the teacher, as highlighted by Lunenburg & Ornstein (2012) and Singh & Yaduvanshi (2015), nurtures a supportive and nurturing learning environment (see Section 2.5.1). Moreover, the research conducted by Munna and Kalam (2021) underscores the fundamental role of teachers in creating an innovative educational environment that enhances learning and promotes the holistic development of learners.

The intentional seating arrangement of learners into small teams, both within the classroom and in outdoor settings, by the participating teachers played a vital role in enhancing the learning environment. The purposeful grouping cultivated a sense of collaboration and teamwork among the learners, enabling them to collaborate effectively and provide mutual support throughout their learning journey. The outdoor classroom environment proved to be a successful extension for learning, highlighting the advantages of occasionally taking learners out to explore. Conducting lessons in outdoor settings added an element of excitement and stimulated creativity among the learners, leading to increased overall engagement and enhanced comprehension. These settings provided more opportunities to explore, experiment, and work collaboratively. Khan et al. (2020) and Nel et al. (2017) also observed the positive potential that outdoor classroom learning has on enhancing the learning experience.

The participating teachers placed strong emphasis on creating an emotionally safe and supportive learning environment (Ramakrishnan & Annakodi, 2013) wherein learners were encouraged to take risks, explore diverse solutions, and freely express themselves without fear of criticism or mistakes (see Section 2.4). This nurturing atmosphere fostered learners' confidence in self-expression, resulting in noteworthy progress in learning outcomes and overall personal development. Referring to Section 2.4, Clapper (2010) and Wibowo et al. (2020) propose that a learner who feels safe and protected is more open to exploring new learning opportunities, while Baars et al. (2023) emphasise the importance of creating a stimulating learning environment where learners feel emotionally secure for optimal learning.

6.5.2 Teacher-Learner Interaction

The interaction between teachers and learners plays an important role in shaping learners' interest, motivation, curiosity, and academic performances (Davis, 2003; Rahman et al., 2020; Yu, 2020). The data collected portrayed the development of a stronger teacher-learner relationship in contrast to a traditional classroom environment. The participants acknowledged the value of the improved interaction, appreciating the advantages of increased levels of engagement and connection. Building on this foundation, Section 2.4 delves into the topic, with Wibowo et al. (2020) emphasising the importance of teacher-learner collaboration in establishing a secure and supportive environment.

The dynamic classroom facilitated by the participating teachers enabled them to practice compassion in various ways, stressing six qualities according to Hendricks (2018): "trust, empathy, patience, inclusion, community, and authentic connection" (p. 8). The participants displayed kindness, building trust, and showed attentiveness by patiently supporting learners when they needed assistance, ensuring that the learners felt supported and motivated, fostering empathy. The participating teachers offered guidance in a nurturing manner, creating a safe space where learners could seek support without hesitation. According to the participants, the positive teacher-learner relationship enhanced engagement, motivation, and collaboration among the learners, ultimately creating a sense of community and fostering a conducive learning atmosphere (Li et al., 2022a; Singh & Yaduvanshi, 2015).

The experiences of the participating teachers highlighted the positive impact of effective teacher-learner interaction in promoting a conducive learning environment and enhancing overall learning outcomes. The data indicate that the positive teacher-learner relationships characterised by mutual respect and understanding were established, resulting in a noticeable reduction in disruptive behaviour within the learning environment. These findings cohere with studies conducted by Li et al. (2022b) and Mallik (2023), who concluded that learners are more likely to engage positively in classroom behaviour when they perceive a positive and supportive relationship with teachers.

The recent study demonstrates that hands-on activities, discussions, and group work promote meaningful interactions between participating teachers and learners. The participants highlighted that facilitating learning activities led to improved communication and interaction between them and the learners. Learners who actively asked questions, sought guidance, and needed assistance benefited from a positive and supportive teacher-learner relationship. Additionally, the participants' caring responses to the learners' thoughts further enhanced the teacher-learner interaction. Harmonising with the insights from Section 2.4 and Section 2.5.1, a constructivist classroom enhances teacher-learner interaction by fostering active engagement and collaborative learning experiences. Teachers play a role as guides, collaborators, and facilitators of learning, creating an environment where learners are empowered to explore, question, and construct their own understanding while interacting with both their peers and the teacher.

Incorporating a variety of active learning tasks provided teachers with opportunities to engage with most learners in different scenarios, fostering stronger interpersonal relationships. The participants' learner-centred approach to teaching not only enriched the learning experience but also created a supportive and inclusive environment, facilitating a deeper connection and mutual growth between the participating teachers and learners (Gwynne et al., 2012).

6.5.3 Collaborative Learning

Collaborative learning is a learner-centred approach where learners interact with each other, collectively engaging in interactions to develop knowledge, skills, and attitude (Clinton & Wilson, 2019; Laal & Laal, 2012; Rands & Gansemer-Topf, 2017; Supena et al., 2021). The data suggests that when learners actively engaged in integrated music-mathematics lessons, they encountered enhanced outcomes related to collaborative learning. This active involvement resulted in significant improvements in learners' problem-solving skills, critical thinking acumen, and overall engagement. These findings parallel the viewpoint presented by Drake and Reid (2020), emphasising the essential contribution of competencies like active listening, collaboration, structured reasoning, innovation, and teamwork within the context of interdisciplinary learning (see Section 2.3). Additionally, these findings coincide with the insights from Section 2.4, where Linton et al. (2014) underscore the importance of learners participating in discussions and collaborative exercises that facilitate the development of deeper comprehension and the construction of knowledge. These proficiencies empower learners to adeptly navigate the intricate connections between the domains of music and mathematics. Furthermore, these outcomes are consistent with the conclusions drawn by Ghavifekr (2020), Kim et al. (2022), and Mandušić and Blašković (2015), who reported similar findings.

Based on the participants' experience, it was revealed in this study that collaborative learning not only initiated analytical thinking but also notably enhanced cooperative problem-solving abilities. These skills are considered crucial in the 21st century, as indicated by Theabthueng et al. (2022). Time limits (Jones, 2007) instilled a sense of urgency during the recent study and productivity, reducing distractions and promoting focused collaboration. Additionally, clear, and concise instructions (Delaney et al., 2018) support productive collaboration, ultimately enhancing the overall success of the music-mathematics lessons.

The inclusion of small, manageable groups (Jeong et al., 2019) proved advantageous for collaborative learning, as it facilitated close monitoring of learners and allowed for timely intervention, ensuring active engagement within each group. Additionally, the small group setting encouraged a conducive and supportive environment for meaningful peer interactions and knowledge exchange among participants.

6.6 Conclusion

Chapter 6 has presented the findings of the study, shedding light on the experiences of the participants regarding the enrichment of mathematics with musical elements in the Intermediate Phase. In essence, there were unexpected findings. It was commendable to witness how the older participants, armed with more traditional training, transitioned into their new roles as facilitators. I'm inclined to believe that without the engaging music activities cultivating a relaxed atmosphere, this transformation might not have been attainable.

It was surprising to witness the participants delivering the music-mathematics lessons to their learners with minimal difficulty. The detailed lesson plan and pre-lesson discussions played an important role. Even though I had to explain note values to most of the participants initially, they instantly apprehended the concept.

Despite all participants agreeing to take part in this study, one of them was initially very reluctant. This teacher held a doubtful stance, but the integration of music added a whole new dimension to the class. By the end of the research, the participant expressed the desire to continue with these integrated music-mathematics lessons.

Approaching the research with an open mind, I had no preconceived expectations about the study's outcome. Thus, to my surprise, I found that generalist teachers, despite lacking formal music experience, were adept at integrating and enhancing mathematics through music. It was also gratifying to observe their enjoyment of the process.

The final chapter will provide a comprehensive summary of the study's key findings, draw meaningful conclusions, and offer recommendations for future research, aiming to guide teachers, curriculum developers, and policymakers in promoting effective integration of music and mathematics in educational settings.

Chapter 7: Summary, Conclusion, and Recommendations

7.1 Introduction

Working through the lens of the constructive alignment approach (Biggs, 2014), this study conducted an in-depth investigation into the experiences and perceptions of generalist teachers who participated in the integrated teaching and learning program. The first chapter offered an introduction and context for the research, delineated the main objectives of the study, and presented the research questions that the study aimed to address. Chapter 2 focused on pertinent literature on constructive alignment as a teaching and learning approach, skills for the 21st-century, current understandings of how learners learn, teaching and learning as constructive processes, and integrated teaching and learning. In Chapter 3, a detailed discussion was presented regarding the methodology employed by the study, which led to the accumulation of data. The fourth chapter elucidated the integrated music-mathematics lessons that were employed in this study. Chapter 5 presented a thorough analysis and interpretation of the data collected. In Chapter 6, the main findings obtained from the data were discussed, aligning them with the pertinent literature as presented in Chapter 2. The present chapter draws the study to a close by revisiting research questions outlined in the first chapter, deliberating on the study's contributions and limitations, presenting recommendations, and suggesting directions for future research.

7.2 Findings from the study

The primary objective of the study was to fulfil the following question: How do generalist teachers in the Intermediate Phase experience the enhancement of mathematics through music teaching and learning? The secondary research questions investigated how the experiences of these teachers perceived conceptual understanding in Intermediate Phase music and mathematics; unveiling the effectiveness of constructive alignment as a teaching and learning approach; and contributed to future planning for the development of teaching and learning models used in the Intermediate Phase.

Each of the secondary research questions played a role in addressing the main research question. The inquiry into 'How do generalist teachers comprehend conceptual understanding in Intermediate Phase music and mathematics?' (first secondary question) revealed that participants recognised the effectiveness of various teaching strategies in enhancing learner engagement and achieving conceptual understanding. Specifically, the integration of diverse and interactive musical activities was noted as transformative for learners struggling with abstract mathematical concepts. Teachers emphasised a shift from traditional memorisation to prioritising conceptual understanding, seeing it as essential for fostering meaningful comprehension. Additionally, participants highlighted the importance of conceptual understanding in the assessment process, underscoring the intrinsic connection between knowledge, skills, and a positive mindset. This collective perspective emphasises the need for a comprehensive and engaging teaching approach in the Intermediate Phase.

The second research question, exploring the effectiveness of constructive alignment as a teaching and learning approach in designing integrated music-mathematics lessons, contributes to addressing the main research question. Constructive alignment facilitates the coordination of learning objectives, teaching methods, and assessment strategies, creating a cohesive support system for learners' understanding and application of content. The researcher tailored the constructive alignment framework to design integrated music-mathematics lessons for Grade 4 learners. Participants integrated purposeful tasks and assignments with real-world applications to foster active engagement and deliberate knowledge construction among learners, extending their intrinsic motivation. The significance of assessing analytical skills, understanding of key concepts, and the ability to justify answers, rather than focusing solely on correctness, was acknowledged.

The third secondary research question, "How can the experiences of the teacher participants contribute to the teaching and learning models used in the Intermediate Phase?" finds its answer in the valuable insights derived from the generalist teachers' experiences, which play a crucial role in refining teaching and learning models in the Intermediate Phase. The participants were exposed to diverse teaching experiences, connected to various teaching and learning models, curriculum design, and policy implications.

The implementation of well-crafted lesson plans, adhering to constructive alignment principles, became a pivotal factor. These plans outlined specific objectives, activities, and assessments necessary to achieve targeted learning outcomes, serving as a roadmap for the teachers. Such outcomes, resulting from these experiences, can significantly contribute to the future planning of integrated teaching and learning models across different subjects for use in the Intermediate Phase.

For this research, opting for a qualitative approach proved to be the most suitable methodology to delve into the experiences of generalist teachers concerning active music-mathematics teaching and learning, as the intention was to explore rather than explain (Nassaji, 2020). The study was conducted at three South African, Afrikaans-medium, middle-class governmental primary schools situated in the Tshwane North district of the Gauteng province. A series of music-mathematics integrated lessons were purposefully designed and delivered individually to six generalist teachers who had no formal music training.

The following themes emerged from the findings:

Table 5

Summary of Research Themes

Themes	
1.	Teaching and learning approach
2.	Knowledge, skills, and positive mind-set attitude
3.	Facilitating a dynamic classroom

The study findings challenge the notion that teachers must possess formal qualifications in music or be proficient musicians themselves to successfully integrate music into mathematics instruction. The research underscores the significance that generalist teachers can effectively incorporate music into mathematics lessons without extensive musical training or instrumental skills, opening opportunities for a wider range of teachers to engage in interdisciplinary teaching. The study highlights that the key lies in creating meaningful connections between music and mathematics rather than focusing solely on musical proficiency. Teachers can foster connections between music and mathematics by engaging learners in activities that highlight the relationships between the integrated subjects. This interdisciplinary approach enriches their understanding and paves the way for a more comprehensive and meaningful learning experience.

The study findings reveal that the integration of music and mathematics not only benefits learners but also expands the teaching opportunities for teachers. It broadens their perspectives, encourages creative teaching approaches, fosters interdisciplinary collaboration, and inspires a deeper passion for teaching. By embracing integration, teachers embark on a journey of professional development and discover the immense potential of interdisciplinary education to enrich the lives of both them and learners.

The outcomes yielded valuable insights into how these teachers can effectively integrate music into their teaching practices. The constructive alignment approach (Biggs, 2014) was employed as a framework to facilitate the creation of empowering mathematics through music learning experiences. This, in turn, assisted participants in understanding how to enable learners to demonstrate their comprehension and application of knowledge in both music and mathematics. The researcher tailored the constructive alignment framework to design integrated music-mathematics lessons that catered to the requirements of Grade 4 learners. This strategy helped lay a strong foundation that incorporated diverse teaching perspectives, including the conceptual understanding of music and mathematics, as well as constructivist learning theory. This emphasised the active role of learners in constructing their own understanding.

By integrating the interdisciplinary music-mathematics curriculum with An et al.'s (2013) instructional model and Bruner's (1960) spiral curriculum, the researcher developed a cohesive learning experience. The study's evidence demonstrated that linking music and mathematics not only deepened understanding but also encouraged critical thinking and fostered the practical application of knowledge. This approach aimed to offer learners with a holistic educational experience that supports interdisciplinary learning and the development of essential skills (see Figure 2).

The researcher was intrigued by the question of how generalist teachers, with no prior experience in teaching music, experience the process of integrating active music learning methodologies into mathematics. As a result, these experiences and insights were interpreted within the context of an authentic school setting during the study.

The research findings highlight that the participants realised the significance of maintaining a balance between a learner-centred approach and providing adequate teacher support. By embracing this harmony, the teachers empowered their learners to become active participants in their education while ensuring they receive the necessary assistance and guidance when faced with challenges. This balanced approach fostered a conducive learning environment that promotes learner growth, engagement, and ultimately leads to learners' success.

A key element identified by the participants' experiences was the provision of a well-crafted lesson plan to integrate music and mathematics. An effective lesson plan, conformed with constructive alignment principles, acts as a roadmap, outlining the objectives, activities, and assessments necessary to achieve specific learning outcomes. Specifically focusing on music-mathematics integration, a well-designed lesson plan offers generalist teachers a clear structure to incorporate musical elements into their teaching, facilitating a comprehensive and purposeful integration of music within mathematics. The lesson plan should include specific details about the music-related content to be taught, such as musical concepts, vocabulary, and skills, tailored to the learning objectives. It must outline activities that actively engage learners in music-making, encouraging their active participation. To support music instruction effectively, the lesson plan should incorporate appropriate materials, such as recordings, visual aids, and worksheets. By providing the participants with the applicable materials needed for each lesson, the study highlights the significance of adequately equipping generalist teachers to successfully implement music-mathematics integration. When teachers have access to well-designed lesson plans that include the necessary materials, they can effectively integrate music into mathematics.

These integrated lessons incorporated fundamental concepts such as time, symmetry, and length. These concepts were synchronised with the guidelines of the national curriculum (Department of Basic Education, 2011a). The researcher identified the importance of catering to diverse learning preferences and tailored teaching strategies and activities, accordingly, incorporating interactive, creative, hands-on, and collaborative elements to captivate the natural curiosity of learners in this age group. Moreover, the researcher considered the relevance of 21st-century teaching and learning skills.

7.3 Limitations of the Study

This single case study had certain limitations that should be acknowledged. One of the boundaries pertains to the sample size, which was limited to three schools. As a result, the findings may not be fully applicable to all schools in South Africa. The small sample size limits the representativeness and external validity of the study's findings. To enhance the study's applicability, future research could involve a larger number of learners from diverse schools in South Africa, using a similar methodology. This would allow for a more comprehensive understanding of how music can enhance mathematics in different educational contexts and increase the applicability of the findings to a broader population.

Another limitation of this study pertained to the potential influence of participants who taught at the same school. The presence of participants from the same school, potentially engaging in discussions and collaborations, may have exerted an impact on their responses, thereby potentially compromising the reliability of their input in the study. To address potential bias, strict instructions were provided to the participating teachers, prohibiting them from discussing their experiences before or during the study.

The incorporation of music was confined to the mathematical concepts outlined in the Grade 4 Mathematics curriculum for the third term. It is essential to identify that the research results might have varied if the integration had encompassed the concepts from the complete Grade 4 Mathematics curriculum.

It is also important to note that the study exclusively centred on the perceptions of generalist teachers concerning the empowerment of mathematical concepts through musical applications. The inclusion of other stakeholders, such as music teachers and mathematics teachers, could yield divergent experiences and viewpoints, ultimately contributing to a more comprehensive understanding of the topic. Therefore, future research pursuits should involve these additional stakeholders to obtain a more holistic perspective.

Notwithstanding the limitations, this study offers significant insights into the advantages and challenges of integrating music and mathematics. It offers valuable insights into the potential benefits arising from this integration, such as increased engagement, interdisciplinary connections, and the development of critical thinking skills. The study also acknowledges the challenges that the participants faced, which included aligning the curriculum requirements of music and mathematics, effectively integrating different teaching methodologies and resources, and managing time constraints within the instructional time available. By addressing both the benefits and challenges, this research enhances our comprehension of how generalist teachers in the Intermediate Phase can proficiently execute the integration of music and mathematics, thereby establishing a sound basis for future exploration and refinement of this educational approach.

7.4 **Contributions of the Study** (see Figure 12)

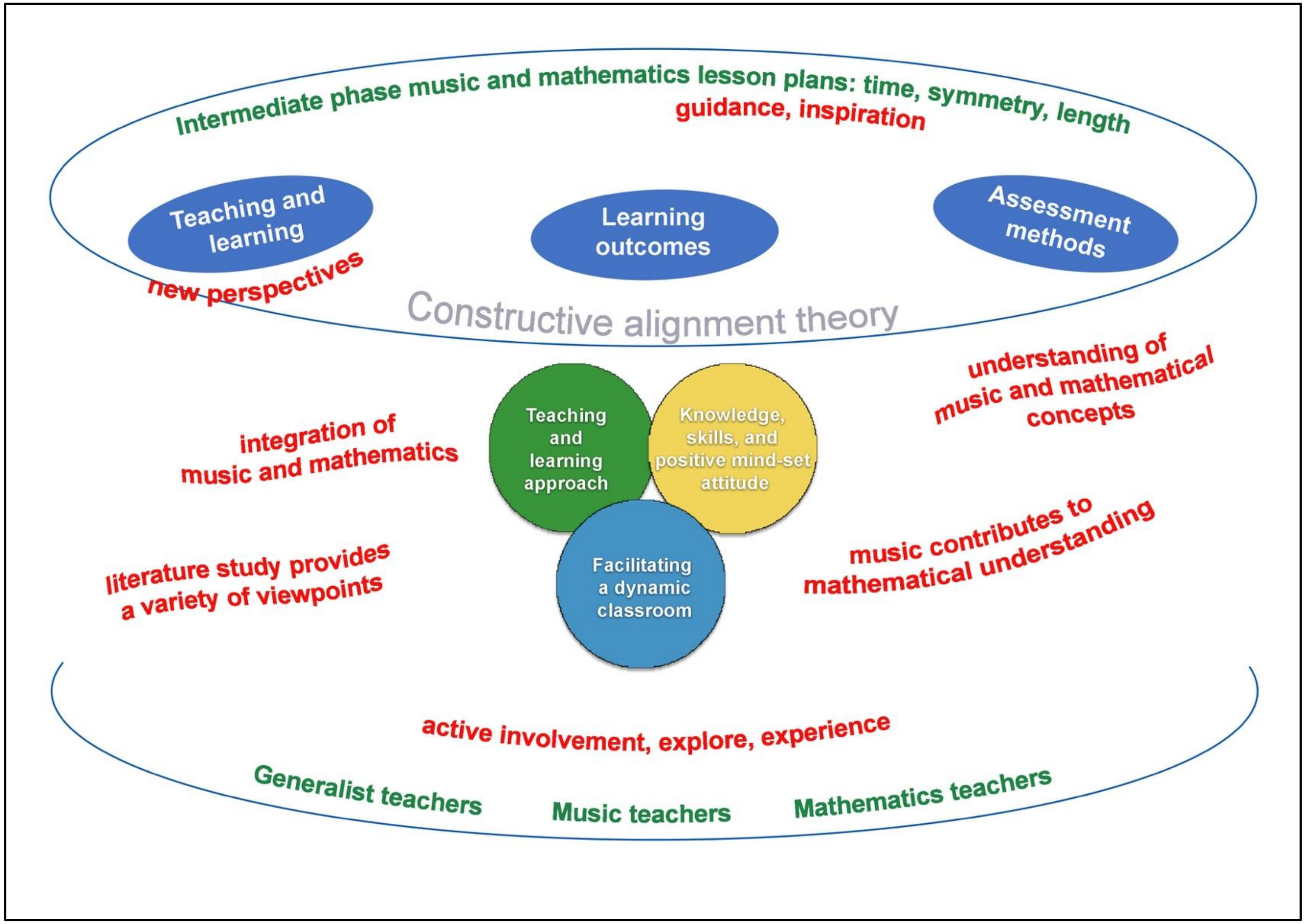
Previous studies on integrated music and mathematics have explored various dimensions of combining these two disciplines. Research in this area has investigated the cognitive benefits of integrating music and mathematics, examining how musical training may enhance spatial-temporal reasoning and mathematical problem-solving abilities (Boruah & Borah, 2021; Edelson & Johnson, 2003; Raja & Bhalla, 2021). Studies have also focused on learner engagement and motivation, exploring how incorporating music in mathematics instruction can increase interest and enjoyment in both subjects (Bakar & Samsudin, 2021; Deonath & Jaggernauth, 2021; Sousa & Pilecki, 2013). Additionally, some studies have centred on teacher preparation and professional development, aiming to equip teachers with the skills and confidence to effectively integrate music and mathematics in their classrooms (Battersby, 2019; DiDomenico, 2017; Vitulli et al., 2013). Technology's role in facilitating integration (Belbase et al., 2021; Cheng et al., 2022; Engelbrecht et al., 2020) as well as research assessing learner achievement (Civil, 2007; Nagy & Malone, 2020; Ruppert, 2006) have also been significant topics of exploration in this research field.

While prior studies had investigated the impact of integrating music on learners' conceptual understanding of mathematical concepts (An et al., 2013; Quinn et al., 2019; Robertson & Lesser, 2013), the current study takes a distinctive approach by integrating a constructive alignment framework, as mentioned earlier. This framework offers a distinct perspective, facilitating a more profound exploration of how the synergy of music and mathematics empowers educational objectives in mathematics, thereby augmenting learning outcomes (see Figure 12).

Before this research, it was evident that some generalist teachers in South Africa have limited understanding and knowledge about integrating music and mathematics, (Biasutti, 2010; Cloete & Delport, 2015; Kriger, 2020; Lovemore et al., 2021). The researcher experienced that a portion of generalist teachers in Gauteng, South Africa, had not yet realised the potential of music in fostering creativity and enhancing mathematics learning. This absence of awareness was particularly prominent among the participating mathematics teachers with a generalist background, who lacked specialised training in music education. As a result, they were unable to fully grasp the advantages associated with an integrated music-mathematics approach.

Figure 12

Summary of Contributions to the Study



There are a limited number of studies focusing on the enhancement of mathematics through music specifically within the Intermediate Phase of education in a South African context. The synthesis of findings has contributed to the development of a comprehensive understanding of how generalist teachers experience and comprehend the integration of music and mathematics. By drawing meaningful conclusions from these diverse perspectives, the research sheds light on the intricate dynamics and implications of combining these two disciplines in educational settings. The study contributes to the understanding of the potential benefits, challenges, and effective strategies for integrating these subjects, enhancing the educational experiences and outcomes for learners in South Africa.

In traditional mathematics education, the emphasis has consistently been on logical reasoning and abstract thinking, whereas music education has been considered as a separate domain centred around artistic expression. However, the integration of music and mathematics challenged this traditional division and brought forth a new perspective that was unfamiliar to the participating teachers. Through active involvement and exposure to the integrated approach, the participants in this research gradually developed a deeper understanding and appreciation for the unique advantages that music offers in the context of learning mathematical concepts. By implementing an integrated music-mathematics approach in their classrooms, the participants had a unique opportunity to explore and experience the potential of this pedagogical approach first-hand. As a result, this study makes a significant contribution to the field of music and mathematics education by introducing new ideas, and valuable insights in the transformative potential of strengthening mathematics through the infusion of musical elements.

The study provides a strong foundation for further exploration and advancement in this interdisciplinary educational domain. The findings of this study serve as a catalyst for ongoing research and innovation, promoting the development of effective teaching practices and curriculum design that bridge the gap between music and mathematics education.

This research holds significant implications not only for generalist teachers, but also for specialised music and mathematics teachers. It highlights the equal importance and emphasis given to both music and mathematics in the integrated lessons and empowers them to explore new avenues and fully embrace the integration of music and mathematics in their teaching practices. Neither subject was considered less significant than the other, highlighting the balanced and equitable integration of both disciplines. By exploring the benefits and effectiveness of this integrated approach, valuable insights and support are provided to music teachers, enabling them to enhance their pedagogical approaches and broaden their perspectives. The cross-disciplinary collaboration between music and mathematics fosters mutual learning, allowing music teachers to gain a deeper understanding of how music can contribute to the learning and understanding of mathematical concepts.

Few resources exist that specifically address the enhancement of mathematics through music, particularly with regard to the concepts of time, symmetry, and length. The integrated music-mathematics lesson plans serve as a valuable resource for generalist teachers, providing them with a concrete and practical example of how to effectively integrate music and mathematics in their instructional practices. By showcasing a well-designed and thoughtfully structured approach to integration, the lesson plans offered teachers' guidance and inspiration for incorporating music into their mathematics lessons. The lesson plans demonstrated specific strategies and activities for effectively blending music and mathematics, showcasing the potential connections and intersections between the two disciplines. Furthermore, the lesson plans provided participants with a clear framework for structuring integrated music-mathematics lessons, outlining the sequence of activities, the learning objectives, and the assessment strategies. In addition, the lesson plans offered teachers a range of creative ideas and resources for incorporating music into their mathematics instruction. Teachers can adapt and customise these ideas to suit the needs and interests of their learners, fostering a personalised and meaningful learning experience.

In addition to highlighting the benefits of integrating music and mathematics in the Intermediate Phase, the thesis stresses the significance of adopting a learner-centred approach, promoting active learning, applying problem-based learning methods, and facilitating critical thinking, creativity, and learner engagement. These insights contribute significantly to the existing body of literature and have practical implications for teachers, curriculum developers, and policymakers seeking to enhance teaching and learning practices, particularly in the South African context. Furthermore, the findings of this study have implications for curriculum developers, as they shed light on the potential benefits of the enrichment of mathematics through musical elements in curriculum design, allowing for a more holistic and interdisciplinary approach to education. Policymakers can also draw upon these insights to inform decisions regarding educational policies and practices, with the aim of improving teaching and learning outcomes in South Africa. This research contributes to the advancement of educational practices by providing practical recommendations and insights that can positively impact the teaching and learning experiences of learners in the context of music and mathematics integration.

The comprehensive literature review (Chapter 2) provides valuable information, establishing the context, theoretical perspectives, and practical implications related to the integration of music and mathematics in the Intermediate Phase. The literature review encompassed a variety of viewpoints and research findings, which laid the groundwork for the current study. These insights into the research landscape guided the subsequent research design, methodology, and data analysis. Furthermore, the references formed a basis for designing and implementing the integrated music-mathematics lesson plans. They informed the selection of instructional strategies, learning objectives, and content that harmonised with best practices and theoretical frameworks identified in the literature. By drawing on the research and pedagogical principles emphasised in the references, the lesson plans were developed based on sound knowledge and effective approaches for enhancing mathematics through music.

In conclusion, this research highlights the significance of conforming learning outcomes, teaching strategies, and assessment methods to establish a coherent and influential learning environment. It draws attention to the importance of constructive alignment in promoting independent thinking, the practical application of knowledge, and motivation to learn. These findings offer valuable guidance for the development of pedagogical frameworks and instructional practices that prioritise meaningful learning experiences. Ultimately, this thesis provides practical implications that can assist teachers and researchers in enhancing teaching practices and improving learner outcomes in Mathematics, not only in the Intermediate Phase but also in subsequent stages of education.

7.5 Further Research Areas

Future research in this area can explore several avenues to further enhance our understanding of the enrichment of mathematics through music in the teaching and learning process. Some potential areas for future research include:

Conducting research over an extended period can yield valuable insights into the sustained effects, developmental changes, and variations in learner outcomes associated with the integration of music and mathematics. This extended approach enables the assessment of academic achievement, cognitive development, and socio-emotional outcomes over time, providing a more comprehensive understanding of the long-term impact of this integration.

By investigating the effectiveness of various teacher development models, researchers can identify approaches that effectively support teachers in integrating music and mathematics into their instruction. This research can shed light on the most effective methods, strategies, and resources to enhance teachers' knowledge and skills in this area.

Considering the influence of cultural and contextual factors on the development of mathematics through music elements can enrich our understanding of this educational approach. Future research can delve into how cultural backgrounds, educational systems, and community contexts shape the implementation and outcomes of integration. By examining the interplay between these factors, researchers can uncover unique challenges, opportunities, and effective strategies that arise in different cultural and contextual settings.

Investigating the use of technology in the integration of music and mathematics can open new avenues for engagement and learning. Future research can explore the effectiveness of digital tools, educational software, and online platforms in supporting the integration process and enhancing learner outcomes. By examining the impact of technology on learner engagement, motivation, and understanding of the subject matter, researchers can identify effective ways to leverage technology for integrating music and mathematics.

Future research has the potential to significantly advance our understanding of how music can enhance mathematics by investigating the aforementioned areas. It can provide valuable insights into effective instructional practices, inform curriculum development, and contribute to the improvement of teaching and learning in this domain. The findings from such research can inform teachers, policymakers, and curriculum designers, enabling evidence-based decision-making and the implementation of strategies that maximise the benefits of integrating music and mathematics in education. This research holds promise for enhancing educational experiences, improving learner outcomes, and deepening our appreciation for the interconnectedness of music and mathematics.

7.6 Conclusion

The research findings accentuate the importance of maintaining a balanced approach in education, where learners are actively engaged and supported by teachers. This harmony enables learners to take ownership of their education while receiving necessary guidance and assistance when needed. By integrating music and mathematics through well-designed lesson plans, teachers can create a conducive learning environment that promotes interdisciplinary learning, deep understanding, and critical thinking. The study challenges the notion that musical expertise is a prerequisite for integration, highlighting that generalist teachers can successfully incorporate music into mathematics instruction by fostering meaningful connections between the two subjects. Furthermore, the integration of music and mathematics expands teaching opportunities, promotes professional growth, and nurtures a deeper passion for education. Ultimately, embracing interdisciplinary education benefits both teachers and learners, leading to enhanced educational experiences and success.

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Appendices

Appendix A: Research Ethics Committee Approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100
Since 1919

20 June 2022

Dear Mrs M Hendriks

Project Title:	Generalist Intermediate Phase teachers' experiences of teaching mathematics through music integration (Gauteng, South Africa)
Researcher:	Mrs M Hendriks
Supervisor(s):	Dr S Cruywagen
Department:	School of the Arts
Reference number:	89092024 (HUM019/0422)
Degree:	Doctoral

I have pleasure in informing you that the above application was **approved** by the Research Ethics Committee on 20 June 2022. Please note that before research can commence all other approvals must have been received.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should the actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely,

Prof Karen Harris
Chair: Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: tracey.andrew@up.ac.za

Room 7-27, Humanities Building, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa
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Appendix B: Gauteng Department of Education Research Approval Letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**25 April 2022**
Validity of Research Approval:	**08 February 2022– 30 September 2022** **2022/157**
Name of Researcher:	**Marna H**
Address of Researcher:	
	Pretoria
Telephone Number:	
Email address:	**Marnahendriks72@gmail.com**
Research Topic:	**Generlist Intermediate Phase teachers experiences of teaching mathematics through music integration ,Gauteng ,South Africa**
Type of qualification	**DMus**
Number and type of schools:	**3 Primary Schools**
District/s/HO	**Thswane North**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

25/04/2022

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below are met. Approval may be withdrawn should any of the conditions listed below be flouted:

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. *The letter would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools, or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s has been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter/document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs, and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort to obtain the goodwill and cooperation of all the GDE officials, principals, and chairpersons of the SGBs, teachers, and learners involved. Persons who offer their cooperation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school program is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her research resources, such as stationery, photocopies, transport, faxes, and telephones, and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers, and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study, the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings, and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a summary of the purpose, findings, and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Mr. Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 25/04/2022

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
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Appendix C: Semi-Structured Interview Protocol Schedule 1 (Phase 1)

UNIVERSITY OF PRETORIA
FACULTY OF HUMANITIES

Faculty of Humanities
Department of Music

Interview:
• Place: • Date: • Time:
Participant
Name: (pseudonym)
Background questions: • Age: • How many years of teaching experience do you have? • Which subjects do you teach? • Do you have any formal music training? Explain your level of music understanding. • Why did you agree to be part of this research study?
Opinion and values questions – focus on teaching Mathematics
1. Which role do you play in the mathematics classroom? Are you presenting information to the learners or are you facilitating learning? 2. From your experience, how well do learners in Grade 4 understand and remember mathematical concepts, such as time, length, and symmetry? 3. How often do your learners get the opportunity to reflect on their mathematical understanding? Please give an example. 4. In your opinion, is it important that your learners get the opportunity in class to communicate their own mathematical ideas with each other? Please give a reason for your answer. 5. Do your learners use their own methods/approaches to solve mathematical problems? If yes, please give an example. If not, is there any reason that they don't use their own strategies?

6. How often, and how, do you review previously taught mathematical skills in the class?

7. How do your learners apply and adapt mathematical ideas to new situations?

8. How often do your learners connect and explore mathematical concepts with real-life examples?

9. How motivated are your learners towards Mathematics? How do you as their teacher motivate the learners?

10. What is your perception of the integration of music and mathematics?

11. Do you use music as part of your mathematics lessons? If not, is there a reason for not using music? If you answered yes, please give an example of how you use music as part of your lesson.

Appendix D: Semi-Structured Interview Protocol Schedule 2 (Phase 4)

Faculty of Humanities
Department of Music

Interview
• Place: • Date: • Time:
Participant
Name: (pseudonym)
Opinion and value questions: focus on teaching music-mathematics integrated lessons
1. Which role did you play during the integrated music-mathematics lessons? In what way, if any, did your teaching and learning approach differ from your previous lessons? How did you experience this role change? 2. After the integrated music-mathematics lessons, how well do you think your learners in Grade 4 understand and remember the mathematical concepts used in the lessons? Please explain your answer. 3. Did the learners get the opportunity to reflect on their mathematical understanding of time, length, and symmetry during the integrated music-mathematics lessons? In your opinion, was it beneficial for their understanding of learning content? 4. In what way did your learners get the opportunity to communicate their mathematical ideas socially during the integrated music-mathematics lessons? Did this social engagement disrupt the discipline in the class? Was it beneficial for the understanding of the mathematical concepts? 5. In your experience, when the learners used their own strategies to solve mathematical problems, how did it affect their understanding of the mathematical concepts? 6. In your opinion, how did the learners benefit, if any, from the different ways in which they engaged with mathematics? 7. How well did your learners apply and adapt mathematical ideas to new situations?

8. In your experience, did the connections with real-life examples make a difference in your learner's understanding of mathematical concepts?

9. Did the integration of music in mathematics change the learner's motivation towards Mathematics? Please explain your answer.

10. Discuss your experiences during the implementation of the integrated music-mathematics lessons.

11. Did the implemented music-mathematics lessons change your perception of the teaching and learning of mathematics? Please explain.

Appendix E: Observation Schedule of Participant Teacher Lesson Presentation

Faculty of Humanities
Department of Music

Observation	
• Date: • Time: • School: • Grade: • Lesson 1/2/3/4: • Participating teacher:	
Observed	**Reflect**
Observation notes: • Throughout the lesson, did the teacher and learners share an understanding of what was being learned and how it was being learned? • Did the teacher monitor learners' understanding and progress? • Did the teacher establish a supportive learning environment (scaffolding)? • How did the teacher and learners interact? • How did learners interact with one another? • Did the learners have a sense of personal agency – capacity to engage and initiate ideas.	
Strengths	
Challenges	
Overall comment	

Appendix F: Broad Overview of the Integrated Music-Mathematics Lessons

Faculty of Humanities
Department of Music

Lesson plan format:

- list of materials (musical works and teaching aids) learners will need to engage in the lesson,
- learning objective of the lesson,
- prior knowledge learners will need to be able to engage successfully in the lesson,
- learning activities – how learners will work to solve the learning problems,
- authentic assessment opportunities (reflect objective of the lesson) to allow the teacher to have a sense learners' understanding during the lesson.

School A	
Musical concepts	**Mathematical concepts**
Note values Phrases Intervals Articulation	Measurement: Length

Lesson 1 → Lesson 2 → Lesson 3 → Lesson 4

- **Lesson 1**
  - **Focus is on music as musical meaning.**
- **Lesson 2**
  - **Music connects to mathematics. More focus on the music.**
- **Lesson 3**
  - **Equal focus on music and mathematics.**
- **Lesson 4**
  - **Focus is only on mathematics.**

<table>
<tr><th colspan="2">School B</th></tr>
<tr><th>Musical concepts</th><th>Mathematical concepts</th></tr>
<tr><td>Metre
Accents
Tempo
Note values</td><td>Time</td></tr>
<tr><td colspan="2">Lesson 1: •Focus is on music as musical meaning.
Lesson 2: •Music connects to mathematics. More focus on the music.
Lesson 3: •Equal focus on music and mathematics.
Lesson 4: •Focus is only on mathematics.</td></tr>
</table>

<table>
<tr><th colspan="2">School C</th></tr>
<tr><th>Musical concepts</th><th>Mathematical concepts</th></tr>
<tr><td>Dynamics
Form
Texture</td><td>Symmetry</td></tr>
<tr><td colspan="2">Lesson 1: •Focus is on music as musical meaning.
Lesson 2: •Music connects to mathematics. More focus on the music.
Lesson 3: •Equal focus on music and mathematics.
Lesson 4: •Focus is only on mathematics.</td></tr>
</table>

Appendix G: Information Sheet for Informed Letter of Consent

Faculty of Humanities
Department of Music

INFORMED CONSENT FORM FOR RESEARCH PARTICIPANTS

Information Sheet

You are being asked to participate in my research study that focuses on the generalist Intermediate Phase teachers' experiences of teaching mathematics through music integration. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

The purpose of this study is to explore how generalist teachers, with no previous exposure to music teaching, experience the implementation of integrated learning through linking ideas and learning activities in music and mathematics. This study will further investigate if the learners' active participation can increase their understanding and application of conceptual links between the two subjects.

The observations and lessons will be conducted during the allocated Intermediate Phase Mathematics periods in the school timetable. No tuition time will be lost and there will be no implications on learners' academic assessment.

If you agree to take part in this study, I will conduct interviews that focus directly on this case study. Data of your input in the course module will also be collected through observation and implementation of music-integrated lessons. If you are interested in participating, please sign the attached consent form. You can keep the information sheet and will be provided with a copy of the consent form. You do have the option of withdrawing before the study commences or discontinuing after data collection has started, without any consequences.

I will ensure that no references to your identity appear in the research findings and discussion. The data will be kept confidential for the duration of the study. On completion of the study, the documents will be stored in a password-protected format at the School of the Arts: Music for a minimum of 15 years and then destroyed.

The results will be presented in my thesis. Aspects of the study may be published in a research journal. I do not envisage any negative consequences for you in taking part. If you need any further information, you can contact me:

Marna Hendriks
marnahendriks72@gmail.com

If you agree to take part in the study, please sign the consent form overleaf.

Appendix H: Informed Consent

SCHOOL OF THE ARTS
UNIVERSITY OF PRETORIA
FACULTY OF HUMANITIES

Faculty of Humanities
Department of Music
Date:

Title of study: Generalist Intermediate Phase Teachers' Experiences of Teaching Mathematics Through Music Integration (Gauteng, South Africa)

Name of participant: ____

- I have read the attached information sheet on the research in which I have been asked to participate and have been given a copy to keep. I have had the opportunity to discuss the details and ask questions about this information.
- The researcher has explained the nature and purpose of the research and I believe that I understand what is being proposed.
- I understand that my personal involvement and my data from this study will remain strictly confidential. Only researchers involved in the study will have access.
- I have been informed about what the data collected will be used for, to whom it may be disclosed, and how long it will be retained.
- I have received satisfactory answers to all my questions.
- I hereby fully and freely consent to participate in the study which has been fully explained to me.
- I understand that I am free to withdraw from the study at any time, without giving a reason for withdrawing.

Participant's signature: _____________ Researcher's signature: ______________

As the researcher responsible for this study, I confirm that I have explained to the participant named above the nature and purpose of the research to be undertaken.

Marna Hendriks marnahendriks72@gmail.com

Appendix I: Principal approval letter

Faculty of Humanities
Department of Music
Date:

Generalist Intermediate Phase Teachers' Experiences of Teaching Mathematics Through Music Integration (Gauteng, South Africa)

To the Principal ____________________of ____________________________________

I hereby request your permission to conduct research involving the generalist Intermediate Phase teachers' experiences of teaching mathematics through music integration. This research project is in fulfilment of the requirements for the degree Doctor of Music for which I am currently enrolled.

Purpose of the study

The purpose of this research case study is to explore how generalist teachers, with no previous exposure to music teaching, experience the implementation of integrated learning through linking ideas and learning activities in music and mathematics. This study will further investigate if the learners' active participation can increase their understanding and application of conceptual links between the two subjects.

Research procedures

Teachers that teach Grade 4 Mathematics are invited to participate in this study. Individual semi-structured interviews will be conducted (and audio-recorded) with participant teachers before they observe lessons (video-recorded according to The Protection of Personal Information Act POPIA) presented by the researcher. Thereafter the teachers will give the same integrated lessons to their own class to explore their understanding of the music-mathematics integrated learning. The researcher will observe these lessons (video-recorded) with written field notes of participant teachers' application of music-mathematics integrated learning experiences; and finally, individual semi-structured interviews will be held with each generalist teacher to gather insight into their experiences and opinions after they presented the integrated lessons.

The interviews will last approximately 40 - 60 minutes and will be held after school to cause the least amount of disruption to their schedules. I will also be making observations during the data collection period. The integrated lessons and observations of lessons will be conducted during the allocated Intermediate phase Mathematics periods in the school timetable. No tuition time will be lost and there will be no implications on learners' academic assessment.

Confidentiality

All information will be treated as strictly confidential. Only you as the principal, the researcher, and the supervisors will know the identities of the teachers involved, but this will not be revealed in any of the research outputs. All raw data – including recorded interviews, video-recorded lessons, and transcripts – will, on completion of the study, be stored in a password-protected format at the School of the Arts: Music for a minimum of 15 years, after which it will be destroyed. During this period, the information gathered may be re-used for further research.

Risks, stress, or discomfort

There are no known risks or stress associated with participation in this study. There will be no benefits awarded due to participation in the study, be they financial or other.

Participants' rights

Participation in the study is entirely voluntary and should a teacher feel uncomfortable with some of the questions or with the knowledge that the interviews are being recorded, or that they are being observed during lessons, they may decline to answer questions or withdraw from the study. Should they choose to do so, it will be without prejudice from the University and the researcher involved in this study. In such an event, the data will be destroyed.

- I hereby acknowledge that this research study has been explained to me.
- I understand what is required from teachers and that they may withdraw at any time should they wish to do so with no ill consequences.
- The teachers will be interviewed; after which they will receive a transcript of the recorded interview for them to check if their views have been accurately documented.

- I acknowledge that the participant teachers will present the music-mathematics integrated lessons after the presentation by the researcher to their own classes.
- I understand that the teachers' identities and details will not be made public at any time and will only be available to me as the principal, the researcher, and the supervisors for the purpose of this study.
- The data will be kept safely for a period of 15 years and may be re-used for further research projects.
- I understand that there are no benefits awarded to the participating teachers for their participation in this study, be they financial or other.
- Their participation is completely voluntary and out of goodwill.

Please tick the appropriate box:

☐ I hereby **give consent** to conduct the research.

☐ I hereby **decline** permission to conduct the research.

______________________	______________________	____________________
Name and Surname	Signature	Date

Contact details of the supervisors:

Dr Sonja Cruywagen   Dr Ronél de Villiers

sonja.cruywagen@up.ac.za   ronel.devilliers@up.ac.za

Contact details of the researcher:

Marna Hendriks

marnahendriks72@gmail.com

Appendix J: Principal's Signed Approval Letters

School A

Please tick the appropriate box:

☑ I hereby **give consent** to conduct the research.

☐ I hereby **decline** permission to conduct the research.

		2022-01-24
Name and Surname	Signature	Date

Contact details of the supervisors:

Dr Sonja Cruywagen
sonja.cruywagen@up.ac.za

Dr Ronél de Villiers
ronel.devilliers@up.ac.za

Contact details of the researcher:

Marna Hendriks
marnahendriks72@gmail.com

School B

Please tick the appropriate box:

☒ I hereby **give consent** to conduct the research.

☐ I hereby **decline** permission to conduct the research.

[redacted]	[redacted]	2022.04.07
Name and Surname	Signature	Date

Contact details of the supervisors:

Dr Sonja Cruywagen
sonja.cruywagen@up.ac.za

Dr Ronél de Villiers
ronel.devilliers@up.ac.za

Contact details of the researcher:

Marna Hendriks
marnahendriks72@gmail.com

School C

Please tick the appropriate box:

☑ I hereby **give consent** to conduct the research.

☐ I hereby **decline** permission to conduct the research.

[redacted]	[redacted]	14/3/2022
Name and Surname	Signature	Date

Contact details of the supervisors:

Dr Sonja Cruywagen
sonja.cruywagen@up.ac.za

Dr Ronél de Villiers
ronel.devilliers@up.ac.za

Contact details of the researcher:

Marna Hendriks
marnahendriks72@gmail.com

i

[i] The researcher omitted the initials and surnames of the principles from the approval letters (Appendix J) to align with ethical guidelines.