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Mathematics in South Africa's Intermediate Phase: Music integration for enhanced learning

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Background: Embracing the influential role of music in education, teachers an cultivate an environment that fosters learners' curiosity, creativity, and enthusiasm for acquiring knowledge. The first author, experienced in teaching Intermediate Phase music and mathematics, was keen to explore how to bridge the gap between the educational vision for 21st-century knowledge and skills and current teaching practices through the adoption of active music integration and appropriate pedagogy to full engage learners.

Aim: The study aimed to explore how general teachers, with no previous formal music exposure perceived and engaged with the process of correlating concepts and learning experiences in music and mathematics.

Setting: The research was conducted over nine weeks in three South African, Afrikaans-medium, middle-class governmental primary schools located in the Tshwane North district of the Gauteng province.

Methods: This study employed a qualitative case study research approach and was situated within the pedagogical design of constructive alignment for effective teaching and learning.

Results: The results underscore the significance of generalist teachers' ability to effectively incorporate music into mathematics lessons without extensive musical training or instrumental skills.

Conclusion: The article challenges the notion that musical expertise is a prerequisite for integration, highlighting the fact that generalist teachers can successfully incorporate music into mathematics instruction by fostering meaningful connections between the two subjects.

Contribution: This article draws attention to the importance of constructive alignment in promoting independent thinking and the practical application of knowledge. These findings offer guidance for the development of pedagogical frameworks and instructional practices that prioritise meaningful teaching and learning experiences.

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

Introduction

Over the past decade, several studies have investigated the impact of integrating music on learners' understanding of mathematical concepts (An, Capraro & Tillman 2013:1; Boruah & Borah 2021:37; Quinn et al. 2019:173; Raja & Bhalla 2021:1911). To contribute to this body of literature, the authors examined how integrating music into mathematics instruction, using a constructive alignment framework, affects the teaching and learning process. Until now, no studies have explored how the utilisation of this framework in planning learning experiences could assist generalist teachers in enhancing educational objectives in mathematics through the synergy of music and mathematics.

This article discusses a single case study (Stufflebeam 2000:279), aiming to explore the teaching and learning experiences of six Intermediate Phase generalist teachers, who had no prior exposure to music instruction. The emphasis is on how these teachers facilitated integrated music-mathematics lessons designed within the constructive alignment framework. This approach provides a novel perspective in exploring how the synergy of music and mathematics empowers educational objectives in mathematics and enhances learning outcomes. The study was conducted in three South African government primary schools, where specifically designed music-mathematics

integrated lessons were intentionally provided to generalist teachers without formal music training. This research aimed to underscore the significance of music in improving mathematics through the establishment of meaningful, active connections between the realms of music and mathematics.

As learners become more actively involved and discover meaning and purpose in their education (Perger, Major & Trinick 2018), they are motivated to forge a deeper connection with the subject matter (Watkins & Kritsonis 2011:2). Learners should acquire knowledge and skills in a meaningful manner through the integration of diverse subjects (Snyder 2001). An integrated curriculum facilitates learners in applying the content in practical scenarios, fostering a positive attitude towards learning and heightened engagement (Lujan & DiCarlo 2017). Research on the integrated teaching and learning approach has demonstrated its numerous advantages, particularly in fostering a deeper understanding of mathematical principles (Bairy 2019:71). This approach contributes to improved academic success in mathematics (Lim et al. 2017), cultivates an engaging and exploratory learning environment and ultimately makes the process of learning mathematics more meaningful for learners (Trinick et al. 2016:12). Furthermore, the integration of music and mathematics allows learners to enhance their understanding of mathematical concepts, fostering the development of problem-solving skills and critical thinking abilities (Wiggins 2001). Active involvement in music-making activities not only enhances attention but also nurtures creativity and encourages perseverance in mathematical tasks (Fox & Surtees 2010). The outcomes of integrated teaching and learning in mathematics, as mentioned above, demonstrate that participating in meaningful integrated experiences enables learners to cultivate a deeper understanding of the interconnections between various subjects (Drake & Reid 2018:32). This integrated approach fosters a holistic understanding that extends beyond isolated knowledge of individual subjects.

The Intermediate Phase of education is a pivotal moment in learners' mathematical development (Wang & Goldschmidt 2003) as it lays the foundation for future mathematical understanding, problem-solving skills and academic success. Learners in this phase undergo significant cognitive development, including the capacity for abstract thinking (Gamino et al. 2022). During this phase, learners are actively forming perceptions about their mathematical abilities and interests, influencing their subsequent approach to mathematics in higher grades. The decisions made during this phase can have long-lasting effects on their attitudes towards mathematics and their future engagement with the subject (Mazana, Montero & Casmir 2019). Hence, it becomes crucial to provide learners with meaningful and engaging mathematical experiences during the Intermediate Phase, nurturing their motivation, curiosity and confidence in the realm of mathematics.

This study explores the experiences of generalist teachers as they facilitate integrated music-mathematics lessons designed within the constructive alignment framework.

Research design

In this single case study, a qualitative approach was utilised, a method particularly beneficial for educational research. Qualitative methods offer valuable insights into the experiential and interpretive aspects of educational phenomena (Cropley 2021).

This study explored the experiences of six Intermediate Phase generalist teachers without prior exposure to music instruction. The aim was to explore the relationship between these teachers and their teaching experiences. Tailored to the constructive alignment framework, the learning experiences ensured alignment between educational objectives, instructional activities and assessments, fostering a cohesive and effective learning environment.

Applying a qualitative approach enables researchers to analyse data collected from diverse perspectives, leading to the generation of novel insights (Cropley 2021). Data for this study were gathered through interviews, observations and examination of documents, allowing for a comprehensive and nuanced perspective on the investigated phenomenon.

The data-collection process, overseen by the first author (referred to as the researcher), was structured into four phases. In Phase 1, the pre-implementation phase, the researcher analysed documents and conducted semi-structured interviews. These documents encompassed Intermediate Phase Annual Teaching Plans (Department of Basic Education 2022), the National Curriculum and Assessment Policy Statement (CAPS) policy (Department of Basic Education 2011a), as well as the policy documents pertaining to music and mathematics (Department of Basic Education 2011b, 2011c). The documents, acknowledged as a valuable data source (Creswell & Creswell 2018:188), provided insights for shaping the effective integration of music and mathematics.

The primary goal of this phase was to gather participants' opinions and values on teaching Mathematics, explore their personal perspectives on enhancing mathematics through music and investigate their conceptual understanding of both subjects. Additionally, the researcher shared lesson plans, engaging in discussions to address any questions or concerns raised by the participants.

Moving to Phase 2, the researcher presented three series of four integrated music-mathematics lessons at each of the three participants' schools (School A, School B, and School C – see Table 1) to one of the Grade 4 classes. Participants observed these lessons individually, after which the researcher provided guidance and support in individual meetings to facilitate the integration of music and mathematics. Phase 3 was dedicated to the researcher

observing participants conducting the lessons in their own Grade 4 classes. Subsequent to the lesson delivery, individual semi-structured interviews were conducted with all participants in Phase 4. Participants shared their perceptions and experiences in facilitating the integrated music-mathematics lessons during these interviews. All four phases were carried out within a 9-week timeframe during 2022.

Acknowledging the role of a researcher was essential in avoiding misinterpretation of participants' intended messages. To uphold accuracy and reliability, the process of member checking, alternatively known as participant validation, involved providing participants with transcripts to confirm the accuracy of how their experiences and understandings were presented (Creswell & Creswell 2018:201).

The authors created integrated music-mathematics lesson plans for this study, drawing on pedagogical principles found in existing literature and South African policy documents. These carefully planned lessons played a vital role in the overall research. Employing Biggs' (2014) constructive alignment framework, the researcher designed purposeful and integrated learning experiences that combined music and mathematics. This approach ensured a systematic alignment of learning objectives, teaching methods and assessment strategies, promoting a cohesive support system for learners' understanding. The constructive alignment framework also embodies characteristics of the constructivist learning approach. The lessons were created to introduce challenges and foster curiosity, establishing a learning environment that encourages active involvement and independent thinking. Opportunities for collaboration and cooperation among learners were incorporated to facilitate meaningful discussions, the exchange of ideas and the shared building of knowledge.

The integrated music-mathematics lessons were designed to highlight mathematical concepts such as length, time and symmetry, per the CAPS policy document for Grade 4, Term 3 (Table 1). The deliberate selection of these specific concepts adhered to the prescribed curriculum. The researcher thoughtfully chose teaching and learning activities to enhance mathematics enrichment with musical elements, incorporating personal creative elements into the music-mathematics framework.

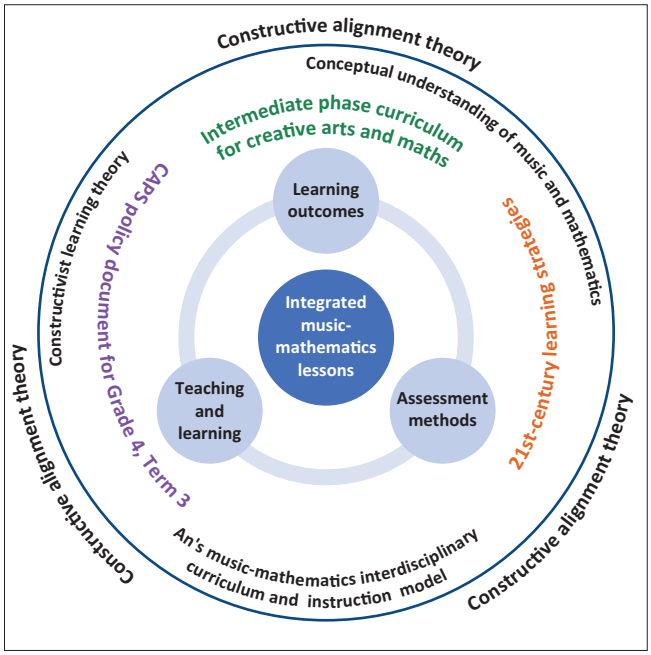
TABLE 1: An overview of the integrated music-mathematics lessons.

Musical concepts	Mathematical concepts
School A	
Note values	
Phrases	Measurement: Length
Intervals	
Articulation	
School B	
Metre	
Accents	Time
Tempo	
Note values	
School C	
Dynamics	
Form	Symmetry
Texture	

Source: Hendriks, M., 2023, 'Generalist intermediate phase teachers' experiences of teaching mathematics through music integration (Gauteng, South Africa)', Unpublished doctoral thesis, University of Pretoria, Pretoria

Methods that enrich the integrated experience of combining music and mathematics incorporate 21st-century approaches, such as critical thinking, active learning, analysis, collaboration, reflection, problem-solving, teamwork and creativity. An et al. (2013:4) proposed an integration model that guided the lessons, seeking authentic, connected and enduring educational engagement for both teachers and learners. Figure 1 illustrates the design of the integrated music-mathematics lesson plan.

The researcher applied Braun and Clarke's (2012:5) six-phase framework for thematic analysis in this study. In Phase 1, the interviews were transcribed, and all collected data, including observations and documentation, were systematically organised, typed and read multiple times to gain a comprehensive understanding of the entire dataset. Recurring elements such as vocabulary, comments, ideas, phrases and opinions were systematically highlighted. In Phase 2, the data were grouped into smaller categories with assigned codes. Relationships were identified through comparisons of the coded elements, leading to a deeper understanding of the data. During Phase 3, the relevant data were systematically sorted into broad main themes, acknowledging potential overlap and contributions to more than one theme. In Phase 4, an in-depth review of the identified themes was conducted, involving refinement, combination or separation as necessary. Transitioning to Phase 5, sub-themes emerged within the data, prompting



Source: Adapted Hendriks, M., 2023, 'Generalist intermediate phase teachers' experiences of teaching mathematics through music integration (Gauteng, South Africa)', Unpublished doctoral thesis, University of Pretoria, Pretoria

FIGURE 1: Integrated music-mathematics lesson plan design.

further refinement and categorisation into smaller, more specific categories. Finally, in Phase 6, the researcher compiled the report, ensuring it incorporated evidence closely in accordance with the purpose of the research.

Constructive alignment as a teaching and learning framework

Constructed by Biggs (1996), the pedagogical framework known as constructive alignment distinctly, defines what learners are meant to acquire and how they are expected to exhibit their understanding before teaching takes place. The concept of constructive alignment comprises two foundational elements. The initial element, grounded in the constructivist learning theory and emphasised by Biggs (2014), promotes a learner-centred approach, emphasising the active participation of learners in the meaningful creation process. The second element, drawn from the instructional design literature, underscores the harmonisation between educational objectives and the assessment targets set for learners (Biggs 1996). In an educational setting defined by constructive alignment, essential knowledge and skills are designed to support learners actively. This support is achieved by incorporating carefully chosen teaching and learning activities, all coordinated with assessing the intended learning outcomes (Biggs & Tang 2011:98).

Aligning these components directs attention to active learner involvement, fostering intellectual development through interactions and tasks rather than passive lecture listening (Roßnagel, Baido & Fitzallen 2021:2). This approach emphasises the deliberate construction of knowledge (Hailikari et al. 2021:11). Once the teacher identifies the intended learning goals, actively engaging learners in instructional tasks becomes essential. Jaiswal (2019:10) underscores the importance of active participation for learners to develop understanding and acquire skills aligned with specified learning outcomes. Consequently, this enhances the learning experience and intensifies motivation for learning (Biggs 2014; Biggs & Tang 2011).

Various perspectives on teaching and learning also support constructive alignment. This includes the understanding of fundamental concepts, which in our study, encompasses music and mathematics. Aligned with the principles of constructivist learning theory, this framework emphasises the active involvement of learners constructing their own understanding. In addition to the constructivist approach, 21st-century skills play an integral role in the field of mathematics, significantly contributing to the advancement of problem-solving, critical thinking and the practical application of mathematical concepts in real-world scenarios (Suh et al. 2021).

Twenty-first-century learning: Embracing an embodied, constructive process

Wiggins (2015) explains that learning is an embodied, constructive process, where understanding is derived from personal experiences, emphasising the need for a learner-centred environment that actively encourages participation in the learning process. In line with this perspective, Ambrose et al. (2010:85) assert that learning is a dynamic process in which learners actively construct understanding through their experiences. Creating meaningful connections between new information and existing knowledge is an active process through which learners construct their understanding (Birenbaum 2003). Toffler and Yousafzai (2020) highlight that learners can achieve a deeper understanding of the material and engage with it more meaningfully.

Constructivism, viewed as an educational theory, emphasises the dynamic process of knowledge construction (Mascolo & Fischer 2005:49). In a constructivist classroom that encourages interaction, learners participate in exploratory and self-directed learning, allowing them to actively explore and discover knowledge independently (Wiggins 2015). The active involvement of learners with their immediate surroundings, leads to the generation of new knowledge, the acquisition of skills and the cultivation of positive attitudes (Wiggins 2015). Teachers play a vital role in this process by designing well-thought-out activities that promote discovery, problem-solving and exploration, thereby facilitating the construction of meaning and the application of concepts and knowledge (Gholam 2019).

This interactive and participatory constructivist approach enables learners to enhance their understanding and retention of the material while also fostering critical thinking, creativity and problem-solving capabilities (Almulla 2023:1). These skills align with the teaching and learning skills essential for 21st-century education, as argued by the edited work of Mentz, De Beer and Bailey (eds. 2019). Following are some key 21st-century skills that teachers should facilitate to guide learners' progress and development: active learning, creativity, self-direction, critical thinking, problem-solving, communication, collaboration, reflection and lifelong learning.

The integration of 21st-century skills in the domain of music empowers learners to actively participate in creative collaboration and effectively express their artistic ideas (Saputra 2021:43). Incorporation of these skills into music education coheres teaching and learning strategies with the demands of a dynamic and interconnected world. This not only enriches learners' musical experiences but also equips them with valuable skills for personal growth (Saputra 2021:45).

Similarly, in the field of mathematics, 21st-century skills play a vital role in improving problem-solving, critical thinking and the practical application of mathematical concepts in real-world situations (Szabo et al. 2020:2). The significance of integrating 21st-century teaching and learning in mathematics lies in its ability to provide learners with the necessary skills, cognitive framework and proficiencies essential for excelling in an ever-evolving world that increasingly relies on technology and interdisciplinary insights (Yulianto, Pramudya & Slamet 2019:750).

Drake and Reid (2018:37) suggest that learners who are fortunate enough to be exposed to curriculum integration may be better equipped to face the challenges of the 21st-

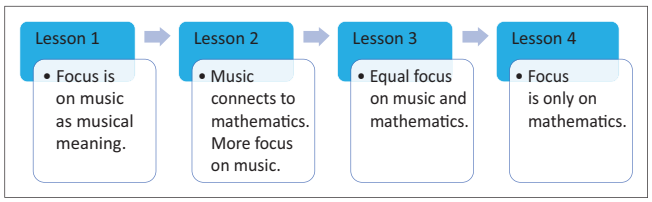
century. In our study, 21st-century skills were incorporated into the integrated music-mathematics lessons presented by participants. The endorsement of curriculum integration is specifically stated in the curriculum documents of South Africa's Department of Education, affirming that this approach contributes to the meaningful development of skills, knowledge, attitudes and values (Lovemore, Robertson & Graven 2021:2). Engaging in music activities can offer a meaningful setting for associating with mathematical concepts (An et al. 2014:151). An et al.'s (2013:3) interdisciplinary curriculum and instruction model in music-mathematics served as a guide for designing and implementing music activities as an integral component of the lessons in this study.

An's model for integration

The interdisciplinary curriculum and instructional model proposed by An et al. (2013:3) proved valuable in assessing the integration of music and mathematics at each phase, considering the diverse levels of their application. In the current study, the researcher adapted the model to harmonise with the Grade 4 requirements in the CAPS curriculum (Department of Basic Education 2011b, 2011c).

The interdisciplinary curriculum and instructional model proposed by An et al. (2013) provided guidance for designing and integrating music activities as an essential component within mathematics lessons in this investigation. The model devised by An et al. (2013) proved valuable in assessing the degree to which music and mathematics were integrated at each phase, acknowledging the varying extents of their application. In our study, the researcher modified the model to align with the Grade 4 requirements outlined in the CAPS curriculum (Department of Basic Education 2011b, 2011c). The model played a key role in evaluating the extent to which music and mathematics were incorporated in each phase (consisting of four lessons per phase), considering the diverse levels of their integration (see Figure 2).

The Intermediate Phase generalist teachers, who did not have prior experience in teaching music, embarked on an innovative journey by applying the constructive alignment approach in the integrated music-mathematics lessons. Guided by the principles of constructive alignment, the authors formulated teaching and learning activities to enhance mathematics learning through the integration of music activities. The lessons highlighted key elements of the constructive alignment framework, including a learner-centred approach, intentional design of knowledge and skills to actively support learners, activities aligned with the assessment of intended learning outcomes, learning experiences fostering motivation, active involvement of learners in constructing their understanding and the application of problem-solving, critical thinking and practical use of mathematical concepts in real-world scenarios. Subsequently, participants delivered these lessons to their classes and shared insights on how music could enhance the understanding of mathematical concepts.



Source: Hendriks, M., 2023, 'Generalist intermediate phase teachers' experiences of teaching mathematics through music integration (Gauteng, South Africa)', Unpublished doctoral thesis, University of Pretoria, Pretoria

FIGURE 2: The modified integrated music-mathematics lesson plan design.

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of Pretoria Faculty of Humanities Research Ethics Committee. The ethical clearance number is 89092024 (HUM019/0422). As human participants were involved in this research, ethical approval from both the University of Pretoria Research Ethics Committee and the Gauteng Department of Education was secured.

During this study, ethical considerations were thoroughly considered. Before obtaining their written consent to participate, all participants were fully briefed on the research purpose and methodology. Participation was voluntary, and individuals retained the right to withdraw from the study at any point without explanation. The researcher maintained the utmost respect for the dignity of each participant and ensured strict confidentiality of all information shared during interviews. Pseudonyms were employed in the findings and discussions to safeguard the anonymity of the participants. The study was conducted with an ethical consciousness enhancing its credibility and reliability.

Findings and discussion

Drawing on the scholarly literature and a thematic analysis of the data collected, the results of this study facilitated a richer understanding of how generalist teachers in the Intermediate Phase enhance mathematics through the integration of music.

Several unexpected findings emerged: older participants, accustomed to traditional training, transitioned with ease into their new roles as facilitators. Engagement with music activities seemed to foster a relaxed atmosphere. Detailed lesson plans and pre-lesson discussions played a crucial role in enabling teachers to deliver music-mathematics lessons with minimal difficulty. Despite the initial need for the researcher to explain note values to most participants, they quickly grasped the concept. One initially doubtful and reluctant participant later expressed a desire to continue with these integrated music-mathematics lessons. The authors had no preconceived expectations about the research outcomes. Despite lacking formal music experience, participant generalist teachers proved adept at integrating and enhancing mathematics through music. The researcher

experienced a gratifying feeling observing their enjoyment in the process.

The reflections from these experiences were analysed revealing three interrelated themes: teaching and learning approach; knowledge, skills and positive mindset attitudes, as well as facilitating a dynamic classroom.

Teaching and learning approach

The shift from teacher to facilitator in education, with a focus on effectiveness, posed challenges and opportunities for participants. The study's findings suggest that the diverse benefits of observed pedagogical approaches, especially the improvement of mathematics through music, have the potential to reshape educational practices.

From teacher to facilitator

Teachers' roles in learner-centred and active learning methodologies are evolving into that of facilitators, guiding learners through the process of learning and discovery (Capogna 2017). In semi-structured interviews before delivering integrated music-mathematics lessons, the participants described their roles, initially leaning towards presenting information rather than facilitating learning. Some participants 'introduced' the learning content and 'explained' the activities to the learners. While all participants claimed to facilitate learning, they primarily served as the main sources of knowledge, assigning worksheets as the main activity. One participant typically initiated lessons by delivering learning materials, with learners passively absorbing the presented knowledge. After observing the integrated lessons, participants recognised the need to shift to a learner-centred approach, though challenges were evident, such as letting go of control and trusting learners to solve problems independently. One participant faced difficulty in refraining from constant direction to her learners, while another struggled to let go of instructing them, a habit he was accustomed to. Trusting learners to solve problems independently was a common challenge for most. Initially, they felt intimidated by the shift in their role, having been accustomed to controlling all aspects of teaching and learning. However, they later recognised that the learner-centred approach yielded better outcomes compared to traditional teaching methods.

Despite initial challenges, participants embraced the facilitator role, acknowledging its positive impact on active learning and engagement. This supports the perspectives of Lunenburg and Ornstein (2012), accentuating that the teacher's facilitative role fosters a supportive learning environment, encouraging learners to explore, inquire and connect based on personal experiences. The participants, having observed the positive impact of the facilitator role in integrated music-mathematics lessons, expressed enthusiasm to integrate music activities into future lessons.

The integrated music-mathematics lessons, supported by relevant teaching and learning materials, not only facilitated the teachers' transition but also provided them with valuable insights into effective facilitation techniques. This harmonises with Wiggin's (2015) and Capogna's (2017) emphasis on the need for strategies supporting teachers in adopting a learner-centred approach. Toffler and Yousafzai (2020) highlight the fact that active involvement enhances learners' understanding and motivation. Fostering teamwork between facilitators and learners further enhances active learning and engagement. This conforms with our participants who recognised the importance of providing assistance, advice and direction to promote active classroom engagement. Regardless of initial difficulties, such as relinquishing control and trusting learners to solve problems independently, participants embraced their role as facilitators, resulting in positive outcomes such as heightened critical thinking, increased creativity and enhanced learner engagement. The teachers involved acknowledged the importance of creating a supportive environment by employing scaffolding and direct instruction as needed. This balanced approach effectively fostered independence in learners while providing structure, enabling them to thrive, develop skills and benefit from essential guidance and support.

Problem-based learning

Problem-based learning (PBL) is an instructional method emphasising learner-centred approaches, using real-world scenarios to foster practical problem-solving skills (Sebatana & Dudu 2022:3). The method aims to instil an analytical approach and a strong sense of ownership in learners (Lapek 2018). The research findings illustrate that certain participants voiced uncertainty and concern about the PBL approach. Some felt uneasy about the potential impact on the quality of teaching, considering PBL's focus on learners rather than the teacher as the primary source of knowledge. Additionally, they admitted not allowing learners the freedom to explore their learning, fearing the potential use of incorrect mathematical methods. After implementing the lessons that incorporated PBL, the participants observed an increase in learner confidence and a notable decrease in learners' fear of making mistakes.

The positive experiences shared by both participating teachers and learners highlight the cultivation of essential skills through PBL and its encouragement of active involvement with real-world issues. Lapek (2018) also affirms that PBL is a learner-centred instructional approach that applies real-world scenarios to nurture problem-solving skills in practical situations. The participants' enthusiasm highlights the potential effectiveness of PBL in improving teaching and learning models during the Intermediate Phase. Problem-based learning emphasises engaging with real-world situations and developing foundational skills, while creative learning focuses on nurturing creativity and independent thinking. When these approaches interconnect, there is a significant change in how participants view mathematics, recognising creativity as imperative for problem-solving.

Creative learning

Creative learning in education involves an innovative teaching approach that prioritises the development of

learners' creativity, imagination and original thinking (Kettler, Lamb & Mullet 2021:13). Initially, participants perceived mathematics as rigid and formulaic. However, as learners engaged in creative problem-solving tasks, participants underwent a significant transformation in their perception of the role and importance of creativity. The change was evident in their expression that creative tasks encouraged learners to explore the intricate interrelationships between music and mathematics, leading to higher levels of thinking and comprehension. This finding synchronises with Hallam's (2010) research, which demonstrated enhanced understanding through active engagement with music. Armed with an awareness of the significant impact of creativity in education, participants enthusiastically embraced the integration of music and mathematics into their teaching practices.

This study emphasised the crucial role of teacher's creative capacities in effectively nurturing creativity in learners. According to Venter and Viljoen (2020), teachers, acting as role models and displaying creative behaviours, significantly influence the cultivation of creativity within the classroom. The participants found that through well-planned creative tasks, these elements seamlessly integrated into the lessons, challenging the idea that creativity should be treated as a separate entity.

Authentic, real-life and real-world experiences

Authentic experiences in education connect classroom learning with practical situations, allowing learners to apply knowledge to real-life scenarios and understand subject relevance (Payne 2022:1). The integration of music and mathematics in this study underscored the importance of tailored learning, encouraging learners to apply classroom knowledge to authentic contexts. Participants recognised the significant role that authentic interaction played in engaging learners and fostering a deeper grasp of the subject matter, inspiring them to apply knowledge meaningfully.

Rillero (2016:1) emphasises the importance of learning experiences that guide learners towards a comprehensive understanding of the study materials and the ability to apply knowledge beyond the classroom. Involving learners in authentic interactions not only deepens their understanding but also provides them with valuable skills that go beyond traditional learning environments.

Through integrating music and mathematics, participants observed learners recognising the relevance and practicality of their education. This led to an enhanced understanding of the subject matter and increased motivation to engage with the content. As affirmed by Hajian (2019), learners who genuinely comprehend can adeptly transfer and apply concepts to real-life situations. The emphasis on practical application and transferability of skills allowed participants in this research to see how learners developed competencies to navigate real-world challenges and contribute meaningfully to various situations or environments. Learners actively engaged with familiar songs such as *Happy Birthday*, applied concepts such as measured length, symmetry and time in real-world situations. These experiences highlight the importance of establishing strong links between theoretical understanding and hands-on experiences.

By integrating purposeful tasks and assignments with real-world applications, participants facilitated active engagement among learners in activities that heightened their intrinsic motivation. This harmonises with the perspective of Hailikari et al. (2021), who argue that employing a constructive alignment approach focuses on learners' active engagement and the intentional construction of knowledge. The data collected in this research, coupled with the findings of Da (2023) and Wiggins and McTighe (2011), support the idea that cultivating a strong sense of competence and independence, along with promoting connections within the learning environment, positively impacts learners' overall learning experiences, leading to increased motivation and resilience in their educational pursuits.

Integration across disciplines

The collected data illustrated that integrating music into mathematics lessons enhanced learners' comprehension of concepts, critical thinking and problem-solving skills. This integration of music further deepened their conceptual understanding, a key element for excelling in the classroom, as underscored by Lim et al. (2017:57). Wiggins (2001) also highlights the synergy between music and mathematics, strengthening learners' understanding of mathematical concepts and fostering their problem-solving and critical thinking skills. Participants recognised that integrating diverse and interactive musical activities provided a transformative learning experience, especially for learners struggling with abstract mathematical concepts. Immersed in the world of music, learners effectively bridged the gap between the abstract nature of mathematics and their understanding. Integrating music into the learning experiences allowed learners to visualise and experience mathematical concepts tangibly, unlocking their potential to grasp complex ideas and apply them confidently. Learners successfully forged meaningful connections between the two subjects, developing a more comprehensive outlook on their intersection in real-world contexts. An integrated curriculum empowers learners to apply their acquired knowledge practically, fostering a positive learning attitude and increased engagement (Lujan & DiCarlo 2017).

Knowledge, skills and positive mind-set

The participants demonstrated commitment to continuous improvement, dedication to nurturing knowledge and skills and maintained a positive mindset. The interdisciplinary approach in our study positively impacted both the participants' teaching methods and the learners' attitudes toward learning.

Teaching and learning practices

Teachers play a crucial role in guiding learners to a comprehensive conceptual understanding by intuitively optimising their capabilities through the integration of a variety of carefully designed learning activities (Fizza & Rashid 2023:236). Adopting diverse instructional methods, participants demonstrated an understanding of how applying their newly acquired knowledge and skills contributed to their positive mindset, fostering effective teaching and learning practices. While facilitating designed lessons, they employed creative strategies to motivate and support learners, adapting to learners' dynamic needs in the learning environment. Strategies incorporated into lessons to enhance knowledge and facilitation skills included learners' active engagement, implementation of critical thinking for improved understanding, establishing real-world connections, fostering higher-order thinking skills, meaningful discussions and collaborative activities promoting knowledge construction. Teachers emphasised the shift from a conventional approach centred on memorisation to one prioritising conceptual understanding.

The participants in our study identified the importance of refining their teaching strategies and actively sought ways to improve their instructional methods. This corresponds with the study conducted by Gravett and Petersen (eds. 2022), which explored teachers participating in professional development opportunities. In these possibilities, teachers reflected on their teaching practices and acquired effective tools to assist their learners in pursuing knowledge and achieving overall success. The current study reveals comparable results, suggesting that the participants' dedication to ongoing improvement not only improved their teaching skills but also demonstrated their dedication to establishing an ideal learning environment for their learners.

The teachers participating in the study observed that teaching for understanding ignited curiosity and motivation among learners. They witnessed a transformation in their learners' attitudes towards learning by highlighting the 'why' and 'how' of the subject matter. The learners became more engaged in the learning process, displaying enthusiasm to explore and discover new knowledge. The emphasis on realising the underlying principles and connections behind the content instilled a sense of purpose and relevance in learners. This approach resulted in a learning experience closely connected to the real world, tailored to address learners' needs and resulted in meaningful and lasting learning outcomes. The participants' teaching practices and beliefs were notably impacted by the adoption of this approach. Progress was evident in the learners' increased proficiency in understanding concepts and effectively applying them in real-life situations. This connection coheres with the research findings of Wiggins and McTighe (2011). They underscore that learners possessing conceptual understanding exhibit the ability to transfer and apply concepts to real-life scenarios, thereby presenting high-order learning opportunities.

Participating in active discussions and interactions boosts learner involvement, aiding in the assimilation of new knowledge. Furthermore, it provides teachers with valuable insights for assessing learners' understanding (Resnick et al. 2018). Our participants' experiences highlighted the significance of learners engaging in conversations and collaborative activities, encouraging critical thinking, information analysis and the establishment of connections across diverse contexts.

The participants' experiences highlighted the effectiveness of asking higher-order questions to promote self-reflection and stimulate critical thinking among learners. Tofade, Elsner and Haines (2013) emphasise the importance of such questions, which prompt learners to investigate and evaluate their understanding and knowledge. Van der Vleuten and Schuwirth (2019) advocate for teachers to facilitate self-reflection throughout the PBL process, guiding learners to assess their own progress and understanding.

Assessment

Assessing learners' educational accomplishments in a meaningful and holistic manner is a crucial element of the educational process (Leenknecht et al. 2021:236). In our study, the participants demonstrated a clear understanding of the inherent link between knowledge, skills and a positive mindset attitude, acknowledging its significance in the assessment process. Instead of merely accentuating the correctness of answers, the participants encouraged learners to justify their responses, focusing on their analytical skills, understanding of key concepts and the ability to provide justifications. Participants cultivated a positive and supportive atmosphere by offering praise and encouragement to learners during activity assessment, synchronising with Al-Ghamdi's (2017) notion that approval and effective feedback are meaningful tools for teachers to employ in enhancing learning.

The participants acknowledged the essential role of constructive feedback in helping learners enhance their understanding and skills. They emphasised the importance of delivering timely feedback to guide instruction and support learner development.

The participants incorporated a variety of active assessment tasks into the integrated music-mathematics lessons to evaluate learners' understanding, skills and a constructive, growth-oriented mind-set across various domains. They gained insights into assessing a broader range of learning outcomes, enhancing the validity and reliability of the assessment process. Horst and Prendergast (2020) also advocate for teachers to create assessment opportunities that allow learners to demonstrate the full extent of their cognitive knowledge, capabilities, attitudes and skills.

Facilitating a dynamic classroom

The facilitative role of the teacher, as emphasised by Lunenburg and Ornstein (2012), contributes to the creation of a supportive

and nurturing learning environment. Additionally, Munna and Kalam's (2021) research underscores the important role of educators in establishing an innovative educational setting that not only enriches learning but also fosters the holistic development of learners. The participants in our study implemented various approaches to create a lively and engaging classroom environment, all the while promoting a deep understanding of concepts in both music and mathematics.

The teaching and learning environment

Purposeful grouping and intentional seating arrangement of learners, both in the classroom and in outdoor settings, played a vital role in allowing participants to cultivate a sense of collaboration and teamwork, thereby enhancing the learning environment. Teaching lessons in an outdoor setting proved to be a successful extension of the learning experience. The learners were enthusiastic, fostering creativity, resulting in increased overall engagement and improved understanding. Additionally, there were more opportunities observed for experimentation, exploration and collaborative work. They also recognised the positive impact that outdoor classroom learning has on enhancing the overall learning experience.

The lessons presented by the participants involved activities that nurtured learners' confidence in self-expression. This led to the establishment of a learning environment that was emotionally secure and supportive. In this setting, learners were motivated to take risks, explore various solutions and express themselves freely without concerns about criticism or mistakes. Wibowo et al. (2020) suggest that a learner who experiences a sense of safety and security is more inclined to engage in exploring new learning possibilities.

Teacher–learner interaction

Teacher–learner interaction significantly influences the development of learners' motivation, curiosity, interest in the subject and academic performance (Rahman et al. 2020). Our findings indicated that the participating teachers experienced a stronger teacher–learner relationship compared to their previous teacher-centred class environments. They recognised the importance of collaborating with learners and appreciated the increased levels of engagement and connection displayed by the learners. The teachers were also able to teach with compassion, incorporating elements such as 'trust, empathy, patience, inclusion, community, and authentic connection' as outlined by Hendricks (2018:8). They demonstrated kindness, fostered reliance and provided patient support to learners without hesitation. Their compassion fostered a sense of community not only between the teacher and learner but also among the learners themselves. This, coupled with mutual respect, resulted in a noticeable decrease in disruptive behaviour within the learning environment. These findings conform to research conducted by Mallik (2023), which indicated that learners are more inclined to exhibit positive classroom behaviour when they perceive a positive and supportive relationship with teachers.

Collaborative learning

Collaborative learning entails active engagement among learners within a learner-centred framework, involving collective interactions to cultivate the development of knowledge, skills and attitudes (Supena, Darmuki & Hariyadi 2021). In our study, participants noted that the dynamic collaborative learning environment produced improvements in learners' collaborative problem-solving skills, critical thinking, participation in discussions, collaborative exercises and overall engagement. This improvement resulted in a deeper understanding and overall success of the music-mathematics lessons. Furthermore, the implementation of clear and concise instructions facilitated productive collaboration, ultimately contributing to the overall success of the music-mathematics lessons.

Conclusion

The primary objective of this article was to delve into the experiences of generalist teachers as they facilitated lessons using a constructive alignment approach, combining the realms of music and mathematics. In the context of this framework, the article aimed to analyse how these teachers perceived and actively engaged in the process of harmonising ideas and educational experiences in both music and mathematics using thoughtfully created lesson plans.

While previous studies explored the impact of integrating music on learners' understanding of mathematical concepts, this study takes a unique approach by incorporating the constructive alignment framework (Biggs 2014), as mentioned earlier. This framework provides a distinctive perspective, enabling a more in-depth exploration of how the integration of music and mathematics reinforces educational goals in mathematics, thereby enhancing overall learning outcomes.

The findings of the study question the idea that teachers need formal music qualifications or personal proficiency as musicians to incorporate music into mathematics teaching. The research highlights the importance of generalist teachers successfully blending music into mathematics lessons, challenging the notion that extensive musical training or instrumental skills are prerequisites. This opens up the opportunity for a broader spectrum of teachers to engage in interdisciplinary teaching.

Emphasising the significance of establishing meaningful links between music and mathematics, the study moves away from a sole emphasis on musical proficiency towards a more holistic approach. Teachers can foster these connections by engaging learners in activities that highlight the relationships between music and mathematics. This interdisciplinary approach not only improves understanding but also creates a foundation for a more comprehensive and meaningful learning experience.

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.

This article underscores the fact that generalist teachers can adeptly integrate music into mathematics lessons without the need for advanced musical training or instrumental expertise. Using well-designed lesson plans, generalist teachers can merge music and mathematics effectively, ultimately enriching the teaching and learning experience.

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