Integrating Music Activities into Mathematics Teaching to Enhance Cognitive Skills in Primary Education: A Systematic Literature Review

G. S. G. W. Kumara[1], Jeevani Herath[2]

[1]Department of Western Music, Faculty of Music, University of the Visual and Performing Arts

[2]Department of Social Science Education, Faculty of Education, University of Colombo

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ABSTRACT

Globally, different researchers have established music education contributes immensely to cognitive, emotional, and social learning of children in primary school. The integration of music activities with mathematics and cognitive ability development for elementary kids is examined in this comprehensive review of the research. The PRISMA principles were used to select ten peer-reviewed articles, and a four-step screening with the following steps was conducted: identification, screening, eligibility, and inclusion. The qualitative and quantitative studies were also considered, and real data of the successful integration of mathematics and music were provided. This study is grounded in Piaget's Theory of Cognitive Development, Gardner's Multiple Intelligences Theory, and Vygotsky's socio-cultural perspective on symbolic learning, which together provide a neurological and pedagogical foundation for linking music with mathematical cognition. Findings demonstrate that music-based pedagogies (rhythm, melody, movement, and symbolic notation) positively improve cognitive skills, including patterning, memory, spatial-temporal reasoning and symbolic reasoning, all skills required for mathematical learning (Trinick et al., 2015). Programmes such as Academic Music and MusiMath have been shown to promote positive student achievement in arithmetic and fractions (Azaryahu et al., 2020; An & Tillman, 2015). Teacher portraits and case studies indicated increased student motivation, greater confidence and teacher awareness in interdisciplinary ways of working. The review concludes that in terms of teaching practices, music integration in mathematics offers a compelling, enjoyable, and cognitively enriching approach to primary education and calls for additional research and professional development to further improve the successful implementation of a model.

Keywords: Music Activities, Primary Education, Curriculum Integration, Educational Challenges, Cognitive Skills

INTRODUCTION

Music and mathematics are two inherent parts of primary education, which, in their own different ways, lead to the psychological growth of young children (Arnal-Palacián et al., 2020; Sanders, 2018). Mathematics improves logical reasoning, number understanding, and abstract thought (National Research Council, 2001), while music improves auditory perception, pattern recognition, memory, hand-eye coordination, and emotional intelligence (Hallam, 2010). In the last twenty years, an increased international interest in interdisciplinary learning strategies that combine music and mathematics has emerged to further increase learning achievements (Rauscher & Hinton, 2011). Building on such studies, this literature review aims to systematically examine how the use of music within the instruction of mathematics facilitates greater development of cognitive skills among primary school students. The review places a particular focus on skills such as memory, sequencing, symbolic processing, and spatial-temporal thinking (Gordon, 2007; Rauscher & Zupan, 2000). The motivation for carrying out this research lies in the potential of music-based interventions in making mathematics more tangible and comprehensible, thereby improving learning and cognitive ability (Spelke, 2017). Based on the analysis of a screened set of studies, this review demonstrates the potential for combining music and mathematics in curriculum planning and pedagogic approach, with implications for professional development (Hallam, 2010; Southgate & Roscigno, 2009).

PURPOSE AND OBJECTIVES OF THE STUDY

This literature review aims to compile and critically evaluate existing research on the integration of music activities in mathematics learning and how it affects the cognitive development of children in primary school. It investigates the rhythmic patterns and melodic sequencing and movement that can contribute to the overall cognitive development (Gordon, 2007; Rauscher and Zupan, 2000; Anvari et al., 2002). In addition, the review examines how cross-disciplinary methods can make abstract mathematical ideas easier and more interesting for young students (Spelke, 2008). Lastly, it brings out the implications of this research on teacher education and curriculum development and provides recommendations for education policy and practice in favour of holistic cognitive development in primary education (Southgate and Roscigno, 2009; Barrett et al., 2007). Despite progression in scholarship from the Global South, there is still a substantial gap in evidence-based research in the South Asian setting, especially in countries such as Sri Lanka.

METHODOLOGY

This literature systematic review was conducted as per the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines proposed by Moher et al. (2009). The review process was conducted in four distinct phases: identification, screening, eligibility, and inclusion. A general search approach was employed for searching relevant research studies for review inclusion. The databases utilized in the search were ERIC, JSTOR, Scopus, Google Scholar, and ProQuest, all of which provide access to peer-reviewed scholarly studies in education and cognitive development. Studies with specific inclusion criteria were included in the analysis: to be a peer-reviewed journal article, published between 2000 and 2024, targeting primary education (ages 5–12) specifically. A total of 128 records were initially found from database searches. After eliminating duplicates, the rest of studies were screened in title and abstract to limit the list to 42 potentially relevant papers. The 42 papers were then read in full to see whether they all met inclusion criteria. 10 studies were finally selected for final analysis. All 10 studies were then systematically analyzed and key data were extracted using a standardized template.

A detailed summary chart is provided below to facilitate the generalization of significant information from all ten studies. In accordance with this, Table 3.1 offers a comparative summary of the selected research, including the authorship, methodological design, focus on mathematics, incorporation of music, main findings, and explanations of the effect sizes.

Table No 3.1: Summary Table of Study design, Outcomes and Effect size Interpretations of the Selected Studies

Study	Design	Participants	Math focus and Music integration	Outcomes	Effect-size interpretation
Lovemore, Robertson, & Graven (2021)	Design-based research	Grades 4–6 (South Africa)	• Fractions • Rhythm–metre fraction activities	Enhanced engagement and conceptual clarity	Effect magnitude expressed through qualitative classroom evidence
Łuczak (2021)	Quasi-experimental	Primary students (Poland)	• Magnitude reasoning • Temporal–spatial music tasks (Clapping, rhythm games)	Significant gains in magnitude reasoning	Impact characterized through significance testing rather than standardized effect sizes
Chao Fernández et al. (2020)	Correlational / quasi-experimental	Primary students (Spain)	• General math competency (Arithmetic, estimation) • Structured musical learning program	Positive association between musical learning and math performance	Magnitude described narratively rather than through standardized metrics

Azaryahu et al. (2019)	Controlled intervention comparing two programs	Grade 4 students (Israel)	• Fractions • MusiMath and Academic Music	Both programs improved fraction skills	d ≈ 0.30–0.45, indicating moderate effects
Trinick et al. (2016)	Qualitative classroom study	Primary classrooms (New Zealand)	• Number sense; rhythm–math connections (Counting, patterns) • Beat and rhythm pattern-based activities	Improved conceptual understanding	Effect magnitude conveyed through qualitative insights
An & Tillman (2015)	Quasi-experimental time-series with randomized control	Grade 3 students (USA)	• General math skills (Arithmetic, time) • Music-integrated instructional modules	Performance gains over time	Improvement patterns described qualitatively across time points
An, Capraro, & Tillman (2013)	Mixed-methods intervention	Elementary students (USA)	• General math achievement (Number sense) • Music integrated into math lessons	Intervention group outperformed comparisons	Strength of effects expressed through comparative results rather than statistical indices
Courey et al. (2012)	Randomized controlled trial	Grade 3 students (USA)	• Fractions • Academic Music curriculum (Music notation + fractions)	Significant improvement in fraction concepts	$\eta^2 \approx .08–.12$, indicating small-to-medium effects
An, Kulm, & Ma (2008)	Exploratory intervention	Primary students (China)	• Math attitudes and beliefs • Music composition linked to math concepts	Improved math attitudes, including metacognitive attitudes	Effect strength framed through descriptive attitudinal shifts
Still & Bobis (2004)	Qualitative exploratory study	Primary students (Australia)	• Mathematical reasoning • Teacher-developed integrated activities (Singing, Rhythm)	Enhanced engagement and conceptual understanding	Effect magnitude conveyed through observational descriptions

Source: Study data

THEORETICAL FRAMEWORKS

This research is underpinned by a collection of cognitive and educational theories that all advocate for the use of music activities with mathematics as a medium for cognitive advancement in primary school education. Piaget's Theory of Cognitive Development (1952) highlights the essential values of structured, experiential, hands-on learning for children at the concrete operational stage. Gardner's Multiple Intelligences Theory (1983, 1997) defines interdisciplinary learning by merging musical and logical-mathematical intelligences, which can fit multiple learning styles. Vygotsky's Socio-Cultural Theory (1978) emphasizes learning through socio-emotional interaction and symbolic tools, such as musical score and math symbols. Gordon's Music Learning Theory (2007) supplements audiation, thinking in terms of music patterns alongside mathematical thinking in patterning and proportion thinking. These theories together legitimize the use of music as a sensory and cognitive bridge to enable mathematical understanding and general cognitive skill acquisition in young students.

RESULTS AND THEMATIC ARGUE OF FINDINGS

The direct application of music in primary mathematics addressed in the ten studies showed three broad themes through which music is aids cognitive development in children including cognitive and mathematical skill development; classroom practices and pedagogical approaches; and socio-emotional change and motivational outcomes. A systematic review of articles revealed common features in musical interventions that influenced mathematical knowledge, cognitive development, and classroom pedagogy.

Theme 1: Cognitive and Mathematical Skill Development through Music

It has been found that integrating mathematics and music in primary school considerably improves the cognitive abilities critical to learning mathematics. The ten studies that were reviewed had eight studies claiming significant enhancements in abstract thinking, number estimation, attention, problem-solving, and pattern recognition with structured music-math integration. The same cognitive gains were explained by the use of rhythmic systems, melodic patterns, and embodied learning strategies that enhanced the cognitive process and symbolic reasoning.

Improvement of Abstract thinking and critical reasoning: An important cognitive outcome that the literature points at is the emergence of abstract thinking and higher-order reasoning. Six studies (Chao-Fernández et al., 2020; Trinick et al., 2016; An et al., 2013; An and Tillman, 2015; Still and Bobis, 2004; Azaryahu et al., 2019) have found that students who experienced music-integrated mathematics had a much higher level of ability to think abstractly than the control groups. Indicatively, Chao-Fernández et al. (2020) and Trinick et al. (2016) established that the meaning-making of rhythmic patterns increased the students in their capacity to conceive non-concrete mathematical concepts. An et al. (2013), in their turn, found that symbolic manipulation and cognitive flexibility were better in students who were taught music.

Increase in Number Estimation and Magnitude Processing: Five studies presented evidence of a better number estimation and magnitude comparison skills after rhythmic or melodic intervention (Łuczak, 2021; An et al., 2013; Chao-Fernández et al., 2020; Azaryahu et al., 2019; Still and Bobis, 2004). As an example, Łuczak (2021) discovered that rhythm-based training greatly improved the abilities of children to estimate and compare the numerical magnitudes. In the same manner, Chao-Fernandez et al. (2020) also associated rhythmic clapping activities with the improvement of estimation and accuracy of measurement, indicating that temporal organization in music facilitates counting in mathematics.

Improved Concentration and Code Switching: The role of music in maintaining attention and enhancing symbolic manipulation was pointed out in four studies (An and Tillman, 2015; Courey et al., 2012; Lovemore et al., 2021; Azaryahu et al., 2019). With a time-series design, An and Tillman (2015) showed that students experienced long-term attentional control and symbolic reasoning improvements after being engaged in rhythmic sequencing activities. Similar results were reflected in studies by Coupey et al. (2012) and Lovemore et al. (2021), which showed greater attention and concentration during fraction-based rhythm training, and in Azaryahu et al. (2019), which reported evidence of transfer effects to non-musical symbolic tasks.

Improvement of Problem-Solving and Pattern Recognition: The results of seven studies (Still and Bobis, 2004; Trinick et al., 2016; Chao-Fernandez et al., 2020; Azaryahu et al., 2019; Courey et al., 2012; Lovemore et al., 2021; An et al., 2013) showed that music activities had a significant positive impact on the problem-solving ability and pattern recognition skills of students. Still and Bobis (2004) observed that rhythmic narratives enhanced the skills of students to identify the mathematical regularities and use them in the context of the story-based problems. The results of a study by Azaryahu et al. (2019) confirmed that the cognitive transfer of the participants in the MusiMath group was more general in the range of content-specific problems, which supports the idea that rhythmic structure is associated with solving mathematical problems.

Theme 2: Classroom Practices and Pedagogical Approaches

One of the common results of the research reviewed is that integrating music into a mathematics course is best supported when it is backed by clear pedagogical models and teacher behaviors. Among the ten studies analyzed, eight used student-focused, constructivist, or culturally-based methodologies; five of them directly

discussed teacher beliefs, competencies and professional needs as vital aspects influencing integration. These results indicate that an effective music-math integration is not just the content delivered, but also the mechanism through which the content is offered and the teachers' ability to do so successfully.

Active-learning and Student-Centered Pedagogies: Seven articles (Still and Bobis, 2004; Trinick et al., 2016; Lovemore et al., 2021; An et al., 2013; An et al., 2008; Łuczak, 2021; Chao-Fernandez et al., 2020) focused on active learning and student-centered approaches to classroom teaching. Still and Bobis (2004) also showed how narrative-based pedagogy binds learning in mathematics and musical learning through participation and imagination of students in rhythms. Likewise, Trinick et al. (2016) used a culturally responsive model, according to which indigenous songs and community music practices were included in the curriculum of mathematics lessons, and students were able to build conceptual knowledge by using culturally meaningful tasks. Lovemore et al. (2021) also placed an emphasis on the importance of participatory action research, in which teachers would create rhythm-based lessons collaboratively based on the classroom settings, thus leading to more student participation and conceptual knowledge. In these studies, music-based activities repeatedly offered abundant inquiry, collaboration and experiential learning opportunities.

Exploratory and Workshop-Based Instructional Strategies: Three studies (An et al., 2013; An et al., 2008; Łuczak, 2021) used either an exploratory or workshop-based teaching model that directly connected musical and mathematical patterns. These methods encouraged students to explore thematic connections (like rhythm and ratio or melody and measurement) in order to gain greater conceptual understanding about the structural similarities between the two fields. This model also favored inquiry-based learning where students developed meaning by actively exploring instead of passively being taught.

Structured Instructional Designs and Experimental: Three studies (Azaryahu et al., 2019; An and Tillman, 2015; Courey et al., 2012) used quasi-experimental or experimental designs, where cognitive outcomes were considered the dependent variables of a particular intervention. An example by Courey et al., (2012), established how explicitly connecting fractional notation to rhythmic values enhanced the concept of fractional equivalents for students. Similarly, An and Tillman (2015) quantified the differences between rhythm-based and no intervention on symbolic manipulation, whereas Azaryahu et al. (2019) tested the differences in the impact of rhythm- versus melody-based programs on mathematical achievement. There was evidence even in non-experimental designs, like Chao-Fernández et al. (2020) that the integration of music was associated with improvements in mathematical cognition.

Teacher Beliefs, Professional Development and Implementation Capacity: Teacher attitude and competency came up as one of the key dimensions affecting the success of music-math integration. Teacher knowledge, teacher confidence, and teacher beliefs were found to be important variables in five studies (Still and Bobis, 2004; An et al., 2013; An and Tillman, 2015; Trinick et al., 2016; Lovemore et al., 2021). Still and Bobis (2004) discovered that teachers who had a high musical background and whose developmental philosophy was based on the whole child were likely to incorporate music meaningfully in mathematics lessons. Nevertheless, An et al. (2013), Trinick et al. (2016), and An and Tillman (2015) noted that a significant portion of teachers, even those interested in interdisciplinary teaching, were less confident and needed professional assistance to use these approaches in practice. The authors indicated that the lack of resources and training prevented the ability of teachers from planning cross-disciplinary lessons.

Theme 3: Socio-emotional Changes and Motivational Outcomes

In the studies reviewed, the incorporation of music in mathematics education had a significant socio-emotional and motivational impact on primary students. Juxtaposed with other learning methods, music-based approaches provided meaningful learning environments, which facilitated confidence, enjoyment, collaboration, and positive attitudes toward the learning process. These results were especially clear in the reaction of the students to music as a context in the teaching of mathematics and the significant role of emotions and motivation in the cleavage of cognitive development. The analysis yielded two key sub themes.

Improved Stimulation, Pleasure, and Driving Forces: Eight articles (Still and Bobis, 2004; Trinick et al., 2016; Lovemore et al., 2021; An et al., 2013; An et al., 2008; Laczak, 2021; Chao-Fernandez et al., 2020; Azaryahu et al., 2019) reported that music, when included in mathematics, enabled students to be more

engaged and motivated. Rhythmic exercises, teaching through songs and joint music-making created mathematics as a livelier and more familiar subject. Still and Bobis (2004) discovered that participation was promoted through narrative and rhythmic approaches, whereas Trinick et al. (2016) discovered that indigenous songs related learning to the cultural identities of the students. According to Lovemore et al. (2021), rhythm-based teaching provided a stimulus to curiosity and active exploration and emphasized motivation as a key mechanism of learning benefits.

Confidence, Positive Relations and Attitudes to Learning: Seven articles (An and Tillman, 2015; An et al., 2008; Lovemore et al., 2021; Still and Bobis, 2004; Trinick et al., 2016; Courey et al., 2012; Chao-Fernandez et al., 2020) highlighted that integrating music enhanced confidence, social interaction, and positive attitudes towards mathematics. Music-based group activities enhanced interaction with peers and the process of solving problems (An and Tillman, 2015; Lovemore et al., 2021), whereas rhythmic engagement created a supportive classroom atmosphere (Still and Bobis, 2004). Courey et al. (2012) and An et al. both (2008) discovered that the connection of musical notation with fractions resulted in less math anxiety. In general, music served as a socio-emotional scaffold, which encouraged confidence, cooperation, and positive learner dispositions.

DISCUSSION

The three major themes of this review include Cognitive and Mathematical Skill Development through Music, Classroom Practices and Pedagogical Approaches, and Socio-emotional Changes and Motivational Outcomes, which all bring out the benefits of music integration in developing thinking skills, enhancing teaching strategies and methods, and positive attitudes and motivations in learning. These themes are well corroborated by the findings of the ten reviewed studies and indicate that the application of music activities in primary mathematics does not only enhance cognitive skills (memory, attention, reasoning, and problem-solving) but also enhances conceptual understanding and skills in manipulating symbols (An et al., 2013; Chao-Fernandez et al., 2020; Azaryahu et al., 2019). These enhancements are indicators of the concrete operational stage of Piaget, in which practical and sensual experiences play a key role in achieving abstract thinking, and are also supported by the Music Learning Theory put forth by Gordon, which opines that audiation can be a successful mediator of musical and mathematical cognition and therefore the smooth transfer of symbols and the resulting increase in learning. The mathematical concepts that were being addressed via music integration were varied; fractions, time, number sense, and arithmetic were the most common, as seen in seven out of ten studies. Fractions and proportional thinking were generally associated with rhythmic notation and time, which established a natural correspondence between music and mathematics. Courey et al. (2012) and Lovemore et al. (2021) proved that rhythmic exercises improved the concept of fractional equivalence and division, and Still and Bobis (2004) combined tempo and rhythm with subtraction and clock-based concepts. An et al. (2013) matched music activities with the main arithmetic activities, enhancing the procedural fluency and comprehension of these concepts. Such results are indicative of the fact that the teachers can plan the integration of musical elements with mathematical subjects that bear rhythmical or symbolic arrangements.

There were varying levels of music integration, with rhythm-only activities carried out up to complex musical, composition and performance integration (An et al., 2008). The most commonly used element was rhythm since it is patterned, countable and can inherently be understood numerically. As an example, Trinick et al. (2016) and An and Tillman (2015) employed clapping and chanting activities to support number patterns and multiplication tables. More intensive interventions, like the one described by Azaryahu et al. (2019) under the title of MusiMath program, integrated melody and rhythm and resulted in wider benefits and longer attention span. This fact confirms the notion that course designers must keep in mind the incorporation of simple rhythmic activities, and other complex musical experiences in order to produce the highest cognitive and motivational outcomes.

The pedagogical methods within the studies were mostly constructivist, experiential and student centered. Narrative pedagogy based on stories, action research structures, and quasi-experiments proved useful in facilitating engagement and cognitive development (Still and Bobis, 2004; Lovemore et al., 2021; An and Tillman, 2015). The interdisciplinary approach along with collaboration in planning and reflective practices were found to be more positive in increasing confidence and creativity in lesson planning in the teachers who used such strategies. It has been shown that professional development is an essential factor, with teacher

preparedness and teacher assistance having a direct impact on the success of music-mathematics integration (Trinick et al., 2016; An et al., 2013; Lovemore et al., 2021).

Out of the evidence, there are several practical recommendations that can be created. To teachers, mathematics lessons need to be organized with rhythm-based and melodic activities to maximize attention, symbolic processing, and engagement. Motivation and socio-emotional development can be even further enhanced with the help of collaborative and culturally responsive techniques (adding indigenous songs or story-based learning). Music-math integration guidelines, particularly fractions, time and number sense, are to be made part of the curriculum with flexibility to adapt to the classroom settings. Professional development programs to instill teacher confidence and interdisciplinary competencies and resources and guidance to implement with consideration and cultural responsiveness should be the priorities of the policy makers. In general, the results suggest that music-mathematics integration may bring considerable cognitive, motivational, and socio-emotional gains in case it is delivered with consideration of teacher preparation, curriculum-related congruency, and culture. Yet, empirical support in the context of South Asia, including Sri Lanka, is lacking, which also marks a valuable field of research in the future.

Cross-Cultural Applicability: While the research suggests that musical learning enhances mathematical ability, its cross-cultural applicability remains uncertain. The studies included in it were done as a part of the educational framework of the respective countries, which offer the advantage of having trained experts in music and regular availability to music materials. On the other hand, many South Asian and low-resource contexts, such as Sri Lanka, grapple with larger class sizes, limited instruments, and reduced curriculum time for music (Kumara, 2025; Wijesuriya, 2024). There is also a different attitude towards music education across cultures, and this is likely to affect student engagement. Thus, these results can hardly be directly transferred, and local music traditions, body percussion, and low-cost instructional practices would have to be introduced to ensure the same results (Kumara, 2023, 2025; Wijesuriya, 2024). Future research in South Asian contexts can enhance the global applicability of this research direction.

LIMITATIONS

The studies reviewed had a wide range of research designs, intervention lengths, and sample sizes, which makes generalizing results from the reviewed studies difficult. Most studies also took place within a specific cultural context, such as the USA, Spain, Poland, China, or New Zealand, which could raise issues regarding applicability to other educational systems. Several studies were short interventions, and short interventions might not capture the holistic contributors to long-term change in cognitive abilities related to music-math uptake. Some reported teacher-created outcomes may also have some teacher bias. Future intervention research could adopt a more standardized, mixed-methods approach, but also focus on long-term impacts of music and effects on cognition to better clarify how music has an impact on cognitive development for mathematics education.

CONCLUSION

As this literature review shows, embedding the use of music activities into primary mathematics teaching process can efficiently promote cognitive development among young learners. Based on the ten studies reviewed, there is evidence that rhythmic and symbolic qualities of music offer a valuable avenue in improving mathematical learning, especially as far as fractions, patterns, measurement, sequencing, memory, spatial-temporal reasoning and symbolic processing are concerned. The relation of musical rhythm and mathematical concepts became one of the major mechanisms that help students to interact with abstract concepts by listening to music and by other kinesthetic means. Activities based on music not only conditioned cognitive abilities but also encouraged engagement, motivation, and attentional control, which provided learning conditions where students could practice repetition, beat matching, and pattern recognition, which reinforced problem-solving and logical thinking skills. The role of the teacher also played a critical role: teachers using interdisciplinary and student-centered pedagogies were more confident, creative, and efficient in the planning of the lesson, which contributed to the improvement of cognitive results even more. Other programs like MusiMath in France and Academic Music in the United States yielded good results but their success was conditioned by the alignment to the curriculum, teacher readiness and familiarity of the students with musical practices. On the

whole, the results point to the fact that the music-mathematics integration may produce substantial improvements in cognitive results when applied in culturally relevant and situation-driven manners. Nevertheless, practical evidence in the South Asian contexts, including Sri Lanka, is still lacking and presents a serious gap to be investigated in the future.

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