INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT
OPEN ACCESS JOURNAL
Vol 15, Issue 1, (2026) E-ISSN: 2226-6348

The Use of Mathematics Concepts to Memorize Musical Note and Rest Duration

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DOI Link: http://dx.doi.org/10.6007/IJARPED/v15-i1/27532

Published Online: 05 February 2026

Abstract
Recently, there have been issues related to difficulties in understanding the values of musical notes and rests. A quasi-experimental study involving 60 pupils from a primary school was conducted. The participants were assigned into two groups of 30 pupils each. The treatment group received an intervention based on mathematical concepts while the control group received conventional instruction over a period of 11 weeks. This study was carried out to examine whether there were significant differences in pupils' mastery of musical note values and rests, as well as in their levels of motivation between the treatment and control groups. The instruments used were tests and modified questionnaires. The findings of the study revealed that the treatment group achieved a significantly higher adjusted post-test mean ($M = 91.20$, $SE = 3.12$) than the control group ($M = 63.33$, $SE = 3.12$), $F(1, 60) = 32.950$, $p < .001$, partial $\eta^2 = .379$, indicating a large effect of the intervention on mastery. The intervention produced a clear and meaningful improvement in pupils' confidence while its effects on motivational interest and perceived usefulness were positive but not statistically significant. Future work should lengthen the exposure to target interest and perceived usefulness.
Keywords: Mathematics, Integrate, Music, Musical Notes Value, Musical Rests Value

Introduction

Music theory is a key component of music learning. The aim of studying music theory is to apply this knowledge and skill to interpret the musical detail and performance choices (Bowman, 2022). Musical detail is difficult to discuss by ear alone without some form of visual representation such as musical notation. The symbolic characteristics of notation provide valuable insight into the organizational aspects of a musical measure, where notes are placed strategically to convey accents on beats, decrease and increase in pitch (Seeyo, Seekhunlio, and Chuangprakhon, 2023). According to Zazulia (2021), rhythm is not discussed explicitly in terms of the number of beats each note must be held, but rather in terms of the various arrangements of notes that yield temporally stable values. Sound duration and pitch level are denoted by notes in variously shaped oval or semi-oval note heads on the musical score, while rests indicate moments of silence within the ongoing rhythm (Seeyo et al., 2023).

Pupils who study music use theoretical knowledge to engage in a range of musical activities such as score analysis, music composition, improvisation, performance and musical appraisal. Musical notation remains foundational in music education because it provides a firmer basis and supports more advanced levels of music instruction (Akıncı, 2024). Music theory and aural skills form the knowledge base for becoming a creative and inquisitive musician (Bowman, 2022). Therefore, music theory activities such as reading and writing notation are important elements of music learning.

The lack of ability to read musical notation is not a new problem, many pupils still have not mastered the skills of reading and writing musical notation. The nature of musical notation impedes students' understanding of the concepts of note values and rests. Van Zoelen (2023) mentions that students frequently encounter difficulties reading musical scores because of the complexity of musical notation. This problem is exacerbated when it becomes a constraint in music learning. Difficulties in music-reading skills prevent many students from continuing their music education and may be a primary reason for their discontinuation of study (van Zoelen, 2023). The complexity of musical notation may also diminish students' interest in and enjoyment of learning. Some teachers contend that learning to read musical notation increases difficulty and reduces enjoyment, although the evidence indicates otherwise (McQueen and Cavett, 2024).

The lack of knowledge in reading and writing musical notation stems from students' negative learning attitudes. Students adopt a passive stance and merely copy theoretical music notes as instructed without comparing different types of notes and rests. Akıncı (2024) reports that students typically play a passive role, recording notes based on the information provided without actively engaging in the learning process. This situation occurs because, as Ong (2025) observes, many teachers have not received adequate training in contemporary pedagogy, thereby limiting their capacity to transform traditional teaching practices to meet students' needs. Music education should be a subject that students anticipate with enthusiasm, since music activities provide opportunities to foster musical creativity, develop musical talent and enable emotional expression through musical performance whether by singing, playing instruments or movement. However, traditional methods of music instruction create a static and monotonous learning environment. Based on the experience and observations reported in the study by M. J. Ismail, Loo, and Anuar (2021) conducted in Malaysia, although the importance of creating an engaging classroom atmosphere is frequently emphasized, music classes are nevertheless often delivered in ways that do not promote enjoyable and meaningful learning. Ong (2025) similarly reports that conventional rote learning has become a dominant characteristic of music teaching and learning in Malaysia.

Music instruction that emphasizes theory without practical application leads students to perceive music as a difficult and burdensome subject. M. J. Ismail et al. (2021) demonstrate this situation by reporting that many exercises are assigned to students without providing opportunities for practical musical engagement in class. This occurs because a shortage of teachers with sufficient musical skills limits students' exposure to music education, particularly the areas of writing and reading musical notation. Jamaludin, Md Noor, Ismail, and Harith (2024) state that most primary school music teachers are not music specialists and they may lack interest in music yet are required to teach it by administrative directive. Ang, Panebianco, and Odendaal (2023) further suggest that many music teachers in Malaysia did not complete university qualifications before beginning their careers as music teachers, which may result in inadequate preparedness to interact effectively with students' parents. The shortage of music teachers is not confined to Malaysia. Recruitment of music teachers in England has declined by 53% since 2010, largely because many prospective trainees cannot afford to train without financial support (Jodie Underhill, 2020). The number of primary school music teachers in Scotland decreased by 50%, from 98 in 2008 to 49 in 2019 (Jodie Underhill, 2020). This situation deteriorated further during the COVID-19 pandemic, compounded by a lack of guidance for delivering instruction during that period.

The deficiency in knowledge of reading and writing musical notation is also evident internationally. This assertion is supported by research conducted by McQueen and Cavett (2024) in England. The problem arises in part from perceptions among some communities especially among students themselves which assume that music education is lesser importance and musical activities are merely recreational. Music education continues to be undervalued by society as a significant school subject (Noor Sham, Ismail, and Sim, 2022). Many people today regard learning music primarily as a recreational activity (Jamaludin et al., 2024; Mantie, 2022). A survey by Zhang (2024) reported that only 4% of students considered music courses to be more important than other disciplines, 28% regarded music courses as equally important, and 68% considered music courses to be less important than other subjects. According to Mantie (2022), schooling systems are organized to ensure students pass standardized examinations and prepare them for careers based on projected future utility, rather than to nurture interests in non-vocational activities such as music.

Difficulties in reading musical notation cannot be ignored because they can adversely affect the quality of singing and instrumental performance. Tosun (2023) reports that sight-reading and memory for notation are common challenges in piano learning. Despite the central role of musical notation in classroom music learning, many primary pupils still struggle to read and apply note and rest values, which undermines their progress in singing and instrumental performance and reduces long-term engagement with music (Tosun, 2023; van Zoelen, 2023). For example, students who have not mastered music-reading skills require more time to memorize the notation of a musical work before singing or playing an instrument. Due to accurate rhythmic literacy is foundational to musical performance and curriculum progression, persistent deficits in notation literacy represent a pressing pedagogical problem that warrants targeted empirical study.

Various efforts have been undertaken to improve pupils' ability to read musical notation. The Ministry of Education Malaysia (KPM) has provided a range of teaching materials and musical resources, including compact discs, textbooks, and the Music Education Teaching Guide for teachers' reference. According to Lim and Mohd Hassan Bin Abdullah (2024), the Curriculum Development Centre also provides the Music Education Resource Book as a means to assist teachers in carrying out their duties with confidence, particularly those who are not Music Education specialists. KPM has also issued the School-Based Assessment (PBS) Management Guide 1st Edition in 2025, as a reference for teachers when assessing pupils based on the Standards Based Curriculum and Assessment Document (DSKP). According to the PBS Management Guide, schools are granted autonomy to implement Music Education assessment in the form of written tests or projects because this subject contains a greater proportion of psychomotor and affective domains than the cognitive domain (Kementerian Pendidikan Malaysia, 2025). The Braille Authority of North America provides a

Music Braille Code for visually impaired individuals so that they have access to learning musical notation. Musical transcriptions that include Braille representations of symbols denoting notational elements are known as "facsimiles" and are provided only for blind teachers and specific requests (The Braille Authority of North America, 2016).

Although there are several studies on the integration of Music Education within the field of Mathematics, a clear understanding of integrating Mathematics and Music requires further examination due to a paucity of studies that focus on incorporating Mathematics into Music learning. According to Chao-Fernández, Mato-Vázquez, and Chao-Fernández (2020), most of the work are built on the relationships and common structures of both music and mathematics components, but studies aimed at teaching and learning of mathematics and music simultaneously are highly unusual and scarce. There is a significant lack of practical integration in many educational settings. Students often have limited opportunities to explore these subjects in arts-based interdisciplinary contexts or through real-world applications (Gresham, 2021; Moldavan and Johnson, 2023; Parr, 2023). This trend does not come as a surprise because content and teaching methods courses frequently present siloed content apart from creative interdisciplinary frameworks that could empower learners (Chao-Fernández, Mato-Vázquez, and Chao-Fernández, 2020; Moldavan and Johnson, 2023). Tara Stradley (2023) likewise suggests further research into learning activities, musical strategies, and teaching plans that have been successfully employed to inform future applications and the integration of core subject content.

In this regard, the current quasi-experimental study evaluates whether integrating mathematical concepts into music lessons improves pupils' mastery of note and rest values and affects motivational outcomes to address this empirical gap and to provide classroom-relevant guidance for teachers. This study therefore examined whether there were significant differences in pupils' mastery of musical note values and rests, as well as in their levels of motivation between the treatment and control groups.

Objectives Research

i. To compare the scores in the level of mastery of musical note values and rests between the treatment group and the control group among primary school pupils.

ii. To compare pupils' levels of motivation between the treatment group and the control group among primary school pupils.

Research Questions

Based on the study objectives, the following research questions are investigated:

i. Is there a significant difference in the scores for the level of mastery of musical note values and rests between the control group and the treatment group among primary school pupils?

ii. Is there a significant difference in pupils' levels of motivation between the treatment group and the control group among primary school pupils?

Research Hypotheses

The following hypotheses, developed from existing theories, will be tested to address the research questions.

H_{01}: There is no significant difference in the scores for the level of mastery of musical note values and rests between the control group and the treatment group among primary school pupils.
H_{02}: There is no significant difference in pupils' levels of motivation between the treatment group and the control group among primary school pupils.

Literature Review

Mathematic Concept

Mathematics is a field of knowledge that studies and organises methods, theories, and theorems including quantity, structure, pattern and any changes of abstract that using symbols and deductive logic to prove properties of objects. Thanheiser (2023) described Mathematics as a body of abstract knowledge that is systematically organised and used to make logical conclusions. Yang et al. (2021) defined a mathematical concept as a statement or description of its connotation and characteristics to represent as a general construct that encompasses more specific constructs. It indicates the entire conceptual system by highlighting similarities and differences with other concepts. For example, a geometric diagram of a right triangle distinguishes a general triangle and a right triangle.

Mathematics is not just about numbers or calculations but it is about structured ways of thinking and reasoning that can be applied to everyday life situations. Early mathematical concepts include understanding shape, quantity, space, dimension or position, pattern, time, number recognition, number representation and numerical operations (Janius, Mohd Ishar, Bang, Sid, and Wong, 2023). Fractions are an essential element for representing non-integer quantities and allow such quantities to be expressed precisely (Tadeu, 2024). Fractions not only represent parts of a whole object but are also used to describe parts of area, length, mass, and capacity or volume. According to Tadeu (2024), a fraction consists of a numerator representing the portion taken and a denominator representing the total number of equal parts of the unit.

In mathematics instruction, teachers should allow pupils to use multiple problem-solving approaches. According to Small (2020), effective fraction teaching emphasises at least three different modes of representation such as area models, visual diagrams, number lines, and symbolic representations, so that pupils can deepen their conceptual understanding of fractions. Teachers should allow pupils to create their own contexts based on their understanding so that every learner has the opportunity to participate in discussions when solving mathematical problems that are appropriate to their level of mastery.

Music Concept

Music has a multiplicity of functions in our daily life. According to Hallam and Himonides (2022), music functions at individual, group and societal levels and acts as a tool for mood regulation, identity formation and the validation of social institutions. According to the American Heritage Collegiate Dictionary, music is defined as an art that arranges sound in time to produce a continuous composition (Johnston, Millbower, and Parkin, 2023). Music theory is one component of music learning. Music educators often seek alternative teaching approaches for music theory.

Musical notation refers to the use of a system to represent music visually by marking pitch, rhythm, dynamics and other performance directions for a given piece. Music consists of notes and rests that differ in duration, known as note values and rests (Tarryn S. Lovemore, Robertson, and Graven, 2021). Musical notation is a set of visual instructions that allows a composer to convey their musical work to other performers across time and space. According to Gök (2023), musical signs function as "phonic" and "conceptual". Musical concepts, terms and symbols that constitute the foundational information must be conveyed to pupils. Gök (2023) further asserts that musical facts and events could remain in pupils' memory only through understanding of these concepts and terms. Western musical notation typically encodes pitch through vertical placement on the musical staff and rhythm through note-head shapes and stems. The concepts of note values and rests resemble the concept of fractions in mathematics. According to Seeyo et al. (2023), durations of notes and rests are arranged in a proportional hierarchy in which the duration of a given note value is twice that of the next smaller value. The division of meter at the beginning of a bar determines the number of beats in each bar (Seeyo et al., 2023).

Mathematics and Music Relationship

Music and mathematics share several characteristic similarities. They can be integrated because as Azaryahu, Ariel, and Leikin (2024) mention western music and mathematics have been recognised as overlapping and similar disciplines since the time of Pythagoras. Both music and mathematics require abstract thinking and make use of symbolic notation (Azaryahu et al. 2024; Azaryahu and Adi-Japha 2022). Mathematical concepts such as symmetry, pattern, ratio, and division are expressed in harmony, rhythm and musical form whereas intervals, rhythm, duration and tempo are represented by numbers (Azaryahu et al., 2024). Harmony describes how sounds relate to one another and are sounded simultaneously. Musical rhythm refers to how sounds are organised in time while musical form denotes how a musical composition is structured into sections. Notes vary in temporal length and their relative durations reflect fractional relationships among them (Tarryn S. Lovemore et al., 2021).

Rhythm and melody are two principal musical elements (Johnston et al., 2023). Rhythm encompasses beats, meter and durations formed from the arrangement of sounds. A beat is a unit of ongoing pulse in music and is grouped into measures according to the time signature known as the meter. Rhythm is represented by different note shapes in each measure according to the time signature (Zazulia, 2021). Pupils learn how to count, multiply and divide to maintain a stable rhythm. In the process of maintaining a steady rhythm or creating rhythmic patterns, pupils use mathematical knowledge within music education. When pupils learn music, they draw upon existing knowledge from other subjects to apply in musical activities (Noor Sham, Ismail, and Sim, 2022).

Music education is related to other school subjects such as mathematics, history, science, and cultural studies (Tara Stradley, 2023). A musician must use fractions and addition or subtraction to determine each note value when reading and analysing a musical score (Noor Sham et al., 2022). Music can improve the ability to transform mental images in the absence of a physical model and certain mathematical skills, such as understanding fractions and ratios (Hallam and Himonides 2022). This demonstrates the interrelationship between mathematics education and music education.

Benefit of Using Mathematical Concepts in Music Learning

The use of mathematical concepts in music learning can assist pupils in understanding musical concepts because mathematical foundations can serve as a framework to explain musical ideas logically. Azaryahu et al. (2024) explain that this mode of learning helps pupils appreciate that Music Education and Mathematics are not isolated subjects but rather two kinds of abstract symbol systems that share a common semantic structure. Both subjects operate according to specific rules and are closely related in terms of form and structure. According to Moldavan and Johnson (2023), integrating mathematics makes music instruction more intellectually stimulating by providing a logical framework for explicating musical concepts. Pupils can identify mathematical foundations in music through exploration of relationships between mathematics and music, such as how sound waves, pitch, tempo, and rhythm can be described using numerical data (Brito, Almeida, and Machado, 2023; Moldavan and Johnson, 2023). The relationship between mathematics and music is particularly evident because mathematical symbolisms are expressed in Western music theory through harmony, rhythm, and musical form (Azaryahu et al., 2024).

Moreover, mathematical concepts can not only be used to explain abstract musical concepts but also to reason proportionally. Moldavan and Johnson (2023) state that integrating mathematics provides conceptual clarity regarding rhythmic patterns and musical durations. Pupils can use proportional reasoning to determine note values and rests within each measure by performing addition and subtraction of fractions, under the awareness that a measure functions as a mathematical unit that may be divided into equal parts (Noor Sham et al., 2022; Parr, 2023). Parr (2023) explains that the division of note values and rests within a measure resembles algebraic equations in mathematics that adhere to the distributive property. Musical composition involves mathematical structures such as sequences, repetition and conditional statements, which can help pupils comprehend musical patterns (An, Tillman, Minces, and Kim, 2025).

The integration of music with mathematical concepts can also have a positive impact on music learning. Yeşilkaya, Eskioğlu, and Jelen (2021) found that matching musical meter with geometric shapes positively affected pupils' learning and their ability to discriminate meters. Azaryahu and Adi-Japha (2022), who examined the effects of integrating music and mathematics to clarify musical concepts and their relation to mathematical concepts, demonstrated that notation linked to mathematical concepts clearly facilitates deeper understanding. This also improved learning outcomes in both domains.

Mathematical concepts can be used to analyse and create music. Composers employ geometric transformations such as moving a geometric figure from one position to another without altering its size, shape or orientation, reflections across horizontal and vertical axes to perform musical transformations like transposition, inversion, and retrograde (Brito et al., 2023). Transposition shifts a sequence of pitches upward or downward by a specified number of semitones. Retrograde reverses the order of pitches in a given sequence. Inversion reflects pitches in a sequence with respect to a reference point of zero. In short, geometric transformations in mathematics correspond to musical transformations. Mathematical concepts therefore provide a systematic framework for analysing complex musical structures. According to Parr (2023), a syncopated canon can be viewed through operations of adding and subtracting small recurring components so that they resemble the whole object.

In general, the use of music can have a positive effect on mathematics learning. Many previous studies discuss the benefits of Music Education and the effects of music learning on pupils' lives. E. Cagape, F. Dapat, J. Dapat Jr., Ericka Guia C. Galvez, and F. Uyanguren (2023) explored teachers' experiences using music to teach multiplication to primary pupils also found that music helps pupils remember facts more easily and learn more quickly. Music integration can also increase pupils' enjoyment and sustain their interest in learning mathematics. Abu Bakar and Samsudin (2021) investigated how musical elements and movement were incorporated into mathematics instruction, showed that integrating music and movement can create a more engaging and meaningful learning environment. García-García, Nortes Martínez-Artero, and Olivares-Carrillo (2024) found that musical training positively affected mathematical performance by showing students receiving musical training achieved higher scores not only in academic mathematics tests but also in mathematical creativity assessments. Several previous studies by Chao-Fernández et al. (2020), Akhshabi, Moradi, and Dortaj (2022), Eddy (2023), Raja and Bhalla (2020), which examined the impact of musical activities on mathematical skills, similarly support the conclusion that the use of music in mathematic lesson can significantly improve mathematics achievement scores.

The Factors Affect Music and Mathematic Integration Consistently

The integration of Music Education and Mathematics occurs infrequently because several factors pose challenges to consistently integrating the two subjects. The primary factor hindering integration is the lack of teacher confidence and teacher expertise in both subjects. Many generalist teachers assume that they have no or limited experience in music and are uncertain about how to facilitate musical activities into other subjects, thus their motivation to use such activities is reduced (T. Lovemore, Robertson, and Graven, 2022; Moldavan and Johnson, 2023; Stramkale, 2024). This leads to a palpable hesitation because teachers worry about gaps in their own musical training or their inability to read formal musical notation (Broza, Azaryahu, and Hershkovitz, 2024). These feelings arise from a lack of training in integrating Mathematics and Music learning. Pre-service teachers often report that their training programs did not instruct them effectively on how to weave the two subjects together (Barg, 2021; Gee, 2023).

Positive perspectives may emerge if integrated music and mathematics practices are shown to benefit pupil learning. Gee (2023) indicates that teachers' positive beliefs and attitudes toward integrating musical content into other subjects can support academic achievement in those subjects. This finding is also supported by Broza et al. (2024) who report positive views among mathematics and music teachers regarding interdisciplinary teaching practices because they observed improvements in student engagement, motivation, and creativity. Positive teacher perspectives and attitudes can sustain the practice of integrating music and mathematics. Tara Stradley (2023) suggests that primary school music teachers should engage in curriculum integration because they believe such integration can support cross-disciplinary learning.

The mode of instruction within a learning environment that integrates music and mathematics affects teaching effectiveness. Silva, Costa, and Lopes (2022) showed that the "doing mathematics through music" intervention was effective in enhancing students' mathematical learning and the differences in students' levels of musical knowledge did not affect its effectiveness. Teachers' attitudes and pedagogical content knowledge influence the effectiveness of integrating music and mathematics in learning. Ali and Anderson (2021) proved that transforming basic musical notation into fundamental fractions using Vygotsky's Scaffolding Theory not only significantly enhanced pedagogical content knowledge of fractions, but also fostered positive attitudes towards the teaching of fractions through music-based interventions.

Furthermore, limited related educational resources and restricted preparation time further complicate implementation. Teachers frequently cite a lack of instructional time, a dearth of educational resources and a high pressure to meet standardized curriculum coverage as reasons for avoiding integrated lessons (Azaryahu, Ariel, and Leikin, 2024; Broza et al., 2024; Johnson et al., 2021; T. S. Lovemore et al., 2021). Bresler (1995) explains that literature on curriculum integration of the arts in regular schools is very limited because there are no formal requirements such as guidelines, assessments, or reference materials like resource books and textbooks, making it difficult to grasp without active exploration.

The learning environment such as infrastructure and facilities that support the integration of music and mathematics also contributes to the successful implementation of integrated instruction. Several previous studies have examined the effect of constructing learning environments that combine music and mathematics. Moldavan and Johnson (2023) studied collaborative musical improvisation using graphs, traditional musical instruments and virtual instruments as part of integrating mathematics into music learning for pre-service teachers. Tools and media influence instructional effectiveness because each differs in complexity, technical skill requirements, accessibility and cost. An et al. (2025) mentions about the importance of the suitability of mathematical teaching resources in learning.

There is also a noticeable disparity in integration across grade levels. While music is more commonly utilized in kindergarten and early primary years to teach basic facts, there is a sharp decline in its usage as students advance to middle and high school (Barg, 2021; Parr, 2023). This situation happens because music is reduced to an optional elective in many secondary school systems, which diminishes its potential to be applied to core subjects like statistics, algebra, or geometry that all students must learn (Parr, 2023).

Methodology

This study used quasi-experimental design because this design can assess the effectiveness of using mathematical concepts in music learning. According to Darusalam and Hussin (2024), a quasi-experimental study is a quantitative design used to test comparative hypotheses between a treatment group and a control group or to determine the cause of an effect.

The validity and reliability of the original music test and the MUSIC Model Academic Motivation Inventory were thoroughly established. The qualitative and quantitative face, content, and construct validity of the original questionnaire from Farahani and Saeedi (2022) was evaluated through review by ten experts and interviews with six students from various semesters. All items exceeded the minimum Content Validity Ratio (CVR) of 0.62 and the Scale-level Content Validity Index (S-CVI) reached 0.97. The original questionnaire reliability was supported by an overall Cronbach's alpha of 0.94, with each of its component's Cronbach's alpha ranging between 0.72 and 0.93 (Farahani and Saeedi, 2022). The music test adapted from Gök (2023) was originally validated by experts in Music and experts in Turkish

Language and Literature. The Cronbach's alpha value of the music test created by Gök (2023) was calculated as 0.91. Although these instruments had been validated and shown reliable in prior studies, they were re-examined for the present research to ensure data quality.

For this study, both instruments were adapted and reviewed by experienced educators and piloted in a primary school. The adapted 25 item music test produced a Cronbach's alpha of 0.934 while the adapted 20 item motivation questionnaire produced an overall Cronbach's alpha of 0.848. Cronbach's alpha values between 0.8 and 0.9 are interpreted as good or high reliability and values above 0.9 indicate very high reliability (Darusalam and Hussin 2024; Perrin 2022). Therefore, the obtained coefficients indicate that the test and questionnaire scores were consistent and reliable.

In this study, the motivation questionnaire items comprised two sections. Section A concerned pupils' background information and prior musical experience. Section B concerned students' perceptions of task value, their self-belief in their ability to succeed and their level of interest in learning activities. A 5-point Likert-type scale anchored from 1 (strongly disagree) to 5 (strongly agree) or from 1 (never) to 5 (always) was used for participants' responses. The questionnaire is an important instrument for obtaining information from the study population relevant to the ongoing research (Sharul Hafiz Mohd Imran, Norsaadah Sapon, and Norsuhaila Sapon, 2023). In addition, a test was used as an instrument to assess the level of mastery of musical note values and rests. In this study, the test not only assessed knowledge of the values of semibreve, minim, crotchet, and semiquaver notes and rests, but also examined basic mathematical concepts such as addition and subtraction for adding bar lines or calculating the total values of notes and rests.

This research was conducted at a primary school. The study population comprised pupils enrolled at a primary school in Malacca. A total of 60 pupils from second-level primary school were selected. The participants were assigned into two groups of 30 pupils each. According to Darusalam and Hussin (2024), the minimum sample size for subjects in an experimental study is 30 pupils per group. Convenience sampling technique was employed to select the sample of second-level primary pupils.

Intervention (Integrating Mathematical Concept in Music Lesson)
Activity 1 began with recognising musical notes and rests. Figure 1 is a diagram illustrating the relationship between mathematics and the values of notes and rests. Pupils observed the diagram and listened to the teacher's explanation regarding note values and rests. Pupils in the treatment group were divided into small groups. Within each group, pupils arranged note cards and rest cards according to their values to reinforce their understanding of note and rest values. After that, each group was given five sheets of coloured paper and pupils were asked to draw the notes and rests on the coloured sheets. Semibreves were drawn on red paper; minims on pink paper; crotchets on green and light blue paper; and semiquavers on yellow paper. The treatment group pupils learned the correct way to draw notes and rests through this activity. Afterwards, the pupils in each group collected the five coloured sheets and made a small booklet to distinguish between the notation values and rests. Figure 2 provides an example of the contents of the small booklet that pupils could produce.

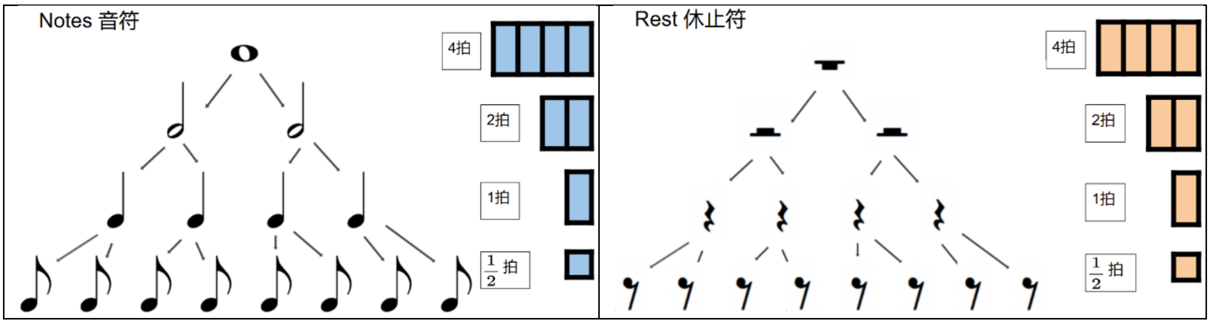


Figure 1 The relationship between mathematics and the values of notes and rests

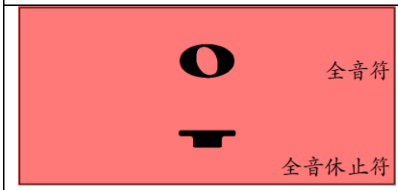
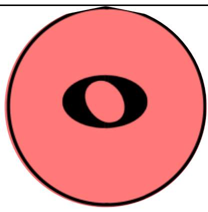
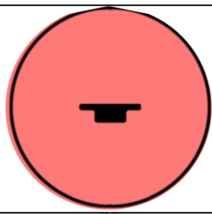
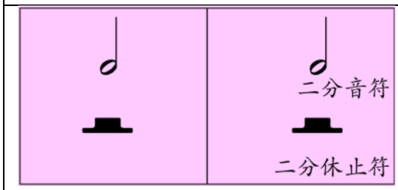
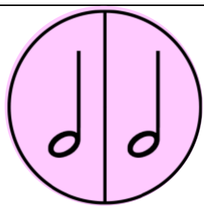
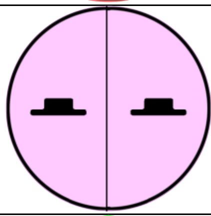
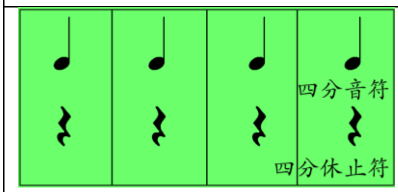
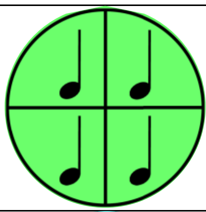
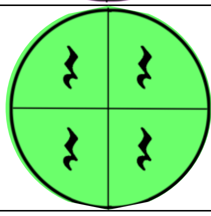
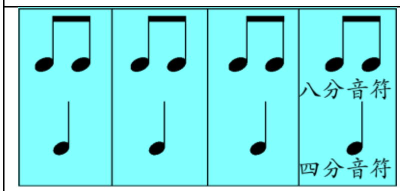
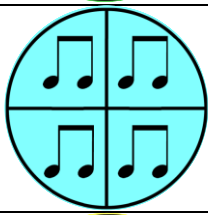
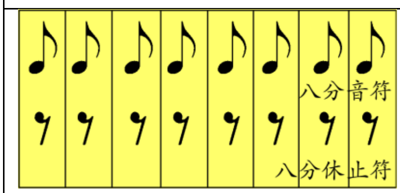
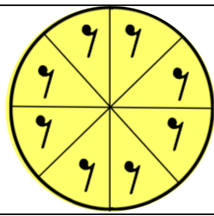
Example of the contents of the small booklet that pupils could produce			Musical note and rest values
			4
			2
			1
			1
			$\frac{1}{2}$

Figure 2 Example of the contents of the small booklet that pupils could produce

Activity 2 provided the treatment group with the opportunity to move according to note values and to stop movement according to rest values. Pupils listened to the teacher's explanation of musical meter before begin the activity. They performed various movements such as clapping, stamping their feet, and snapping their fingers to songs in $\frac{4}{4}$, $\frac{3}{4}$, and $\frac{2}{4}$ time signatures. The songs selected were popular tunes appropriate for and commonly heard by children. Pupils were also given the opportunity to play the tambourine in time with the music.

Activity 3 required the treatment group to create at least four bars of rhythmic patterns in $\frac{4}{4}$ time and to clap the rhythmic patterns created by other groups. Pupils were instructed on the $\frac{4}{4}$ meter. The upper number indicates the number of beats per bar, while the lower number indicates the note value that equals one beat. A $\frac{4}{4}$ meter therefore means there are four beats in each bar. Pupils discussed within their groups while creating various rhythmic patterns using the notation and rests. This activity was repeated twice. The first iteration was conducted under teacher guidance and the second was led by each group's appointed leader. After creating the rhythms, peers listened and provided evaluations while the other groups clapped the rhythmic patterns they had created.

Descriptive analyses were performed immediately after each data collection to obtain statistical information such as the mean, standard deviation, minimum, and maximum values for each group. As Darusalam and Hussin (2024) mention descriptive statistics are used to describe and characterize the attributes of variables, but descriptive statistics alone cannot be used to generalize findings from the sample to the population. These descriptive statistics provide an initial overview of pupils' levels of mastery.

In addition, inferential statistical tests were conducted. The requirements of linearity, independence of data, homogeneity of variance-covariance matrices, and multivariate normality were verified prior to executing the Multivariate Analysis of Covariance (MANCOVA). Multivariate Analysis of Covariance (MANCOVA) was carried out to analyse levels of musical mastery and motivation. According to Tashtoush, Qasimi, Shirawia, and Hussein (2025), MANCOVA was selected to account for any potential confounding factors and provide a comprehensive examination of the study's dependent variables. MANCOVA serves to adjust for control variables so that they do not confound the dependent variables (Darusalam and Hussin, 2024). The study included confounders, such as pretest results to account for potential confounding factors.

The Findings

In this study, a total of 60 pupils from a primary school in the state of Melaka served as the sample. Thirty pupils were assigned to the treatment group and another thirty pupils to the control group. Respondent background information collected included age, gender, and frequency of participation in musical activities. All respondents were 12 years old.

Table 1 presents respondent frequency and percentages by gender for the 60 pupils in the sample. The results show that 32 pupils (53.3%) were male and 28 pupils (46.7%) were female.

Table 1
gender (n=60)

		Frequency	Percent	Valid Percent
Valid	Male	32	53.3	53.3
	Female	28	46.7	46.7
	Total	60	100.0	100.0

According to Table 2, the majority of respondents, 31 pupils (51.7%) had never participated in singing activities. Eleven pupils (18.3%) rarely participated in singing and ten pupils (16.7%) sometimes participated. Only three pupils (5.0%) often participated in singing activities while five pupils (8.3%) always participated.

Table 2
Singing

		Frequency	Percent	Valid Percent
Valid	Never	31	51.7	51.7
	Rarely	11	18.3	18.3
	Sometimes	10	16.7	16.7
	Often	3	5.0	5.0
	Always	5	8.3	8.3
	Total	60	100.0	100.0

In addition, table 3 shows the frequency distribution and percentage of respondents who engage in recorder-playing activities. Based on the table, most of the respondents, 34 pupils (56.7%) had never played the recorder. 19 pupils (31.7%) rarely play the recorder and seven pupils (11.7%) sometimes play the recorder.

Table 3
Recorder

		Frequency	Percent	Valid Percent
Valid	Never	34	56.7	56.7
	Rarely	19	31.7	31.7
	Sometimes	7	11.7	11.7
	Total	60	100.0	100.0

MANCOVA Assumptions

Prior to conducting the Multivariate Analysis of Covariance (MANCOVA), all fundamental design and distributional assumptions were systematically examined. The assumption of independence of observations was satisfied, as each participant belonged to either control group or treatment group and contributed a single set of responses. Screening for univariate outliers using boxplots revealed no extreme values across all dependent variables. Multivariate outliers were assessed using Mahalanobis distance, with observed values ranging from 0.104 to 17.146, all of which were below the critical chi-square value of 18.47 (df = 4, $p < .001$), indicating the absence of multivariate outliers. Univariate normality of residuals was supported by non-significant Shapiro–Wilk and Kolmogorov–Smirnov tests ($p > .05$) across groups. Multivariate normality was further evaluated through Mahalanobis distance in relation to the expected χ^2 distribution and inspection of the chi-square Q–Q plot. Although minor deviations were observed at the upper tail, the departures were considered mild and acceptable, supporting the appropriateness of proceeding with MANCOVA.

Assumptions related to variance, relationships among variables, and covariate structure were also met. Box's M test (Box's M = 14.484, F = 1.340, $p = .202$) was non-significant, indicating homogeneity of variance–covariance matrices across groups. Homoscedasticity was evaluated through visual inspection of residuals-versus-predicted scatterplots which displayed largely random scatter without clear funnel patterns and only minor deviations in a limited range, collectively supporting the homoscedasticity assumption. Linearity between covariates and dependent variables was confirmed through bivariate and matrix scatterplots, which demonstrated approximately linear and monotonic relationships within each group and no evidence of pronounced non-linear patterns. Moreover, multicollinearity diagnostics was assessed using tolerance and Variance Inflation Factor (VIF) values, all of which exceeded 0.10 and were below 10 respectively, indicating no multicollinearity concerns. Overall, these findings confirm that all major MANCOVA assumptions were adequately satisfied, thereby provides substantive support for proceeding with the planned MANCOVA.

Examining the use of Mathematical Concept on the Level of Mastery of Musical note Values and Rests

Descriptive analysis in table 4 showed that the post-test mean score of the treatment group (M = 81.60, SD = 18.81) was higher than the control group (M = 72.93, SD = 23.55). The mean score for the interest construct in the treatment group (M = 3.625, SD = 0.719) was higher than the control group (M = 3.125, SD = 0.525). Similarly, the mean score for the confidence construct in the treatment group (M = 3.89, SD = 0.721) exceeded the control group (M = 2.958, SD = 0.609). The mean score for the usefulness construct in the treatment group (M = 3.322, SD = 0.85) was also higher than the control group (M = 2.84, SD = 0.598).

Table 4
Descriptive Statistics showing the differences between the treatment and control groups

	Group	Mean	Std. Deviation	N
Post test	Control Group	72.93	23.552	30
	Treatment Group	81.60	18.809	30
	Total	77.27	21.578	60
Post interest	Control Group	3.1250	.52523	30
	Treatment Group	3.6250	.71919	30
	Total	3.3750	.67334	60
Post confidence	Control Group	2.9583	.60914	30
	Treatment Group	3.8917	.72124	30
	Total	3.4250	.81212	60
Post usefulness	Control Group	2.8444	.59842	30
	Treatment Group	3.3222	.85089	30
	Total	3.0833	.76807	60

Table 5 presents the four common multivariate tests (Pillai's trace, Wilks' lambda, Hotelling's trace, and Roy's largest root) typically used to indicate a statistically significant multivariate effect for the group factor. There was a significant difference between the treatment and control groups, $F(4, 51) = 11.197$, $p < .001$; Wilks' Lambda = .532; partial $\eta^2 = .468$. The partial eta squared value ($\eta^2 = .468$) indicates a very large multivariate effect size. According to Darusalam and Hussin (2024), a partial eta squared value exceeding .138 denotes a large effect size. This analysis supports the conclusion that the treatment and control groups differ significantly and that the multivariate null hypothesis is rejected.

Table 5
Multivariate Tests [a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Group	Pillai's Trace	.468	11.197[b]	4.000	51.000	.000	.468
	Wilks' Lambda	.532	11.197[b]	4.000	51.000	.000	.468
	Hotelling's Trace	.878	11.197[b]	4.000	51.000	.000	.468
	Roy's Largest Root	.878	11.197[b]	4.000	51.000	.000	.468

a. Design: Intercept + Pretest + Pre interest +Pre confidence + Pre Usefulness +Group
b. Exact statistic

Table 6 shows the group had a highly significant effect on post-test achievement, $F(1, 60) = 32.950$, $p < .001$, partial $\eta^2 = .379$, $R^2 = .547$, adjusted $R^2 = .505$. These results indicate that, after controlling the pre-test scores, there is a significant difference in post-test achievement between the treatment and control groups. The R^2 value indicates that 54.7% of the variance in post-activity achievement is explained by the predictors ($R^2 = .547$; adjusted $R^2 = .505$), demonstrating a strong explanatory power for these variables. The group also had a large and significant effect on confidence, $F(1, 60) = 24.078$, $p < .001$, partial $\eta^2 = .308$; $R^2 = .662$, adjusted $R^2 = .631$. This analysis shows that there is a significant difference in confidence levels between the treatment and control groups control group after controlling for initial confidence levels. According to Darusalam and Hussin (2024), a partial eta squared value exceeding .138 indicates a large effect size. The R^2 value indicates that 66.2% of the variance in post-activity confidence is explained by the predictors ($R^2 = .662$; adjusted $R^2 = .631$).

Conversely, the analysis indicates that the effect for the interest construct did not reach statistical significance, $F(1, 60) = 3.129$, $p = .083$, partial $\eta^2 = .055$; $R^2 = .444$, adjusted $R^2 = .393$, although the effect size for interest approached the medium range. The R^2 value indicates that only 44.4% of the variance in post-activity interest is explained by the predictors ($R^2 = .444$; adjusted $R^2 = .393$). The analysis also indicates that the effect for perceived usefulness was not significant, $F(1, 60) = 3.321$, $p = .074$, partial $\eta^2 = .058$; $R^2 = .419$, adjusted $R^2 = .365$, although the effect size for perceived usefulness approached the medium range. According to Darusalam and Hussin (2024), a partial eta squared value of .06 indicates a medium effect size. The R^2 value indicates that only 41.9% of the variance in post-activity perceived usefulness is explained by the predictors ($R^2 = .419$; adjusted $R^2 = .365$). In summary, this analysis indicates significant effects on musical mastery and confidence, but does not demonstrate significant effects for interest and perceived usefulness.

Table 6
Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Groups	Post Test	7597.169	1	7597.169	32.950	.000	.379
	Post Interest	.861	1	.861	3.129	.083	.055
	Post Confidence	5.866	1	5.866	24.078	.000	.308
	Post Usefulness	1.244	1	1.244	3.321	.074	.058

a. R Squared = .547 (Adjusted R Squared = .505)

b. R Squared = .444 (Adjusted R Squared = .393)
c. R Squared = .662 (Adjusted R Squared = .631)
d. R Squared = .419 (Adjusted R Squared = .365)

Estimated marginal means adjusted for the covariates were 58.42 for the pre-test achievement, 3.2000 for pre-activity interest, 3.1500 for pre-activity confidence and 2.9444 for pre-activity perceived usefulness after controlling for baseline scores. Based on table 7, the adjusted mean post-test achievement for the control group was 63.331 (SE = 3.120; 95% CI [57.075, 69.587]) while for the treatment group was 91.202 (SE = 3.120; 95% CI [84.946, 97.459]). The large difference in these means indicates a substantial treatment effect on post-test achievement after covariate adjustment. The adjusted mean post-activity confidence was 3.038 (SE = 0.101; 95% CI [2.834, 3.241]) for the control group and 3.812 (SE = 0.101; 95% CI [3.609, 4.016]) for the treatment group. This analysis shows a significant and meaningful increase in confidence for the treatment group. The adjusted mean post-activity interest was 3.227 (SE = 0.108; 95% CI [3.010, 3.443]) for the control group and 3.523 (SE = 0.108; 95% CI [3.307, 3.740]) for the treatment group. The adjusted mean post-activity perceived usefulness was 2.905 (SE = 0.126; 95% CI [2.653, 3.157]) for the control group and 3.262 (SE = 0.126; 95% CI [3.010, 3.514]) for the treatment group. Although post-activity interest and perceived usefulness means were higher for the treatment group than for the control group, their confidence intervals overlapped more noticeably than post-test achievement and post-activity confidence. These results align with the univariate test findings showing significant effects for achievement and confidence but not for interest or perceived usefulness.

Table 7
Estimated marginal means
Estimates

Dependent Variable	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Post test	Control Group	63.331[a]	3.120	57.075	69.587
	Treatment Group	91.202[a]	3.120	84.946	97.459
Post Interest	Control Group	3.227[a]	.108	3.010	3.443
	Treatment Group	3.523[a]	.108	3.307	3.740
Post Confidence	Control Group	3.038[a]	.101	2.834	3.241
	Treatment Group	3.812[a]	.101	3.609	4.016
Post Usefulness	Control Group	2.905[a]	.126	2.653	3.157
	Treatment Group	3.262[a]	.126	3.010	3.514

a. Covariates appearing in the model are evaluated at the following values: Pretest = 58.42, Pre Interest = 3.2000, Pre Confidence = 3.1500, Pre Usefulness = 2.9444.

Table 8 presents Bonferroni-adjusted pairwise comparisons between the treatment group and the control group. The treatment group exhibited significantly higher mastery as indicated by the difference in adjusted post-test means (mean difference = 27.872, SE = 4.856, p < .001; 95% CI [18.137, 37.606]). The treatment group also showed significantly higher confidence than the control group (mean difference = .774, SE = .158, p < .001; 95% CI [.458, 1.091]). The significant p-values (p < .001) and the positive sign of (I − J), where I denotes the treatment group and J denotes the control group, reflect that the treatment group attained significantly higher levels of mastery and confidence level compared to the control group.

The treatment group showed higher interest than the control group but the effect did not reach significance after Bonferroni adjustment (mean difference = .297, SE = .168, p = .083; 95% CI [-.040, .633]). The treatment group also showed higher perceived usefulness than the control group but the effect was also not significant after Bonferroni adjustment (mean difference = .357, SE = .196, p = .074; 95% CI [-.036, .749]). The non-significant p-values (p > .05) and the positive sign of (I − J) indicate that although the treatment group achieved higher scores in interest and perceived usefulness compared to the control group, these differences were not statistically significant.

Overall, the paired comparisons confirm that the treatment produced significant improvements in post-test achievement and confidence following the intervention, whereas the treatment effects on interest and perceived usefulness were smaller and not statistically significant in this sample.

Table 8
Pairwise Comparisons

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Post Test	Control Group	Treatment Group	-27.872*	4.856	.000	-37.606	-18.137
	Treatment Group	Control Group	27.872*	4.856	.000	18.137	37.606
Post Interest	Control Group	Treatment Group	-.297	.168	.083	-.633	.040
	Treatment Group	Control Group	.297	.168	.083	-.040	.633
Post Confidence	Control Group	Treatment Group	-.774*	.158	.000	-1.091	-.458
	Treatment Group	Control Group	.774*	.158	.000	.458	1.091
Post Usefulness	Control Group	Treatment Group	-.357	.196	.074	-.749	.036
	Treatment Group	Control Group	.357	.196	.074	-.036	.749

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Discussion
This study tested whether there were significant differences in pupils' mastery of musical note values and rests, as well as in their levels of motivation between the treatment and control groups. After adjusting for pre-test mastery of musical note values and rests and pre-activity motivation, the mathematics-framed instruction produced a large, statistically significant improvement in pupils' mastery of musical note values and rests. The adjusted means for control group is 63.33 whereas the treatment group is 91.20 (Paired difference = 27.872, p < .001). I. H. Ismail (2025a) indicates that concepts help students to understand more abstract or complex ideas by providing them a clear mental framework for organising information. This analysis result is consistent with prior research showing that explicitly linking musical notation and rhythm to mathematical concepts like counts, grouping, fractions and proportional relationships of durations help learners map abstract notation on to operational procedures, which speeds mastery of reading and performing note values and rests (Ali and Anderson, 2021; Işıtan and Doğan, 2020; Sanz et al., 2024). Several previous studies report that presenting time, rhythm, and meter as mathematical structures such as counts per bar and

subdividing beats makes notation less arbitrary and more transparent to young learners (Işıtan and Doğan, 2020; T. Lovemore et al., 2022; Tarryn Shirley Lovemore, 2023; Yeşilkaya et al., 2021).

When Mathematical structure is made explicit, it can provide students with concrete framework that can reduce working memory load and support procedural fluency. Concepts support individuals' memory by linking new information to existing concepts when encountering new information or experiences (Cosmas and Hon, 2024; Ismail, 2025a). Vargas-Hernández and Vargas-González (2022) emphasize that meaningful learning occurs when students are able to connect new knowledge with prior knowledge and subsequently apply that knowledge to solve new challenges. The present findings are supported by Hendriks and Cruywagen (2024), who report that integrating mathematics and music can improve students' conceptual understanding, critical thinking, and problem-solving skills. Işıtan and Doğan (2020) also found that pupils not only showed positive development in understanding addition and subtraction of fractions but were also able to solve musical problems that required use of those operations.

The combination of explicit mathematical framing and active rhythm practice is a plausible causal pathway to improve pupils' mastery of musical note values and rests. Hallam and Himonides (2022) describe some meta-analyses and long-term studies about the way rhythm and active music making produce the most reliable transfer to spatial-temporal reasoning and sequencing skills that underlie musical notation mastery.

The intervention also produced a large and significant increase in students' self-confidence. The adjusted means for control group is 3.038 whereas the treatment group is 3.812 (Paired difference = .774, $p < .001$) after the intervention was implemented. This increase suggests that students felt more confident in their ability to understand and remember musical note values and rests when mathematical concepts were used as learning support. This finding indicates that learning approaches play an important role in influencing students' confidence in music learning. I. H. Ismail (2025b) mention that positive learning experiences can build confidence and courage to face new challenges, while support from teachers, peers, and family provides essential emotional encouragement for students' readiness to learn.

Confidence is an important factor affecting students' mastery and motivation. Students who possess confidence in their own abilities are more likely to engage actively and persistently in learning. The use of mathematical concepts in music learning provides a clear structure, thereby reducing students' anxiety about making mistakes. The integration of mathematics into music learning can make music less intimidating for students who are more comfortable with logical thinking and the use of geometric representations to explain abstract concepts, such as making complex rhythms more concrete and easier to understand (Moldavan and Johnson 2023; Yeşilkaya et al. 2021). Continuous active participation in various musical activities also helps reduce performance anxiety, as students are given repeated opportunities to demonstrate their skills, which indirectly enhances their confidence levels (Jamaludin, Md Noor, Ismail, and Harith, 2024; Noor Sham et al., 2022). These findings are further supported by Hendriks and Cruywagen (2024), who found that integrating music and mathematics into learning experiences enables students to visualize concepts concretely, thereby allowing them to understand complex ideas and apply them with confidence. These findings are aligned with current studies showing that cognitive support through systematic mathematical structures helps students master musical concepts with greater confidence.

The findings of the study demonstrate that students in the treatment group exhibited an increase in interest ($p = .083$) and perceived usefulness of learning note values and musical rest ($p =.074$) but both constructs did not reach statistical significance. The treatment group has a higher level of interest compared with students in the control group (Paired difference = .297, $p = .083$). This condition indicates that music learning integrates mathematical elements is effective in capturing students' attention and enhancing their readiness to engage actively in music learning.

From an educational psychology perspective, interest is a crucial component of intrinsic motivation that influences students' level of engagement and persistence in the learning process. Renninger and Hidi (2022) state that the development of interest begins with interest triggering, a process that motivates students to seek information and may be self-generated through recognizing connections between content across different subject areas. In this study, the use of mathematical concepts helped students understand the logical relationships between note values and musical rests, thereby making music learning more structured and easier to comprehend. In addition, according to Renninger and Hidi (2022), diverse instructional contexts can also trigger and sustain students' learning interest. Multiple modes of representation were provided to allow students to access information and knowledge through different sensory modalities. This is important because as noted by Burden and Byrd (2025), students differ in the ways they acquire and understand information presented to them. Therefore, various learning strategies that provided opportunities for active student involvement were employed in this study, such as movement to rhythm, hands-on activities, group discussions, group-based rhythm creation presentations and similar activities.

However, motivation constructs like interest and utility task value are often slower to change than immediate performance or confidence. Interventions that can foster enduring individual interest commonly require repeated engagement and long-term exposure rather than a short and single intervention because interest must be maintained before it can be internalised (Asher, 2023; Tan, Gillies, and Jamaludin, 2024). A learner's interest may stagnate, disappear or even regress to an earlier situational phase without environmental support or repeated triggers (Tan et al., 2024).

Students' interest in the skills or similar musical knowledge is significantly influenced by the students' perceptions of the connections between the skills taught and themselves. Increases in interest and task value are strongest when an intervention explicitly connects academic content to a student's personal identity, goals or real-life utility (Guo and Fryer, 2025; Hecht, Grande, and Harackiewicz, 2021). Musical notes and rests support academic goals, performance goals and fulfill future aspirations. However, it is difficult for students to establish relevance as identification to the skills taught in a music lesson because students frequently feel uncertain or lack a clear understanding of some essential components of personal identity, including personal strengths, ideal career, and life purpose (Guo and Fryer, 2025). For students who do not plan to become musicians, rhythmic literacy supports goals such as joining all the musical activities, becoming a performer or music therapist and even developing discipline and persistence skills that valued in all careers.

Musical notes and rests can be meaningful to students beyond technical music skills. This learning approach helped students view learning holistically rather than in isolation by positioning music within a framework closely related to other life skills such as problem-solving skills, communication skills and interpersonal skills (Johnson et al., 2021). According to Ong (2025), project-based learning, peer teaching and group musical improvisation further strengthen skills such as teamwork, problem-solving, and critical thinking, which are increasingly required in contemporary educational contexts. Musical notes and rests help students see themselves as capable, expressive, and disciplined learners. When students understand that mastering note values and rests leads to visible improvement in performance, they are more likely to set personal learning goals, monitor their own progress and persist in practice. Music education not only emphasizes the mastery of technical skills but also fosters cognitive, emotional, and social development through a more holistic approach (Johnson et al., 2021; Ong, 2025).

Overall analysis shows that the use of mathematic concepts in music lesson produced a large and significant difference in pupils' mastery of musical note values and rests (Paired difference = 27.872, $p < .001$), as well as students' self-confidence (Paired difference = .774, $p < .001$). There was also an increase in interest and perceived usefulness in the expected direction but did not reach statistical significance ($p = .083$ and $p = .074$ respectively). The increase in interest observed in the treatment group demonstrates that the use of mathematical concepts is an effective pedagogical strategy for enhancing students' motivation in learning musical note values and rests. However, it needs repeated triggers and long-term exposure to sustain the increasing interest. The conventional teaching methods employed in the control group were found to be less effective in stimulating students' interest, particularly when abstract musical concepts were involved. The multivariate results and partial η^2 values show large effects overall, $F(4, 51) = 11.197$, $p < .001$; Wilks' Lambda = .532; partial $\eta^2 = .468$, indicating the treatment accounted for a substantial portion of variance in the outcome set.

Based on the findings of the study, music teachers are recommended to systematically integrate mathematical concepts into the teaching and facilitation (PdPc) of musical note values and rests. Teachers may employ mathematical concepts such as fractions, ratios and time as unit calculations to help students understand musical note values in a concrete and meaningful manner. Teaching strategies such as the use of visual mind maps, movement-based activities, and group problem-solving exercises can enhance students' conceptual understanding and strengthen the connections between musical concepts and mathematical concepts. This integration of mathematics and music not only supports music learning but also enables students to apply mathematical skills in authentic contexts.

Schools are encouraged to support the implementation of mathematics and music integration by providing a conducive learning environment and appropriate instructional resources. This includes the provision of teaching aids that combine musical and mathematical elements, such as interactive software, rhythm learning kits and structured visual materials. In addition, schools may promote collaboration between music teachers and mathematics teachers through joint lesson planning or professional learning communities (PLCs). Strong administrative support will ensure that the implementation of this integration can be carried out consistently and effectively at the school level.

District Education Offices and State Education Departments are recommended to design and implement continuous professional development programmes that emphasize the integration of music and mathematics education. Specialized training related to integrative pedagogy, the design of concept-based integrated activities and the use of formative assessment can enhance teachers' competencies in implementing innovative teaching approaches. Furthermore, PPD and JPN may conduct regular monitoring and evaluation for the implementation of integrated teaching practices in schools to ensure instructional quality aligns with the goals of holistic education.

Teacher Education Institutes (IPG) are encouraged to enhance teacher training curricula by incorporating elements of integrated teaching in a more structured manner, particularly the integration of music and mathematics at the primary education level. Pedagogy courses may be enriched with practical training, case studies and instructional design assignments that combine both disciplines. Early exposure of pre-service teachers to the importance of the integrative relationship between music and mathematics will help produce educators who are more creative, reflective, and prepared to implement high-impact teaching practices in the classroom.

In line with the aspirations of the Malaysia Education Blueprint (PPPM), the Ministry of Education Malaysia is encouraged to consider cross-curricular subject integration as part of national policy and curriculum enhancement efforts. The Ministry may support further research and pilot projects that evaluate the effectiveness of integrating music and mathematics in primary schools before scaling up implementation at the national level. In addition, the development of national-level pedagogical guidelines and integrated instructional modules can facilitate consistent and effective implementation across schools.

In addition, future research should involve larger sample sizes and include diverse school contexts, including both urban and rural schools. The inclusion of varied samples can enhance the applicability of the findings and enable the generalization of results to a broader population of primary school students. Large-scale studies also allow for subgroup analyses, such as comparisons based on gender, academic ability levels, or students' socioeconomic backgrounds.

Furthermore, future research is recommended to examine the long-term effects of the intervention through retention tests administered several weeks or months after the intervention. Long-term evaluation is important to determine whether improvements in the mastery of musical note values and rests are sustained over time or are merely temporary. Such findings would provide more meaningful contributions to understanding the true effectiveness of instructional approaches based on the integration of music and mathematics.

Moreover, future research is encouraged to incorporate a mixed-methods approach by including qualitative data such as teacher interviews, classroom observations, and student reflections. These qualitative data can help explain the learning mechanisms involved, including how students interpret and apply mathematical concepts within musical contexts. The integration of quantitative and qualitative data will provide a more holistic understanding of the effectiveness of the intervention and contribute to the development of more effective and contextually grounded pedagogical models.

Conclusion

Students were found to have a better understanding of the importance and application of musical concepts when these were linked to mathematical concepts that they had previously learned. In this study, the integration of mathematics helped students perceive music not merely as a memorization-based activity but as something logical and useful. The combination of mathematics and music revealed meaningful relationships that may not have been previously recognized. Motivation constructs like interest and utility task value are often take a longer time to change than immediate performance or confidence. Thus, the long-term effects of the intervention are recommended to examine several weeks or months after the intervention.

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