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Music and Mathematics: Processing Repetition Techniques with the Least Common Multiple (LCM) in *Rajékan* Music Composition

Hery Budiawan✉, Rizky Fauzy Ananda

Universitas Negeri Jakarta, Indonesia

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Abstract

This article aims to find a new way to process repetition in musical composition with the least common multiple (LCM) mathematical approach. Music and mathematics have a very close relationship; in music, the element of mathematics with the derivation of physical science is the most relevant and always interesting study of musical composition. This study aims to analyse the music composition of Rizky Fauzy Ananda's work, *Rajékan*, by looking at mathematical theory with the approach of The least common multiple (LCM). The method used with practice-led Research as an approach to music composition. The creation research methodology used is Artistic Research through a Practice-Led Research approach which is also integrated with mathematical theory and musicology, especially music composition. The results of this creative Research prove that repetition in music and in the context of life is important and mathematics always present in human life. Repetition has largely underpinned development in music. In the context of life, reps are things that always exist in everyday life, such as worship activities and lifestyles. Such repetitive phenomena can also provide certain learning or meaning for the individual. In the context of education, reps are the easiest and most basic way of learning to learn and recall about understanding something. Repetition processing whose ideas come from the phenomenon of researchers' self-experience, produces two repetition processing techniques with the LCM mathematical style (1) magnification and reduction of sound values that make up the cycle, (2) imitation.

Keywords: Practice-Led Research, Repetition, Least Common Multiple (LCM), Music Composition, Mathematics

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INTRODUCTION

Music and mathematics are two fields that are often thought to be closely related. This is because many aspects of music, such as rhythm and melody, can be represented using mathematical concepts. For example, the pitch of a musical note can be represented using frequency, which is a measure of how many vibrations per second a sound wave produces (Raghu, 2018)wood, membranes. Likewise, the duration of a note can be represented using time, which is a measure of how long the note lasts.

There are many mathematical concepts, some of which include algebra, geometry, calculus, trigonometry, and

✉Corresponding author:
E-mail: herybudiawan@unj.ac.id

number theory (Maifi et al., 2021; Stoutemyer, 1983). Algebra is the branch of mathematics that deals with the study of equations and variables, while geometry is the branch that deals with the properties and relationships of points, lines, angles, and shapes. Calculus is a branch of mathematics that deals with the study of rates of change, such as rates of change of position or rates of change of acceleration (Noor Afniandari et al., 2021). Trigonometry is a branch of mathematics that deals with the study of triangles and the relationships between the sides and angles of triangles. Number theory is the branch of mathematics that deals with the study of numbers and their properties of numbers.

The least common multiple (LCM) of two or more numbers is the smallest positive integer, a multiple of all numbers (Djanković, 2021). For example, the LCM of 2 and 3 is 6, because 6 is the smallest positive integer that is a multiple of 2 and 3. Likewise, the LCM of 4 and 6 is 12 because 12 is the smallest positive integer, a multiple of 4 and 6 (Dias, 2005). Therefore, to find the LCM of two numbers, you can use the following steps:

List the multiples of each of the numbers, starting with the smallest multiple of each number. Find the smallest multiple that appears on both lists. This is the LCM of the two numbers. For example, to find the LCM of 4 and 6, you could list the multiples of 4 and 6 as follows:

> Multiples of 4: 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, ... Multiples of 6: 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, 66, 72,... The smallest multiple that appears on both lists is 12, so the LCM of 4 and 6 is 12 (Essouabri et al., 2022).

The least common multiple (LCM) is a concept from mathematics that is not typically used in music. In music, the most common use of the term "LCM'' is in the context of "lowest common multiple," which is a term used to describe a group of notes that are played at the same time, with the lowest note being the "lowest common multiple" of the group (Runisah & Ismunandar, 2020). Some many other concepts and techniques are more central to the study and practice of music. For example, musical notation, melody, harmony, rhythm, and form are all important concepts in music theory. LCM makes *Rajékan's* musical work an idea of creation. Many composers depart from mathematics and physics. *Rajékan* is a term for *rajékan* soy sauce, a linguistic term for repeating words in the Sundanese language. These interjections are then used as ketchup *rajékan* or a repetitive word such as "*trang-tréng-trong*" from the word 'trang' which mimics the sound of a pot repeatedly clashing or cooking in the kitchen, and "*dar-dér-dor*" from the word '*dor*' which mimics the sound of repeated pistol fire (Yudibrata, 2003). These two examples include ketchup *rajékan trilingga,* a rewording that is a word repeated three times and undergoes a change in the sound of the vowel.

Kecap Rajekan is a base word that is used repetitively or mentioned twice. It can be said twice as a full word for the first and second word (such as *aki-aki, bapa-bapa*, etc.); or only the first syllable for the first word and full word for the second word (such as *babagi* from *bagi-bagi*). However, there is also an exception called *kecap rajekan semu,* in which the repetition is part of the base word. For example, the words *papatong, kukupu* , and *pipiti* have repetition, but the first syllable has no base word. *Kecap rajekan* is classified into six categories:

1. *kecap rajekan dwipurwa*
2. *kecap rajekan dwi madya*
3. *kecap rajekan dwi murni*
4. *kecap rajekan dwi reksa*
5. *kecap rajekan trilingga*
6. *kecap rajekan binarung rarangken* (Fitriyani, 2019).

This work puts forward a concept of developing mathematical theory (LCM), which is the basis for the idea of music composition, where LCM is a technique for processing reps in *Rajekan's* music composition. There are a lot of musical works about repetition techniques, from simple to complex. This work as an offer techni-

que to process repetition with the least common multiple (LCM).

Repetition can generally be interpreted as repetition. Repetition in linguistics can be interpreted as an iteration applied to an important sound, word, or part with the intention of affirmation. In educational psychology, repetition is a method to understand a learning concept by reteaching after remembering, saying, hearing, and doing than understanding (Wikanengsih, 2010). The word in music can be interpreted as the iteration of motifs, rhythm patterns, chords, and parts. It is one of the simplest and most fundamental composition techniques. In addition to minimalist music, reps also appear in sonatas-shaped works. The recapitulation section has important points for recapturing, renouncing, reviewing, and repeating what has been introduced in the exposition section at the beginning of the (Hammerschmidt et al., 2021; London, 1994)absolute durations may seem longer as the tempo—the rate of an underlying pulse or beat—increases. Yet, the perception of tempo itself is not absolute. In a study on perceived tempo, participants were able to distinguish between different tempo-shifted versions of the same song (± 5 beats per minute (BPM.

Psychologist Diana Deutsch discovered the illusion of "*The Speech-to-Song illusion"* in which a recording of a repetitively played part of a speech can make the passage sound musical (Rowland et al., 2019). The repetitive part gives rise to a regularity of tempo and rhythm that makes it sound musical. Reps also cause expectations for their listeners.

A study of the repetitive works of Howard Skempton states the role of repetition from a psychological point of view can lead to a sense of expectation/expectation and thus the desire to make a repetition of disturbing patterns (Suhaya et al., 2020), which are then recreated to present a sensation of satisfaction in a particular moment (Cavett, 2022; Hananto & Sukerta, 2020). From the above statement, it can be concluded that reps play an important role in music. Repetition is widely used as the basis for development in music.

In music composition from Reich's work, Reich's previous repetitive pattern of "*Come Out"* into a tape *is looped,* and then Reich tries to play the same figure on the *keyboard* along with the tape loop, then tries to accelerate ahead of the *tape loop* which results in (Reich & Paul, 2004; Schwarz, 2009). The experiment was then continued with the work "*Piano Phase"* in which two acoustic piano instruments with humans playing them tried to produce *phasing* without the aid of electronic devices (Schwarz, 2009).

Several piano works that can be found to explore repetition in both solo piano and piano four hands can be exemplified by the piece 'Piano Phase' by S. Reich, composed in 1980. In this work, two pianists play simultaneously with the same rhythmic pattern but at different tempos. This concept of repetition becomes intriguing to listen to as a form of developmental repetition.

The tempo increase lasts until the pattern shifts to one-sixth of the notes and then again holds the initial tempo; after some repetition, the tempo is raised again until the pattern shifts to one-eighth of the pattern play played by the first pianist, and so on until the second pianist again plays a pattern identical to the first pianist (Digney, 2022; Epstein, 1986)organizational support, and service under pressure.

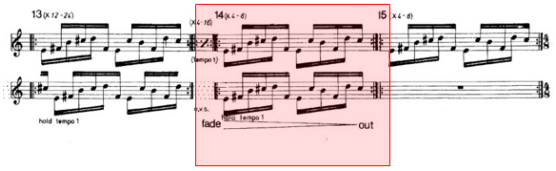

Figure 1. The final phase of pattern 1 is in the " *Piano Phase"* (Reich, 1980).

Repetition through the LCM technique becomes interesting to discuss and can be used as a separate composition technique with various kinds of processing. Moreover, the process of creating and analyzing this work is a step in how the world of musical composition is not only related to taste, but music is very close to the exact

sciences, so many possibilities for the use of LCM are able to provide a new style of music with the processing of new techniques as well.

This LCM research novelty in a technique of processing reps in musical composition. By using this technique, composers can create musical works by making only one musical sentence, then the theme of the work sentences is processed with this LCM to make the music work intact. Composers do not need to think about the melodic ideas of the next sentence of the song; just with the concept of LCM the musical work will be created and have its own sensation with the processing of reps through LCM. Moreover, the LCM technique in music lies in its ability to simplify the composition process by using the concept of LCM to process repetitions of a single musical sentence into a cohesive and unique musical work. It allows composers to focus on a single melodic idea and create a complete musical work without the need for additional melodic ideas. This can lead to a new approach to music composition and may result in new and innovative musical works.

METHOD

The creation research methodology used is artistic research through a *Practice-Led Research* approach which is also integrated with mathematical theory and musicology, especially music composition. This approach is a scientific research methodology that reveals the creative process of art creation from the artistic experience. Artistic research can also be understood as conducting historical or historiographical research to re-actualize older forms, technical objects, or modes of expression (Schwab, 2019). *Practice-Led Research* is a research approach that combines creative practice, creative methods, and creative results into a research design and as part of the research results (Candy, 2006, 2011).

In creative practice, of course, a creative thinking process is needed. A thought can be said to be creative if it becomes an original and adaptive idea, solution, or insight (Runco & Chand, 1995). Figure 2 is a diagram of the process and basic components of creative thinking.

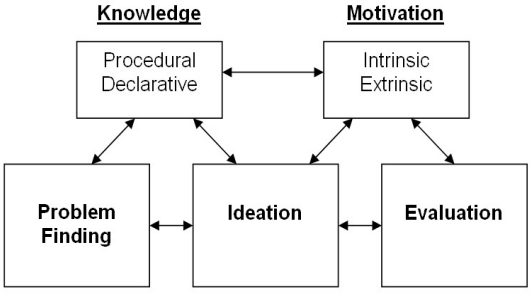

Figure 2. The creative process (Runco & Chand, 1995).

In this diagram, there are two levels where the first level (Problem discovery, Ideation, and Evaluation) has a relationship between simple but important abilities (*skills*) to understand creative thinking, while the second level (Knowledge and Motivation) is a component that influences but does not control factors but depends on the main factor (Budiawan & Martyastiadi, 2020; Runco & Chand, 1995). The stages of creation in *Practice-led Research* are dynamic, so they do not have binding and structural steps, adjusting to the researcher's unique way. The stages of creation research that researchers go through are derived from literature reviews and some of the researcher's artistic past experiences; Data Collection (Minimalist Music, Repetition, Sundanese), Creation Deepening, and Studio Works.

RESULT AND DISCUSSION

The work entitled "*Rajékan*" (with the letter é voiced the same as e in the word evaluation) is taken from the term *ketchup rajékan*, a linguistic term for repeating words in the Sundanese language. This work is an absolute piece of music based on the development of a repetition technique with an enlargement (augmentation) and reduction (diminish) of the value of notes to a series of melodies.

In this work, the researcher enlar-

ged the note value by 1 ½ times, 2 times, 3 times, and 4 times, and reduced the note value by ½ times and ¾ times presented in the form of a marimba ensemble. In its processing, researchers chose a *Pitched Percussion* type instrument because this type of instrument can be freer to sound notes that are rather tight and fast with clearer attack articulation compared to wind or friction instruments.

Audio is presented with VST *(Virtual Studio Technology)* on the Sibelius notation writing an application which can be accessed via the following link: *Rajékan Audio*. In this practice-based Research, the composer had a special set of plots in creating *Rajékan*'s work. The following are the steps that composers perform:

Movement I (Exposition)

The initial part of the work includes the introduction of the main motif or theme and its development in the same way as the exposition part in *Fuga*. Motifs are introduced one by one, starting from the theme, followed by its development with certain rules called the repetition cycle. To create a repetition cycle, researchers perform several stages.

In the initial stage, composers can create an original motif or theme that will be repeated and developed in terms of its pitch values. This serves as the basis for applying the least common multiple (LCM) as a technique for processing repetition. The researcher then observes the composer performing calculations by determining the potential rhythmic occupancy based on the duration of the notation and time signatures of the theme. If the duration of a theme occupies one complete measure, the rhythmic occupancy is considered 100%. Similarly, if the duration of a theme occupies two complete measures, the rhythmic occupancy is valued at 200%. In cases where the theme does not occupy a complete measure, the ratio of filled beats to the time signature used can be used to calculate the rhythmic occupancy.

The number of voice divisions and the types of value developments are determined, ensuring that the number of voice divisions corresponds to the number of value developments. This step is essential for determining the LCM of the value developments and recording the result. In the first movement, the resulting LCM is divided by the predetermined types of value developments, and each result is recorded. This step is necessary to calculate the number of repetitions for each type of value development within one cycle.

Multiplying the LCM result and the calculated results from the fifth step by the respective rhythmic occupancy percentages allows for the determination of the duration (in beats/time signatures) for each type of value development and a cycle. A crucial point to consider is creating a repetition cycle mapping diagram. The number of voice rows corresponds to the number of value developments in the motif, the number of measure columns matches the duration of the cycle (in terms of measures), and the highest value augmentation is placed in the top row while the lowest value diminution is placed in the bottom row. In this research, the table was made to guide the work process of the composers, but for the filling of the value of the rhythm change notes and others, the composer has the full right to enter the number of repetitions of motifs that refer to previous compositional work.

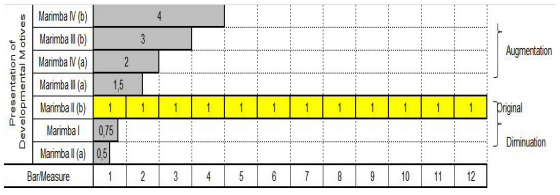

Figure 3. Music Composition Proses.

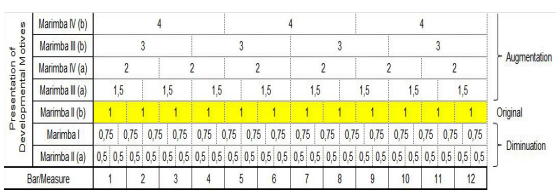

Figure 4. Mapping reps that have been filled in with the calculation results.

After the diagram is finished, it is applied to the score by introducing the

repetitioned theme first, followed by the development motif one by one, as is the case in Fuga's works. The appearance of the motive must exactly correspond (or to multiples) with what is already calculated in the diagram; otherwise, the repetition cycle will not occur. After all the voices and motives of development have emerged and there has been a cycle, the work with this development rep technique can be continued to the second part.

Movement II (Development)

In this section, each instrument/ sound division plays a whole variety of predefined note value development types alternately and sequentially. In order not to have the same repetition in one cycle or parallel (there is a type of repetition of the development of the same motif that is reviewed vertically or horizontally), the author performs the following steps that make this work processed serialism. The table below is an example of what composers can do in repetition through LCM Instruments Order.

Table 1. Presentation of Motive.

Instrument	Order						
	I	II	III	IV	V	VI	VII
Voice/Inst. A							
Voice/Inst. B							
Voice/Inst. C							
Voice/Inst. D							
Voice/Inst. E							
Voice/Inst. F							
Voice/Inst. G							

In the second movement of development, several important compositional tasks are carried out, with the primary task being the selection of desired instruments by the composer, which are placed in the index column for instrument allocation. Meanwhile, the index rows are filled with the presented order a voice/instrument division, following a series of development presentations applying the following sequence: ×0.5, ×0.75, ×1, ×1.5, ×2, ×3, ×4 (this series can be adjusted and does not have to be sequentially arranged from smallest to largest as used by the composer).

Table 2. The initial filling of the motif presentation table with a predetermined row.

Instrument	Order						
	I	II	III	IV	V	VI	VII
Voice/Inst. A							
Voice/Inst. B							
Voice/Inst. C							
Voice/Inst. D							
Voice/Inst. E							
Voice/Inst. F							
Voice/Inst. G	×0,5	×0,75	×1	×1,5	×2	×3	×4

After the series is placed in the bottom row, the researcher or composer proceeds to fill the table with subsequent rows, ensuring that each row follows the same sequence as the bottom row without introducing any gradual changes in the series.

Table 3. Advanced filling of tables with the same series but in different sequence sequences.

Instrument	Order						
	I	II	III	IV	V	VI	VII
Voice/Inst. A							
Voice/Inst. B							
Voice/Inst. C							
Voice/Inst. D							
Voice/Inst. E							
Voice/Inst. F	×0,75	×1	×1,5	×2	×3	×4	×0,5
Voice/Inst. G	×0,5	×0,75	×1	×1,5	×2	×3	×4

In the next step to apply LCM here, the composer places the smallest multiple by multiplying the number as shown in the table below. What needs to be noted is that all rows and columns are filled, this stage is carried out by researchers to ensure and verify that the series remains consistent and that no development is the same reviewed horizontally (rows) or vertically (columns), so that each column and row has a different number before the motif is executed in the musical work.

Table 4. Sof completed sequences are filled in and verified.

Instrument	Order						
	I	II	III	IV	V	VI	VII
Voice/Inst. A	×4	×0,5	×0,75	×1	×1,5	×2	×3
Voice/Inst. B	×3	×4	×0,5	×0,75	×1	×1,5	×2
Voice/Inst. C	×2	×3	×4	×0,5	×0,75	×1	×1,5
Voice/Inst. D	×1,5	×2	×3	×4	×0,5	×0,75	×1
Voice/Inst. E	×1	×1,5	×2	×3	×4	×0,5	×0,75
Voice/Inst. F	×0,75	×1	×1,5	×2	×3	×4	×0,5
Voice/Inst. G	×0,5	×0,75	×1	×1,5	×2	×3	×4

In order to apply LCM in musical

works (composition), the next step involves composers verifying the division of sounds or instruments and entering them into the instrument index column, as shown in table 5. The sequence of note value development in the piece "*Rajékan*" is then presented. Once the sequence of development for each voice division or instrument is determined, the researcher applies it to a musical script (sheet music) with all the sounds distributed simultaneously according to the order specified in the table. Each development is played once without repetition. A repetition cycle may occur in this second part, and its duration can be calculated by adding up the values of the entire note value development. In the case of this work, changes in tone values of 0.5, 0.75, 1, 1.5, 2, 3, and 4 result in a cycle duration of 12.75 (11 full rhythms + 3 beats). If the cycle continues, the subsequent cycle will end on the rhythmic segment of the 25th order of the 2nd beat. To conclude this part of the work, researchers chose to use the initial tone of one theme throughout the entire sound section, making a few simple adjustments.

Table 5. Order of presentation of the development of the value of notes on the work "*Rajékan*".

Instrument	Order						
	I	II	III	IV	V	VI	VII
Marimba I	×4	×0,5	×0,75	×1	×1,5	×2	×3
Marimba II (a)	×3	×4	×0,5	×0,75	×1	×1,5	×2
Marimba II (b)	×2	×3	×4	×0,5	×0,75	×1	×1,5
Marimba III (a)	×1,5	×2	×3	×4	×0,5	×0,75	×1
Marimba III (b)	×1	×1,5	×2	×3	×4	×0,5	×0,75
Marimba IV (a)	×0,75	×1	×1,5	×2	×3	×4	×0,5
Marimba IV (b)	×0,5	×0,75	×1	×1,5	×2	×3	×4

Description and Analysis of the Work "*Rajékan*"

Rajékan is taken from a linguistic term in Sundanese *kecap rajékan,* which means reword. This work is given the title because it is based on reps or commensurate terms in music for repetition. The repetition technique in this work was developed by means of enlargement (augmentation) and reduction (diminus) of the value of notes. The work is presented in the form of a marimba ensemble with seven presenters.

The main motif or theme found in rhythm 1 contains (similar) notes found in the barrel *degung* with da tones approaching Ab tones in the Western scale (Figure 6). The symbol contained in the score is a sign that the motif is an original theme or motif without any development of augmentation or diminution. This pattern continues to be played until one rhythm before part B, (time to 32).

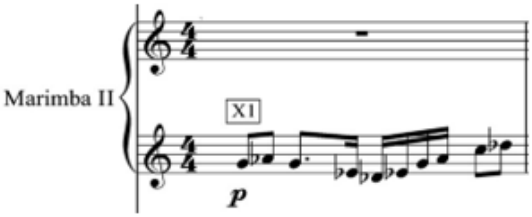

Figure 5. The main motif or theme in work "*Rajékan*" is found in Marimba II (b) in rhythm 1.

The development of motifs and the magnification of note values can be seen and observed in rhythm 3, particularly focusing on Marimba IV (a) in the composition "*Rajékan*." This is done by researchers with a view to analysing the technique of magnifying the value not as much as twice the value of the main motive, which is visually indicated by a certain symbol X2 . Through a detailed examination of the musical script (score) and musical interpretation, the researcher has the full right to select the creative work created by the composer and explore the artistic impact of this technique on the overall music composition.

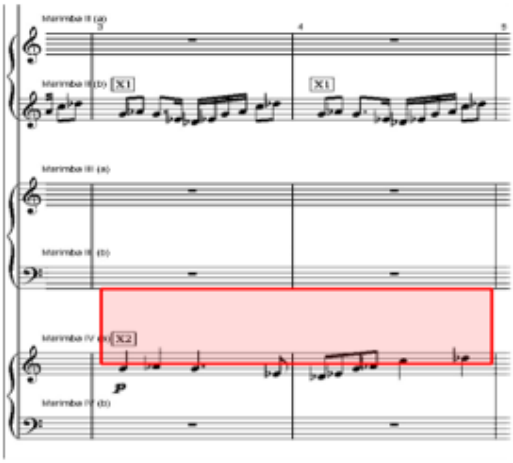

Figure 6. The appearance of the main motif that has been augmented two times in Marimba IV (a) in conjunction with the original motif in Marimba II (b) starting from rhythm 3.

A motif with the development of a one-and-a-half-time note value augmentation begins to appear in rhythm 6 on Marimba III (a) with a symbol (X1. 5) as its marker. By looking at table 5 in row III marimba with LCM usage used; x 1.5; x 2; x 3; x 4; x 0.5; x 0.75. The use of these multiples means that the musical movements in Marimba III and others will never be the same, but unlike canon works, with LCM we make the works seem to be complex Fuga movements.

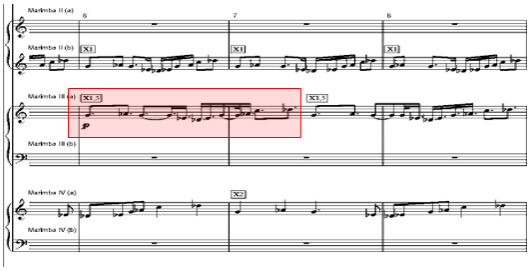

Figure 7. The appearance of the augmentation development motive 1.5 times in rhythm 6 in Marimba III (a).

A motif with the development of a three-time addition of note values begins to appear in rhythm 9 on Marimba III (b) with a symbol as its marker X3. In marimba III (b) this becomes a based line of musical works which is a repetition technique with LCM through enlargement of note values by magnification multiplication; x 1; x 1.5; x 2; x 3; x 4; x 0.5; x 0.75. LCM provides space for movement in each note that is written, making the motif or theme of the position like a bass sound separate from the repetition processing through the LCM approach.

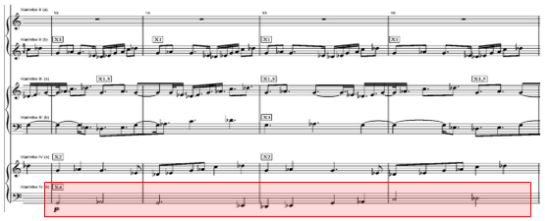

Figure 8. The appearance of the motive for the development of augmentation 3 times in rhythm 9 in Marimba III (b).

A motif featuring a four-time addition of note values emerges in the twelfth rhythm on Marimba IV (b), marked by a distinctive symbol X4. This development runs parallel to other musical elements and never coincides with the same motif. However, the composer has the ability to control the duration of this motif's presence by manipulating a predetermined table. By employing calculations involving small and large multiplication units in relation to the departing notes from the initial motif, the composer can determine the length of time this motif will be heard. This motif, characterized by the addition of note values in multiples of four, makes its appearance in the twelfth rhythm on Marimba IV (b) and is denoted by a symbol. Throughout its development, this motif remains independent from other musical motifs, running in parallel without ever intersecting. Nevertheless, the composer has the flexibility to dictate how long this motif will be heard by employing a precalculated table. By calculating the multiplication units for both small and large note values in relation to the departing notes from the original motif, the composer can control the duration of this motif's presence in the composition.

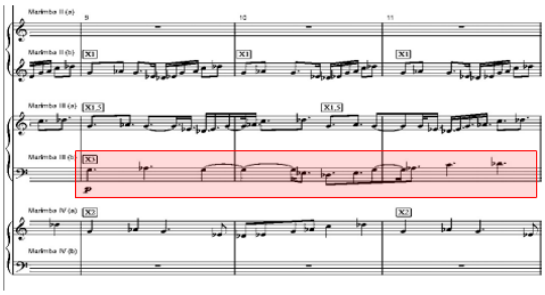

Figure 9. The appearance of the motive for the development of augmentation 4 times in rhythm 13 in Marimba IV (b).

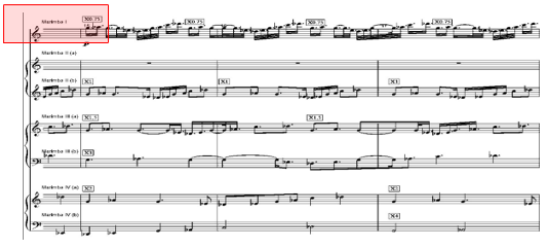

Figure 10. The appearance of the development motif is minuses 3/4 times in rhythm 15 in Marimba I.

In the composition, a motif undergoes a development characterized by a diminution of three-quarters of its original time value. This development commences in the fifteenth rhythm on Marimba I, and it is distinctly marked by a symbol X0.75. As this motif evolves, its temporal duration becomes increasingly condensed, creating a sense of compression and acceleration within the musical structure. Initially, the motif is introduced in its full time value, occupying a certain duration within the rhythmic framework. However, as the development unfolds, the composer implements a diminution technique that reduces the motif's time value by three-quarters. This means that the motif's duration becomes significantly shorter, creating a compressed and intensified musical effect.

The 1/16 rhythm serves as the starting point for this development, with Marimba I being the instrument that brings forth the motif. The motif's presence is emphasized through the use of a symbol as its marker, indicating its significance within the composition. This symbol acts as a visual cue, alerting the performers and listeners to the evolving nature of the motif. As the development progresses, the motif with the diminished time value continues to reappear throughout the composition, contributing to its overall rhythmic complexity. The repetition and variation of this motif, now condensed in duration, adds a sense of urgency and forward motion. It becomes a recurring element that engages the listeners' attention, creating a dynamic and evolving musical experience.

The composition introduces a motif that undergoes a development characterized by a reduction of half its original time value. This development emerges in the rhythm of the 18 pads on Marimba II (a) and is distinctly marked by the symbol X 0.5. The motif, initially presented with its original time duration, undergoes a transformation as its temporal value is halved, resulting in a more compact and accelerated musical effect.

Starting in the 18th rhythm, Marimba II (a) takes centre stage in introducing this motif development. The symbol X 0.5 acts as a marker, signalling the change in the motif's time duration. It serves as a visual cue for both performers and listeners, drawing attention to the altered rhythmic structure and the subsequent intensification of the musical passage. As the motif develops, its time value is consistently reduced by half. This means that its duration becomes progressively shorter, creating a sense of compression and increased tempo within the composition. The motif reappears at various points, maintaining its halved time value, and contributes to the overall rhythmic complexity and energy of the piece. The recurrence and variation of this motif, now condensed in duration, imparts a sense of urgency and forward momentum. It becomes a prominent element that shapes the musical narrative, evoking a sense of tension and heightened dynamics. The deliberate use of the X 0.5 marker ensures that performers and listeners can follow the motif's development and appreciate the transformative effect it has on the composition.

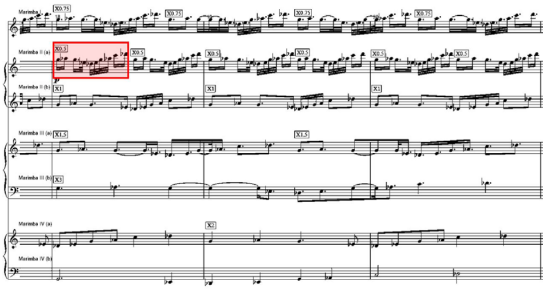

Figure 11. The appearance of the development motif is minuses 1/2 of the time in rhythm 18 in Marimba II (a).

The polyrhythmic formed from the presentation of development motifs and original motifs played simultaneously is 1:11/2:2:3: 4:6:8 with motif patterns that cross several rhythmic segments to be able to start from the beginning of the motif with the exact same tone simultaneously. The pattern collides on rhythm 21 with the explanation of the graph below then the repetition pattern will collide back on rhythm 33 (although researchers eventually in rhythm 33 continue with part B), thus forming an asymmetric polyrhythmic. In the case of this work, a repetition collision will occur once every 12 times. This can be found using the LCM formula (Smallest Guild Multiple) of the value of the entire amount of development, both augmentation and diminution.

In the second part (time 33-45), each presenter plays a variety of motif developments sequentially and alternates with the order that has been created in Table 6. After the entire series of each end, the work closes with a slowdown in tempo *(molto rall)* 2 rhythms before the last rhythm and ending with the note G beginning with marimba IV (b) as the lowest note, then followed later by Marimba I, II, III, and IV (a) on time 46.

Table 6. Mapping the repetition cycle in work "*Rajékan*".

Presentation of Developmental Motives																	
	Marimba IV (b)	4				4				4							Augmentation
	Marimba III (b)	3			3			3			3						
	Marimba IV (a)	2		2			2		2			2					
	Marimba III (a)	1,5		1,5		1,5		1,5		1,5		1,5		1,5			
	Marimba II (b)	1	1	1	1	1	1	1	1	1	1	1	1	1			Original
	Marimba I	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	Diminuation
	Marimba II (a)	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	
	Bar/Measure	21	22	23	24	25	26	27	28	29	30	31	32				

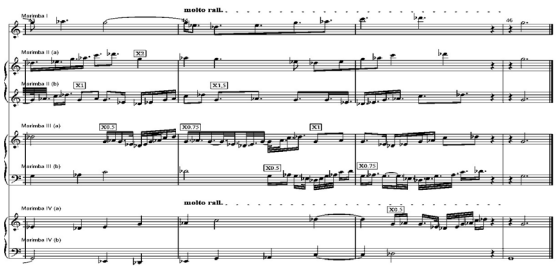

Figure 12. Rhythm 43-46 "*Rajekan*"

As the title implies, this work is inspired and based on repetition. The phenomenon of repetition in the researcher's self-experience is interpreted into repetition in musical terms which is then developed by magnification (augmentation) and reduction (diminish) of the value of notes. This work is an absolute piece of music whose interpretation is focused on numerical computing (calculation). The main motif in this work uses the application of the *degung b*arrel in the Sundanese *degung* karawitan with the distance between the notes in cents of (in order) 424-70-212-424-70 (Fausta, 2019a) with the da tone (in Sundanese terms) approaching the Ab tone (in Western terms), then the Mi tone approaches the G tone, Na approaches the Eb tone, the It tone approaches the Db tone, and the La tone approaches the C tone.

The emergence of development motifs that are played simultaneously with original motifs and other developments produces chords incidentally and polyrhythmically. These namely rhythmic patterns, contrast, and are independent at the same time (Kamien & Kamien, 2013). However, the polyrhythmic formed is an asymmetric polyrhythmic with the possibility of collision that can be calculated by the smallest common multiple (LCM) of the 2 largest developments (enlargement or reduction) of the note value. In this work "*Rajékan*" the greatest multiple of his communion is worth 12 with an original motif of 1 rhythm. Thus, collisions or cycles will occur in every 12 rhythmic segments.

Discussion

In the context of composition, reps are the easiest and most basic way to de-

velop musical composition techniques. The repetition processing carried out by researchers produces a repetition processing technique with the magnification and reduction of the sound value that forms the cycle (Ananda et al., 2022; Hargreaves, 1984, 2012). Minimalist music produces several works that use repetition whose components do not change. Originally repetitive moments were the most striking feature of minimalist music. Many minimalist composers work with highly repetitive patterns, such as Philip Glass, who essentially concentrated on static repetition and harmony for electrically amplified violins in his composition "Strung Out" (1967) (Ensemble & Culture, 1990). While Glass tends to vary repetition, Steve Reich uses this musical technique for his audio cassette compositions and his work "Piano Phase" (1967) in a way that continues unchanged (Hill et al., 2018; Schwarz, 2009). In *Rajékan*'s work its use and application is different from research or repetition processing techniques from other composers, LCM works in music composition work is perceived by researchers as a new way that can ease the making of musical works (Azaryahu et al., 2023), just as the manipulation of motifs in music composition can make the time of working on musical works more effective ways (A. L. Uitdenbogerd & Zobel, 1998; A. Uitdenbogerd & Zobel, 1999).

In this research, the least common multiple of the time signatures in a piece of music is if one part of a song is in 3/4 time and another part is in 4/4 time, the LCM of these time signatures would be 12/4, which is equivalent to 3/1 (also known as "whole note" or "*quadruple* whole note" time). In particular, discovered that there are three methods for determining the least common multiple (LCM) between two numbers: Creating a multiple and divide involves creating an ordered list of consecutive multiples of one number while simultaneously checking each new entry for divisibility by the second number (Bollobás, 2022). Prime-factorization involves comparing the prime factorization of the two numbers and locating the minimal product of prime powers that contains both of their factorization (Heyman & Tóth, 2022). Set intersection involves creating an ordered list of consecutive multiples of each number and finding the first one that appears in both lists. This tells the musician the length of one cycle or measure of the repeating pattern in the music and helps to synchronize the different parts of the solo, duet, trio, and ensemble. From the results of the discussion above, techniques for enlarging and reducing note values using LCM were carried out. In the mathematical sciences this technique aims to take two or more integers as input and returns the smallest positive integer divisible by all input integers without leaving a remainder (Bagdasar, 2014).

In other respects, the use of reps in music generally aims to influence the emotions of the human beings who listen to it; in minimalist music, the listener is deliberately invited to listen to a repetitive theme in order for the listener to go "trance" (Rowland et al., 2019). Similarly, in Indonesian ethnic art performances, one of which is the "lumping horse" in the music *kuda lumping* deliberately repeated so that listeners, in this case the "*kuda lumping*" actor, can "trance" so that the show is more interesting (Hendriko & Effendy, 2019a, 2019b). In this Research, LCM as a repetition technique was not used to influence human emotions but as a technique for making compositions in the processing of musical themes which were used as tools to create musical works with only short themes. In the sub-discussion, several ways have been given to use this LCM technique as a concrete form of application of composition techniques (Azaryahu et al., 2023). In contrast to minimalist musical works in repetition processing such as Steve Rich does repetition processing techniques, but he does it by way of playing tempo (Dauer et al., 2021). Steve Reich's piano phase offers listeners an easy-to-hear formal structure with unpredictable local events. For example, repeating patterns can create strong expectations broken by small devi-

ations in time and pitch.

In musical composition, *Rajékan* is very different from Steve Rich's style of music processing (Schwarz, 2009). During the development of his composition "piano phase," Steve Reich became captivated by the idea of creating an electronic device specifically designed to execute the phasing process. This device would serve as an instrument, capable of being played in live performances to replicate a distinct type of phasing activity. Unlike previous phasing techniques that focused on altering the rhythmic relationship between two identical melodic patterns (Schwarz, 2009), Reich's new approach involved initiating with a chord and gradually shifting individual tones out of phase. This transformation would transition the initial vertical harmonic entity into a continuously evolving series of horizontal melodic patterns. Reich's fascination with this concept drove him to explore new avenues of musical expression and expand the possibilities of phasing composition. *Rajékan* repetition processing with LCM technique plays at note value and plays ensemble marimba with the same tempo; in minimalist music above ensemble plays with different tempos in each instrument. Weakness in tempo processing there is a tendency to inaccurate the end of the musical work as well as when playing in the middle of the work. However, when using the LCM technique, players can minimize and even be accurate in playing the work in the middle and at the end of the work.

The different musical works in the classical era also used the repetition technique; in that era, the repetition technique was used by means of a pitch modulation system or instrument change with the same motif. An example can be taken from Beethoven's Fifth Symphony. Beethoven did a lot of reps by means of modulation and instrument displacement.

Repetition with the use of LCM in its development and utilization can be found in-game music or game music, where the music acts as background music that constantly undergoes repetition or looping and puts the function of music as a state of mind. A type of music with repetition considered to work effectively "hypnotizing" to bring game players into the desired mindset towards gaming, *Rajékan* is one part of manipulation the listener through the LCM technique.

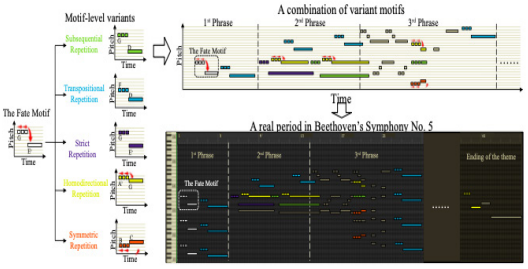

Figure 13. Beethoven's *Fifth Symphony* with analysis music computing (Hu et al., 2022).

CONCLUSIONS

Finally, the use of The Least Common Multiple (LCM) in "*Rajékan*," a work by Rizky Fauzy Ananda, has shown how closely mathematics and music are related. The study looks at how mathematical elements, especially those derived from physics, are fascinating and extremely important in the realm of music composition, producing new knowledge that is useful for the composition process. By examining the effectiveness of employing LCM, this study sought to identify novel techniques in the field of music composition. A practice-led research strategy was used in the technique, which combined musicology, mathematical theory, and creative study specifically in the context of music composition. Repetition in music, independent of context, strongly overlaps with mathematics, according to the study, making LCM a useful tool for composing music.

Composers concentrate on creating themes or motifs that are then implemented utilizing the LCM technique, as described in this article. Additionally, composers continually develop new methods and produce comprehensive musical works of art by incorporating insights from several fields. Through personal experiences, the researcher has found two repetiti-

on processing methods that use the LCM mathematical style: (1) multiplication and reduction of sound values to form cycles, and (2) imitation. Repetition has been crucial to the development of music. The use of LCM in "*Rajékan*" exemplifies the intimate relationship between music and mathematics. This study highlights the potential and benefits of using LCM and advances the study of innovative compositional strategies. By fusing mathematical concepts with creative research. Composers can broaden their creative horizons by doing research, which will enrich the compositional process and help them understand the complex connections between music and mathematics.

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