

CONFERENCE PROCEEDING

The Ethnomathematics Implementation of Lingsir Wengi Song Version Sunan Kalijaga in Mathematic Learning

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ABSTRACT

Mathematic is the main knowledge of life and has a dominant role in other fields. One of them is music. Based on material function and module in transposition function, notes changes can be defined in the mathematical equations. Analyzing the transposition function of tonal notes through stages which includes changing the tones to the form of an integer modulo 12, is called the integer Model of the pitch. Then, analyze the defined transposition function. The results of the exploration research of the Sunan version of the LM song using the transposition function had obtained: 8 variations of tone changes in the song includes C-F-G-F-G#-C-A-D#-G#-F-C.

Keywords: *Mathematics, Music, Transposition Function, Modulo*

INTRODUCTION

Culture is knowledge and conception, embodied in symbolic and non-symbolic communication models, about technology and skills, customary behavior, values, beliefs, and attitudes of people that have developed over a long period. From a cultural perspective, it cannot be separated from the social reality of the dynamics of life that develop in society. Music as an art has intrinsic value that reflects and presents a picture of cultural conditions related to areas of human life. It shows that music has major influence role in human life, including in the field of mathematics.

Mathematics and music have a strong relationship. In ancient Greece, acoustic music was created from a mathematical point of view. Relationships formed in mathematics are able to compose algorithms that are specific to music. As a result, the application of mathematics in music culture, including ethnomathematics, and optimization analysis of the art of music. Ethnomathematics is a bridge between culture and mathematics. Ethnomathematical studies in mathematics include the fields of architecture, ornament, patterns or motifs, agricultural activities, even kinship and religious practices that are in harmony with patterns that exist in nature. Thus, culture has a broad and unique view such as traditional activities, farming, playing, how to dress, how to solve socio-cultural problems, and music.

In this study, researchers chose music from the song Lingsir Wengi. The song had chosen to clear up misunderstandings about the meaning of the song based on the community, that there is something mystical because it can be seen in the film 'Kuntilanak'. The song will be reviewed in the original meaning created by Sunan Kalijaga. The creation of the song Lingsir Wengi which was created by him was using the macapat standard or the Javanese gending standard which has 11 kinds of grip. One of the gending grips used by Sunan Kalijaga in the song Lingsir Wengi is the Durmo grip. Pakem Durmo has characteristic, that includes feeling gloomy, hard, and

sad atmosphere with a soft and heart-wrenching feeling. However, the song's misunderstanding started with the film 'Kuntilanak'. In the movie, the actor Julie Estel sang it using the grip of durmo which means to call the kuntilanak.

Research on the art of music in mathematics has also been carried out, including the research "Computing Melodic Templates in Oral Music Traditions". It explains that the computation of traditional Spanish music melodies, namely Flamenco, can form a continuous function of the MID pitch, and the time required in the span of one traditional music performance Flamenco. Mathematics and music have support in a social relationship that was formed in society. The analysis of fractals contained in the music, based on the explanation has described, this study will do the same thing, namely analyzing the instrument of the song Lingsir Wengi version of Sunan Kalijaga by paying attention to the concept of modulo and transposition functions.

MATERIALS AND METHODS/ METHODOLOGY

Data

Data that used in this research is Lingsir Wengi note. It comes from chromatic tone. Here are the lyric and the pitch song as Sunan Kalijaga version:

C F G7 C
Ling-sir We-ngi
 Menjelang tengah malam
 F G7 C Am D7 G7 F C
Se-pi du-rung bi-so nen-dro
 Sepi tidak bias tidur
 C F G7 C G7 F C
Ka-go-dho mring we-wa-yang
 Tergoda bayangmu
 F G7 C Am D7 G7 F
Kang ng-re-ri-dhu a-ti
 Di dalam hatiku
 C F G7 C
Ka-wi-ta-ne
 Permulaannya
 F G7 C Am D7 G7 F C
Mung sem-bro-no njur ku-li-no
 Hanya kebiasaan bercanda

TRANSPOSITION FUNCTION

Definition 1 Function

A relation between A and B is called a function if every element (member) of set A is paired with exactly one element (member) of set B [21]. It is denoted by $f:A \rightarrow B$ read as "f maps A to B". In the equation of the function formed, the set A is called the origin or domain of the function f and the set B is the friend area or codomain of the function f. Suppose the function $f: \{1,2,3\} \rightarrow \{7,8,9\}$ is defined with:

$$f(1) = 7$$

$$f(2) = 8$$

$$f(3) = 9$$

The example states the set $A=\{1,2,3\}$ as the domain and the set $B=\{7,8,9\}$ represents the codomain and range of the function $f:A\rightarrow B$. The three equations show that each member of the domain is paired with exactly one member of the codomain.

Definition 2 Transposition. Let n be an integer mod 12, then the function $T_n:Z_{12}\rightarrow Z_{12}$ is defined by $T_n(x)\equiv x+n(\text{mod } 12)$ [22], [23]

n : nth transposition, with $n=0,1,2,\dots,11$

x : tone

Transposition Function

Definition of 3 Modulo. If m is a positive number then a is congruent to b with modulo m (written $a\equiv b(\text{mod } m)$) if and only if m divides $(a-b)$. If m does not divide $(a-b)$ then a is said to be incongruent with b (written $a\not\equiv b(\text{mod } m)$) [24].

RESULTS AND DISCUSSION

The analysis of Transposition Function on Lingsir Wengi Song

In the mathematical exploration process, were contained in the Lingsir Wengi song, the researcher focuses on the material of the transposition function that can be formed from the chromatic scales found in the Lingsir Wengi song. The transposition function has been defined with a definition 2. The steps applied to the process to obtain the form of the transposition function from the song Lingsir Wengi go through four stages, including:

Analisis Integer Model (MID) Pitch

The process of analyzing the functions contained in the Lingsir Wengi song begins with determining the notes and continues by changing the notes of the song in the form of integers with the concept of modulo ($\text{mod} = 12$) and continues with the analysis of the concept of the transposition function on the notes formed in the Lingsir Wengi song. As follows:

C-F-G-C
 F-G7-C-Am-D7-G7-F-C
 C-F-G7-C-G7-F-C
 F-G7-C-Am-D7-G7-F

Based on the chromatic notes of the Lingsir Wengi Song obtained, the tone analysis step is continued and converted into the form of an integer mathematical equation ($\text{mod } 12$). So that, the steps which explain the transposition function obtained from the notes of the Lingsir Wengi song in music into mathematics are shown in Table 1.

Tabel 1. Cromatic Note of Lingsir Wengi Song

Notes in Music	Notes in Mathematics Tone
$C = \{C, E G\}$	$C = \{0, 4, 7\}$
$F = \{F, A, C\}$	$F = \{5, 9, 0\}$
$G = \{G, B, D\}$	$G = \{7, 11, 2\}$
$G\# = A\flat = \{G\#, C, D\#\}$	$G\# = A\flat = \{8, 0, 3\}$
$D\# = \{D\#, G, A\#\}$	$D\# = \{3, 7, 10\}$

To find out the process of changing notes in Lingsir Wengi Song, the researcher uses the concept of transposition modulo 12. The use of modulo 12 is because it is under the scales that are the reference in the study, in this case, the chromatic scales had arranged into 12 kinds of each one octave formed. Chromatic note notation uses seven variables and assumes the first seven letters of the alphabet. So that obtained 8 variations of tone changes contained in the song Lingsir Wengi. It starts with a note change C-F-G-F-G#-C-A \flat -D#-G#-F-C

The following is an analysis of the transposition function on the notes of the Lingsir Wengi song which includes eight changes in the tone of the song.

Tone C into C, so $n = 0$ $C = \{0, 4, 7\}$ became $C = \{0, 4, 7\}$	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_0(0) \equiv 0 + 0(\text{mod } 12)$ $T_0(0) \equiv 0$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_0(4) \equiv 0 + 0(\text{mod } 12)$ $T_0(4) \equiv 4$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_0(7) \equiv 7 + 0(\text{mod } 12)$ $T_0(7) \equiv 7$
Tone C into F, so $n = 5$ $C = \{0, 4, 7\}$ became $F = \{5, 9, 0\}$	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_5(0) \equiv 0 + 5(\text{mod } 12)$ $T_5(0) \equiv 5$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_5(4) \equiv 4 + 5(\text{mod } 12)$ $T_5(4) \equiv 9$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_5(7) \equiv 7 + 5(\text{mod } 12)$ $T_5(7) \equiv 0$
Tone F into G, so $n = 2$ $F = \{5, 9, 0\}$ became $G = \{7, 11, 2\}$	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_2(5) \equiv 5 + 2(\text{mod } 12)$ $T_2(5) \equiv 7$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_2(9) \equiv 9 + 2(\text{mod } 12)$ $T_2(9) \equiv 11$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_2(0) \equiv 0 + 2(\text{mod } 12)$ $T_2(0) \equiv 2$
Tone F ke G#, so $n = 3$ $F = \{5, 9, 0\}$ became $G\# = \{8, 0, 3\}$	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_3(5) \equiv 5 + 3(\text{mod } 12)$ $T_3(5) \equiv 8$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_3(9) \equiv 9 + 3(\text{mod } 12)$ $T_3(9) \equiv 0$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_3(0) \equiv 0 + 3(\text{mod } 12)$ $T_3(0) \equiv 3$
Tone G# ke C, so $n = 4$ $G\# = \{8, 0, 3\}$ became $C = \{0, 4, 7\}$	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_4(8) \equiv 8 + 4(\text{mod } 12)$ $T_4(8) \equiv 0$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_4(0) \equiv 0 + 4(\text{mod } 12)$ $T_4(0) \equiv 4$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_4(3) \equiv 3 + 4(\text{mod } 12)$ $T_4(3) \equiv 7$
Tone C ke A\flat, so $n = 8$ $F = \{0, 4, 7\}$ became $A\flat = \{8, 0, 3\}$	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_8(0) \equiv 0 + 8(\text{mod } 12)$ $T_8(0) \equiv 8$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_8(4) \equiv 4 + 8(\text{mod } 12)$ $T_8(4) \equiv 0$

	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_8(7) \equiv 7 + 8(\text{mod } 12)$ $T_8(7) \equiv 3$
Tone A∂ into D#, so $n = 7$ A∂ = {8, 0, 3} became D# = {3, 7, 10}	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_7(8) \equiv 8 + 7(\text{mod } 12)$ $T_7(8) \equiv 3$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_7(0) \equiv 0 + 7(\text{mod } 12)$ $T_7(0) \equiv 7$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_7(3) \equiv 3 + 7(\text{mod } 12)$ $T_7(3) \equiv 10$
Tone D# into G#, so $n = 5$ D# = {3, 7, 10} became G# = {8, 0, 3}	$T_n(x) \equiv x + n(\text{mod } 12)$ $T_5(3) \equiv 3 + 5(\text{mod } 12)$ $T_5(3) \equiv 8$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_5(7) \equiv 7 + 5(\text{mod } 12)$ $T_5(7) \equiv 0$ $T_n(x) \equiv x + n(\text{mod } 12)$ $T_5(10) \equiv 10 + 5(\text{mod } 12)$ $T_5(10) \equiv 3$

CONCLUSION

The results of exploratory research on the song Lingsir Wengi version of Sunan Kalijaga using the transposition function, it was included the process of changing the tone of the song in numbers (integer MIDI Pitch models) using modulo 12. The use of modulo 12 in this study is based on the division of notes on the chromatic scale, to obtain 8 variations of changes the tones obtained in the song Lingsir Wengi include: C-F-G-F-G#-C-A ∂ -D#-G#-F-C. In the process of changing each note of the Lingsir Wengi song, there is a mathematical process using the transposition function. The transposition function is obtained by the process of changing notes and the concept of modulo.

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