Ethnomathematics on Surabaya Regional song notation

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Abstract. Music correlates to mathematics in the form of pattern concepts, formulas, and calculations that can be used as variations of ethnomathematics-based learning. One of the mathematics learning’s goals, according to the National Council of Teachers of Mathematics (NCTM), is a cultural purpose. This research aims to describe the results of mathematical element analysis in Surabaya regional songs. The research method used was qualitatively descriptive. The data sources used in this study were researchers, literatures, and field practitioners. Data collection techniques used were interviews and documentation studies. The documentation study was carried out by making a literature assessment corresponding to the required data. The data analysis technique used was Miles and Huberman’s models encompassing data reduction, data presentation, and conclusion drawing stages. The results of study showed that there is a mathematical element in the regional song from Surabaya. The mathematical elements found in the analysis of block notation scores and number notations are summation of same-number fractions, summation of different fractions, multiplication of fractions, data processing in modes form, as well as data presentation in the form of tables, bar diagrams, and line charts. In addition to finding the mathematical elements in Surabaya regional songs, this study also proves that there is a correlation between music and mathematics.

1. Introduction

Culture is a region’s and a country’s characteristic [1]. Culture comes from the habits of the community that eventually become the characteristic of a region. To maintain cultural uniqueness, rules and norms are required. Culture is the work of human culture [2]. This is evidenced by the creation of society, beliefs, art and customs. Cultural elements are languages, knowledge systems, community organizations, systems and technologies for living equipment, livelihood systems, religious systems, and the arts. Every element of culture will transform into a culture [3]. One element of culture is art, in this case art is the embodiment of art ideas, art activities, and art objects. Art is a space to think about and taste so that it transforms into a cultural configuration [4]. Each region in Indonesia has a distinctive art from their respective regions. This is demonstrated by the presence of regional dances, regional songs, traditional regional music, different batik in different regions, and others. The embodiment of the culture that incarnates in the art form is the existence of traditional regional music. Traditional regional music learning in elementary schools is realized through classroom and extracurricular learning. The use of music in learning can increase stimulus and has a positive impact on students.
In addition to learning music, there is also math learning in elementary school. There are symbols, deductive science, according to Ruseffendi, the science of order and organized patterns [5]. Mathematics is actually an idea that is not only abstract but exists in the "real world" [6]. This is in accordance with the existence of Ethno-based learning mathematics, an approach in its implementation explaining the reality of environmental and cultural relationships with mathematics [7]. Ethnocentric-based learning can be done by analyzing culture in the term of mathematics. It also confirms that mathematics is actually a part of the culture. According to Radford, mathematics is one of the cultural mathematics education, not a new phenomenon but a proven cultural subject from the repositioning of mathematical content onto industrial, economic, political, and of course cultural motives [8]. The integration of music and mathematics has a positive effect on students' attitudes and beliefs in mathematics learning and can give students the opportunity of learning mathematics actively with critical problem solving process [9]. This is supported by the link between music and mathematics in the form of mathematical processes related to various mathematical concepts through music. For example (a) students communicate math ideas with their peers; (b) students represent mathematical concepts; (c) students link the content of mathematics in the math curriculum to a variety of real-life situations; (d) students think about the meaning of mathematics from a reasonable and logical perspective, and (e) students can solve math problems using a variety of problem solving strategies. Moreover, learning mathematics in a musical context allows students to present and understand mathematics in an interesting way so that they are able to analyze, interpret, and understand mathematics through different disciplinary perspectives [10].

Considering the statement above, the author wants to do a research on "Ethnomathematics in Surabaya Regional Song Notation". The reason the author chose folk songs as the object of research is that folk songs are one type of learning that has been taught since elementary school. In addition, this study uses an analysis of regional song notation based on the mathematical elements contained within it. The regional songs used are rek Ayo Rek and Semanggi Suroboyo. This analysis refers to the mathematical elements contained in the beam music notation and number notation of the two songs. This study aims to illustrate the results of analysis of mathematical elements in Surabaya folk songs. This research is expected to provide learning variations based on ethno mathematics and to become the basis of further research. This research is also expected to influence the development of research based on ethno mathematics and to prove the relationship between music elements and mathematical elements.

2. Methods
This research used descriptive qualitative method. The analysis process came from the thinking of researchers supported by literature that confirms the study findings [11]. This study aimed to find and to describe the results of mathematical element analysis in notation of numbers and notation of song blocks Rek Ayo Rek and Semanggi Suroboyo. The sources of research data used in this study included researchers, literature, and field practitioners. The data obtained in this study included the results of analysis of mathematical elements in the notation of songs in Surabaya area, literature supporting theory and analysis, as well as the results of field practitioner interviews. To get data from data sources, data collection techniques are required. Considering the needs for research data, the data collection techniques selected were interviews and document studies. The use of interview techniques was aimed at field practitioners, the type of interview used is a semi-structured interview to obtain the suitability of the data needed by researchers. Meanwhile, document study techniques were intended to collect documents from clear sources and proven authenticity. The documents collected were then analyzed and processed descriptively.

To support the data collection process, research instruments are needed. The main instrument used in this study was the self-researcher, who played a role in the process of analyzing mathematical elements on song notation [12]. The supporting instruments in this study included analytical guidelines (analysis tables), documentation guidelines, interview guidelines, and validation sheets. After the data collection process has been done, the data needs to be processed in data analysis stage. The analytical technique used in this research was Miles and Huberman’s data analysis technique model consisting of data reduction, data interpretation, and image/verification conclusions [13]. Data reduction stage was
done by the process of analyzing beam and number notations of both songs and then followed with the interpretation stage of notation. The analyzed data will be interpreted using research supporting theory in the last stage, namely drawing conclusions. To prove that the data obtained from this research is credible, a data validity test is required using Credibility, Transferability, Reliability, Confirmation [11]. Credibility test was conducted using source triangulation consisting of writers, literature, and field practitioners. Transferability was done with a clear presentation of the customized data between the data obtained and the data presented. The reliability recheck stage, and the data obtained can be confirmed in the study source.

3. Results
Surabaya is the largest and oldest city in Indonesia, with a total area of 330.45 km². Surabaya is also known as the city of heroes, the title given related to the heroic spirit and to commemorate the battle on November 10, 1945 in Surabaya [14]. The title of the city of heroes was given to Surabaya since the incident of tearing Dutch flag, red, white, and blue into the red and white one by Surabaya heroes on November 10, 1945. The incident occurred at the Yamato hotel in the Tunjungan area. The atmosphere of the street is captured in Surabaya Local Song, Rek Ayo Rek. This song is keroncong pop genre composed by a solo artist, Mr. Is Haryanto, and popularized by Mus Mulyadi in the 1970s. The second regional song is Semanggi Suroboyo, this song has a keroncong genre that composed by S. Padimin in 1950s and popularized by Tatiek Wiyono. This song tells Surabaya typical food, namely pecel semanggi. The song tells enjoyment, uniqueness, presentation method, and price of pecel semanggi [15].

The interrelationship between music and mathematics can be seen from beats, patterns, and beats. Adapting to the structure and principles of beam notation, some mathematical elements are found in number and beam notations of Surabaya regional songs. The mathematical elements can be seen from the analysis of beam notation of the songs (see table 1).

| Table 1. The results of the analysis of beam notation of Surabaya Regional song. |
|---|---|---|---|---|---|---|---|---|---|
| Rek Ayo Rek Song | Semanggi Suroboyo Song |
| **Bar Notation** | **Mathematical Analysis** | **Notes** | **Bar Notation** | **Mathematical Analysis** | **Notes** |
| ![Bar Notation](image1) | $\frac{1}{4} \times \frac{1}{4} = \frac{1}{8} + \frac{1}{8} \times \frac{1}{4}$ | Fractional summing and multiplication material | ![Bar Notation](image2) | $\frac{1}{4} \times \frac{1}{4} = \frac{1}{8} + \frac{1}{8} \times \frac{1}{4}$ | Fractional summing material |
| ![Bar Notation](image3) | $\frac{1}{2} + \frac{1}{4} = \frac{1}{2} \times \frac{1}{4}$ | Same fractional summing material | ![Bar Notation](image4) | $\frac{1}{2} + \frac{1}{4} = \frac{1}{2} \times \frac{1}{4}$ | Same fractional summing material |
| ![Bar Notation](image5) | $\frac{1}{2} + \frac{1}{4} = \frac{1}{2} \times \frac{1}{4}$ | Fractional summing and multiplication material | ![Bar Notation](image6) | $\frac{1}{2} + \frac{1}{4} = \frac{1}{2} \times \frac{1}{4}$ | Fractional summing material |
| ![Bar Notation](image7) | $\frac{1}{2} + \frac{1}{4} = \frac{1}{2} \times \frac{1}{4}$ | Same fractional summing material | ![Bar Notation](image8) | $\frac{1}{2} + \frac{1}{4} = \frac{1}{2} \times \frac{1}{4}$ | Same fractional summing material |
From the results of mathematical element analysis on the beam notation of Rek Ayo Rek and Semanggi Suroboyo song obtained, there are 3 mathematical elements in both songs: fractional summation material with same denominator, fractional summation with the different denominator, and fractional multiplication. The first is fractional summation with same denominator. It consists of 2 variations of fractional summation with same denominator: $\frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{4} + \frac{1}{4}$ and $\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$ both of which when operated will result in a value of $\frac{4}{4}$. Fractional summation with the same denominators will occur when the beam notation of the song consists of the same type of beam note. The second is fractional summation with different denominators. It consists of eight variations: (a) $\frac{1}{4} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8}$, (b) $\frac{1}{2} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8}$, (c) $\frac{1}{4} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8}$, (d) $\frac{1}{8} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16}$, (e) $\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$, (f) $\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$ and (g) $\frac{1}{2} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$ all of which when operated will result in a value of $\frac{4}{4}$. The third mathematical element is fractional multiplication material, consisting of 3 (three) variations in the song: (a) $\frac{1}{2} \times \frac{1}{8} = \frac{1}{16}$, (b) $\frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$ and (c) $\frac{1}{2} \times \frac{1}{8} = \frac{1}{16}$. The interrelationship between music and mathematics can be seen from beats, patterns, and beats. Adapting to the structure and principles of beam notation, some mathematical elements are found in number and beam notations of the Surabaya regional songs. The sum of each notation bar produces a rhythmic value on each song, indicating that mathematics is related to beam notation on a song (see table 2).

**Table 2.** The results of analysis on number notation of the "Rek Ayo Rek" and "Semanggi Suroboyo" songs.

| Song                  | Number of Tone Beats |
|-----------------------|----------------------|
|                       | Sol (5<) | La (6<) | Si (7<) | Do (1) | Re (2) | Mi (3) | Fa (4) | Sol (5) | La (6) |
| Rek Ayo Rek           | 20       | 16      | 4       | 41     | 41     | 32     | -      | 8       | 14     |
| Semanggi Suroboyo     | 11,5     | 9,5     | 1       | 22     | 23,5   | 32,5   | 1      | 14      | 5      |

The results of analysis can be represented histogram and line chart. The analysis of number notation numbers in is presented in the figure 1 below.
The results of analysis of mathematical elements in the number notation of "Rek Ayo Rek" regional song proves that there are some variations in the number notation. There are some variations in the presentation number notation in "Rek Ayo Rek" song leading to another ethnomathematic variation in the notation of Surabaya regional songs. The representation of histogram shows that the highest values are found on do (1) and re (2) charts of 41, while the lowest value there is a si tone (7<) equal to 4. The use of line chart in representing mathematical elements in song’s notation provides another variation in ethnomathematics learning. This representation is used to view a significant chart of values appearing on each chart in the notation score of "Rek Ayo Rek" song.

This is also true for the notation score of "Semanggi Suroboyo" song. Referring to the mathematical element analysis of the number notation of "Semanggi Suroboyo" song, the result of number notation analysis on the score of "Semanggi Suroboyo" song is represented (see figure 2).

The results of analysis of mathematical elements in the notation of numbers on the song "Semanggi Suroboyo" also showed the presence of mathematical elements in the number notation of song. This results in other variations in ethnomatmatics associating math and musical art with regional songs. Based on the results of representation, it can be seen that the highest value of number tones in "Semanggi Suroboyo" notation score is found on the mi (3) chart, 32.5, while the highlighted value is found on two charts: si (7<) and fa (4) amounting to 1. The representation of line chart leads to another variation in ethnomathematics learning associating music art, especially regional songs, with math learning. Also, this line chart can be seen as less stable but it is this that makes the beauty, uniqueness, and characteristic of each song.

4. Discussion
The results of analysis of beam notation and number notation scores on Rek Ayo Rek and Semanggi Suroboyo regional songs show the conformity between mathematics and music. The basic competencies corresponding to the material can be found in the results of beam notation analysis following
Permenendikbud (Minister of Education and Culture’s Regulation) No. 37 the Year 2018 about the curriculum of 2013 [16], are among others: (1) grade 3; 3.5 Explaining fractional summing and subtraction with the same denominator, 3.1 Explaining fractional summing and subtraction with different denominators, 3.2 Describing fractional and decimal multiplication and division. Meanwhile, based on the results of notation numbers analysis, the basic competencies are, among others:(1) grade 4; 3.11 Explaining the students' data and their environment presented in histogram; 4.11 Collecting students' data and their environment, and presenting them on histogram. (2) class 5; 3.7 Describing data related to students or their environment and how they are collected; 3.8 Describing the presentation of data related to students and comparing it with data from the surrounding environment in the form of lists, tables, drawing charts (pictograms), histogram, or line chart; 4.7 Analyzing data related to students or the environment and how they are collected; 4.8 Organizing and presenting data related to students and comparing with data from the surrounding environment in the form of lists, tables, drawing charts (pictograms), histogram, or line charts. (3) Grade 6; 3.8 Describing and comparing modes, medians, and means of a single data to determine which value exactly represents the data; 4.8 Solving problem related to mode, median, and, mean of a single data in troubleshooting. This is divided into 4 types of mathematics learning material: fractional summation with same denominator, fractional summation with different denominator, fractional multiplication, and data processing and presentation.

The results of the beam and number notation analysis of the scores in "Rek Ayo Rek" and "Semanggi Suroboyo" songs prove that the regional musical element contains mathematical element within it, enabling the traditional music to be used as a mathematics learning medium or learning resource in elementary school. To apply music as a medium and learning resource in mathematics, a mature learning strategy is required. The learning strategy, according to Gonny Schellings, is a plan in which there are patterned activities to achieve the goals of learning that have been established [17]. The preparation of this learning strategy is inseparable from ethnomathematics-based learning. Theoretically, ethnomathematics is a new concept that arising from the integration of mathematics into social, political, and cultural fields [18]. The preparation of learning strategies is expected to be able to understand several important aspects of education, one of which is to practice High Order Thinking Skills (HOTS) in students. The correlation between music and mathematics can be found in the notation of a song. According to Carlos Santos-Luis, Music learning can improve proportional reasoning related to certain mathematical concepts namely fractions and ratios. In addition, it can affirm spatial-temporal reasoning in some mathematical operations [19]. This indicates a positive relationship between music and mathematics because music learning is believed to improve the understanding of proportional mathematics and fractions which is a basic prerequisite for a mathematics learning. It aims to make mathematics learning not only a sure value but also a form of composition, aesthetics, and cultural value.

5. Conclusion
In local traditional music area, exactly on the scores of "Rek Ayo Rek" and "Semanggi Suroboyo" notation songs, some mathematical elements are found. The mathematical elements found in the beam notation of both songs are related to the material of fractional summation with the same denominator, fractional summation with different denomination, and fractional multiplication. In material of fractions, the same summation pattern was found in one song. Each song structure has a pattern, in the number of "Rek Ayo Rek" song there is a pattern of 4 birama, the beat of which are repeated exactly 4 times, while in "Semanggi Suroboyo" song there is a pattern of 4 birama whose beats are repeated 3 times. Meanwhile, the elements found in the number notation of both songs are related to material about data processing in the form of modes and materials about the presentation of data in the form of tables, histogram, and line charts. The absence of these elements proves that indeed between music is interrelated to mathematics.

6. Suggestion
Some suggestions are intended to various parties based on the results of the research conducted. Furthermore, the researchers are expected to use ethnomathematics that has been found as the materials
to develop learning media and teaching materials that integrate music into mathematics. In addition, it is expected that further research can explore more deeply the mathematical elements existing in other regional songs, whether it is typical birama, notation, or musical instruments of the region so that it can be used later as a variation of mathematics learning. To educational institutions and teachers, especially in Surabaya area, this research can be made a reference or source of ideas in developing mathematics learning through the song of the Surabaya area which is one form of local culture. So that later will be able to realize one of the objectives of mathematics learning, namely cultural objectives.

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