Ethnomathematics Journal
Volume 4, No. 1, Maret 2023 (53-66)
Online: http://journal.uny.ac.id/index.php/ethnomath

THE IMAGINARY LINE ACROSS YOGYAKARTA LAND AS AN ETHNOMATHEMATHICS STUDY

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Abstract: In attempt to explore Yogyakarta, the heritage city of Indonesia, the well known landmark, *Tugu Pal Putih* and the Yogyakarta Imaginary Line is explored. The purpose of this paper is to describe that this cultural context may be used as a reference for geometry learning. The method used in this research is a descriptive qualitative involving two historian experts in interviews. The results are that this line can be explored through ethnomathematics studies based on points, straight lines, comparison of distances between points on the imaginary line and the extension of the imaginary line. This line can be illustrated by an imaginary point located at the *Tugu Pal Putih* as the starting point to focus on thinking of the mathematical object. This line not only divides Yogyakarta imaginatively but also according to natural boundaries such as rivers. The extension of the imaginary line forms an area called the fertility area. The description of the patterns formed on the Yogyakarta Imaginary Line through ethnomathematics is expected to be used further as materials in the mathematics learning process.

Keywords: Yogyakarta imaginary line, Tugu Pal Putih, Yogyakarta Palace, Mount Merapi, Parangkusumo Beach

How to cite:

Febriani, F., Sunandar, A. P., Syamsuri, U. A., & Dwandaru, W. S. B. (2023). The imaginary line across Yogyakarta land as an ethnomathemathics study. *Ethnomathematics Journal*, *4*(1), 53-66. https://doi.org/10.21831/ej.v4i1.59984

INTRODUCTION

Ethnomathematics is a broad view of mathematical knowledge in relation to its development in various cultures (D'Ambrosio, 2012). Ethnomathematics links mathematics practiced by members of cultural groups who have similar experiences and practices with mathematics in a unique form (Cimen, 2014). Several studies regarding Yogyakarta culture in ethnomathematics include: 1) research by Mauluah (2022) who studied mathematics around the Yogyakarta Palace, 2) research by Prahmana et al.

(2021) who researched the *pranatamangsa* system and birth-death ceremonies in Yogyakarta, and 3) ethnomathematics studies on *Javanese Primbon* (Utami et al., 2019). However, research that reveals The Imaginary Line of Yogyakarta with ethnomatmatics studies does not yet exist.

The Special Region of Yogyakarta (Daerah Istimewa Yogyakarta, or DIY) is a province in Indonesia that has the status of a special region or special autonomy, which is a legacy before the independence of the Republic of Indonesia. The province consists of four regencies, i.e.: Sleman, Bantul, Kulonprogo, and Gunungkidul, and one municipality city, namely the city of Yogyakarta, with the well known tourist area namely Malioboro Street. DIY is a special region because it has a philosophical axis and is included in the palace, Kraton DIY Cultural Heritage Area based on the Decree of the Governor of DIY No. 75 of 2017. Malioboro Street, which is located in the city of Yogyakarta, is also part of the philosophical axis or commonly called the Imaginary Line, which is a destination and attraction of the city of Yogyakarta, which is rich in history, tourism, culture, and the center of the economy in Yogyakarta (Ashari, 2022), which is a semi-pedestrian area as a whole based on the Grand Design Master Plan for the Malioboro Area 2020 (Jovenski, 2022). Malioboro Street is laid out as an imaginary axis from north to south that connects the Yogyakarta Palace to Mount Merapi in the north and the southern sea as a supernatural symbol. This imaginary concept pattern was disrupted when the Dutch colonial built Vredeburg Fort (1790) located south of Malioboro Street (Ashari, 2022). Hence, it is very interesting to discuss the relationship between this imaginary line and Ethnhomathematics.

The Yogyakarta Imaginary Line is the line that connects Mount Merapi, the Yogyakarta Palace, and the South Coast. This line is called an imaginary line because there is no visualization of the line. The imaginary line stretching from north to south has various philosophical meanings. The imaginary lines symolize the journey of human life, i.e.: its origin and where it returns (Karsono & Wahid, 2008). This line is closely related to belief in the relationship between human life and the universe, as well as human life and God (Meliana & Caroline, 2020).

Apart from being filled with philosophical meaning, the Yogyakarta Imaginary Line plays an important role in the development of various historical buildings and areas in Yogyakarta. These various components are for example: *Pathok Negoro* Mosque (Setyowati et al., 2018; Meliana & Caroline, 2020) and Malioboro (Cahya et al., 2017). Various buildings or areas that are built have a certain distance from the imaginary line or are on that line. This causes the formation of certain patterns on imaginary lines or

new areas or buildings that can be measured with the imaginary line as a reference point. The existence of patterns formed on the Yogyakarta Imaginary Line can be explored further. This exploratory process can be done through ethnomathematics.

The existence of exploration of the patterns formed on the Yogyakarta Imaginary Line through ethnomathematics can be used further as material in the process of learning mathematics. This can be done by relating it to the material of Geometry. Previous studies about learning Geometry by exploring certain patterns through ethnomathematic include: 1) studying Geometry through Yogyakarta *batik* patterns (Prahmana & D'Ambrosio, 2020), 2) studying geometric elements contained in *gorga* (ornaments in Batak houses) (Ditasona, 2018), and 3) studying Geometry from Javanese culture such as horse-drawn carriages, *joglo* houses, and *batik* (slope, *ceplok*, and *jlamprang* motifs) (Pramudita & Rosnawati, 2019). The utilization of Geometry in culture includes exploring many geometric and flat shapes.

The use of Yogyakarta Imaginary Line through ethnomathematics in the Geometry subject plays a role in the contextual learning process. Contextual learning in mathematics helps in guiding students to master mathematical concepts (Hoogland et al., 2018; Salavera et al., 2019). This is because students are actively involved in choosing, compiling, organizing, touching, planning, investigating, questioning, and making decisions so that mathematical concepts are interconnected from one concept to another (Rochsun & Agustin, 2020).

Contextual learning of mathematics can make use of Indonesian culture. There are several studies that have tried to carry out contextual learning processes through Indonesian culture including: 1) the use of Kambuik Kuantan Singingi culture used in Geometry materials such as cylinders with a contextual learning process framework (Isroi et al., 2022), 2) further research explores the concept of division, congruence and similarity, triangular prism, and half sphere with Barongko Cake (Pathuddin et al., 2021), and 3) other research collaborates ethnomathematics-based contextual learning with Sundanese culture (Supriadi et al., 2014).

The purpose of this study is to explore the Yogyakarta Imaginary Line with mathematics through the study of ethnomathematics. This paper is expected to be a reference for the contextual materials in Geometry learning process. In this case, we explore Gometrical concepts of points, distances, areas, and their measurements and comparisons. We argue that using this context, students may not only be shown the example of mathematics in real life, but also be known of the existence of the Yogyakarta Imaginary Line and its underlying beauty.

METHOD

Research Design

The method used in this research was descriptive qualitative. The research stages used were adopted from Lambert & Lambert (2012). The research design was adjusted to the objectives of this study. This research aimed to explore the Imaginary Line of Yogyakarta through ethnomathematics study. The specific research question was as follows: How can we explore the Yogyakarta Imaginary Line through ethnomathematics study?

Data Collection

The data collection process began with literature review. The search process was based on predetermined keywords. The source selection process in the article was carried out starting from reading the abstract then if it was deemed appropriate, reading the full text. The database used as a source of article searches came from Google Scholar. The keywords used in the search include: Yogyakarta Imaginary Line, ethnomathematics, Yogyakarta Culture, Yogyakarta Map, Geometry, and Mathematics. Data collection for map making was done through satellite image data accessed from usgs.gov. The Indonesian landform map data was accessed from the Geospatial Information Agency.

Further data collection was carried out using interview techniques. The resource persons in this research were selected using purposive sampling technique. This was done because sources who knew about the Yogyakarta Imaginary Line were selected. The interviewees in this study were one (1) *lurah abdi dalem* of the Yogyakarta Palace and one (1) lecturer in the History Education Department UNY. The interview instrument was made with two main questions, namely 1) the history of the formation of the Yogyakarta Imaginary Line and 2) the philosophical meaning of the Yogyakarta Imaginary Line.

Data Analysis

The analysis process was carried out based on various information that had been obtained at the data collection stage. The analysis was conducted on the philosophical meaning data obtained from the literature review process, interviews, and geometric analysis of the Yogyakarta map.

The analysis of philosophical meaning was carried out by mixing data obtained from literature review and interviews. The interview process served to clarify various information that has been obtained at the literature review stage. At this stage,

codefication was carried out on the sources. The codefication includes the *abdi dalem* as "AD" and the expert lecturer as "IS".

Further analysis was carried out through the map results. Various data obtained were analyzed using ArcGIS 10.8.1 and Google EarthPro software to produce maps along with imaginary lines, which were then analyzed with ethnomathematics. The analysis was conducted through the distance between objects along the line, namely Mount Merapi, *Tugu Pal Putih*, Yogyakarta Palace, Krapyak Stage, and Parangkusumo Beach, as well as the distance of surrounding objects, namely vegetation and rivers with imaginary lines as reference points. The results of the analysis were then used as contextual content for Geometry material. The stages of analysis can be seen in Figure 1. The analysis flow in this study can be seen in Figure 1.

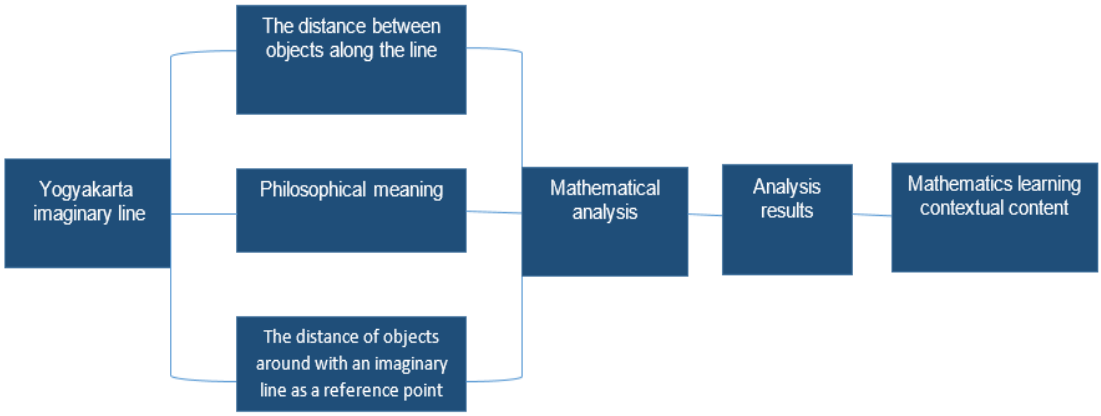

Figure 1. Analysis Flow

The results of the review were written in three parts. These sections include: 1) point and straight line, 2) comparison of the distance between points on the Imaginary Line, and 3) expansion of Yogyakarta Imaginary Line.

RESULTS AND DISCUSSION

The imaginary line stretches from Mount Merapi in the north to the South Coast. Along the imaginary line there is also a philosophical line that connects *Tugu Pal Putih*, Keraton, and Panggung Krapyak (See Figure 2). There are several mathematical components that can be explored on the Imaginary Line of Yogyakarta, including: point and line.

Points and Straight Lines

A point has a position but has no size or magnitude, so it is said to be dimensionless (Pereira, Wijaya, Zhou, & Purnama, 2020). Meanwhile, a straight line is the shortest distance between two points (Webb, 1974). A line is uniquely determined by two points, and the line passing through points A and B is denoted by $\overleftrightarrow{AB}$. Similarly, the length of a finite line segment

ending at these points can be denoted by $\overline{AB}$. A line can also be denoted by a lowercase letter (Jurgensen et al., 1963). The line between A and B can be seen in Figure 3.

Figure 2. Imaginary Line and the philosophical axis of Yogyakarta

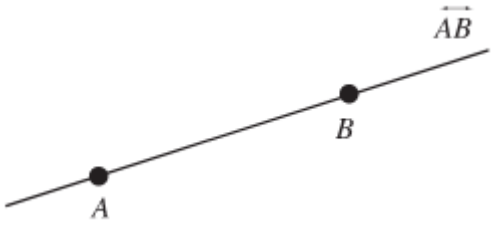

Figure 3. A Straight Line AB

Based on the definition of points and lines in Geometry, a correspondence can be made between Geometry and the components of the Yogyakarta Imaginary Line. The Yogyakarta Imaginary Line is formed through the points of Mount Merapi, *Tugu Pal Putih*, Yogyakarta Palace, Krapyak Stage, and Parangkusumo Beach. These correspondences can be seen in Table 1.

Table 1. Correspondence of Geometric Components and Imaginary Line of Yogyakarta

No.	Component of Geometry	Correspondence	Component of Yogyakarta Imaginary Line
1.	Point	⇔	1) Mount Merapi, 2) *Tugu Pal Putih*, 3) Yogyakarta Palace, 4) Krapyak Stage and 5) Parangkusumo Beach.
2.	Straight Line	⇔	Yogyakarta Imaginary Line

These points contain various philosophical meanings. Mount Merapi and Parangkusumo Beach have meaning as an anchorage. The reason for this philosophical meaning is:

> "The South Coast is used as an anchorage because of the belief in the existence of Nyi Roro Kidul who is considered the ruler of the South Sea Coast and Mount Merapi is considered as a savior because it erupted during the attack by the Sultan of Pajang."-AD

Another point is Panggung Krapyak, which has philosophical meaning as the beginning of life. The philosophy of Panggung Krapyak to the north depicts the human journey from being born from the mother's womb, growing up, getting married, until giving birth to children (*sangkaning dumadi*). The point of Kraton Yogyakarta symbolizes the source and center of life surrounded by various worldly temptations such as Beringharjo Market. The point of *Tugu Golong Gilig* symbolizes the existence of the Sultan in carrying out his life process. This is shown by sincerely worshipping God Almighty accompanied by a determination towards the welfare of the people (*golong-gilig*) and based on a pure heart (white color) (Karsono & Wahid, 2008; DIY Cultural Office, 2016).

Comparison of the Distance between Points on the Imaginary Line

The distance between points on the imaginary line can be seen in Figure 4. Based on this information, the comparison of the distance between points along the imaginary line can be determined.

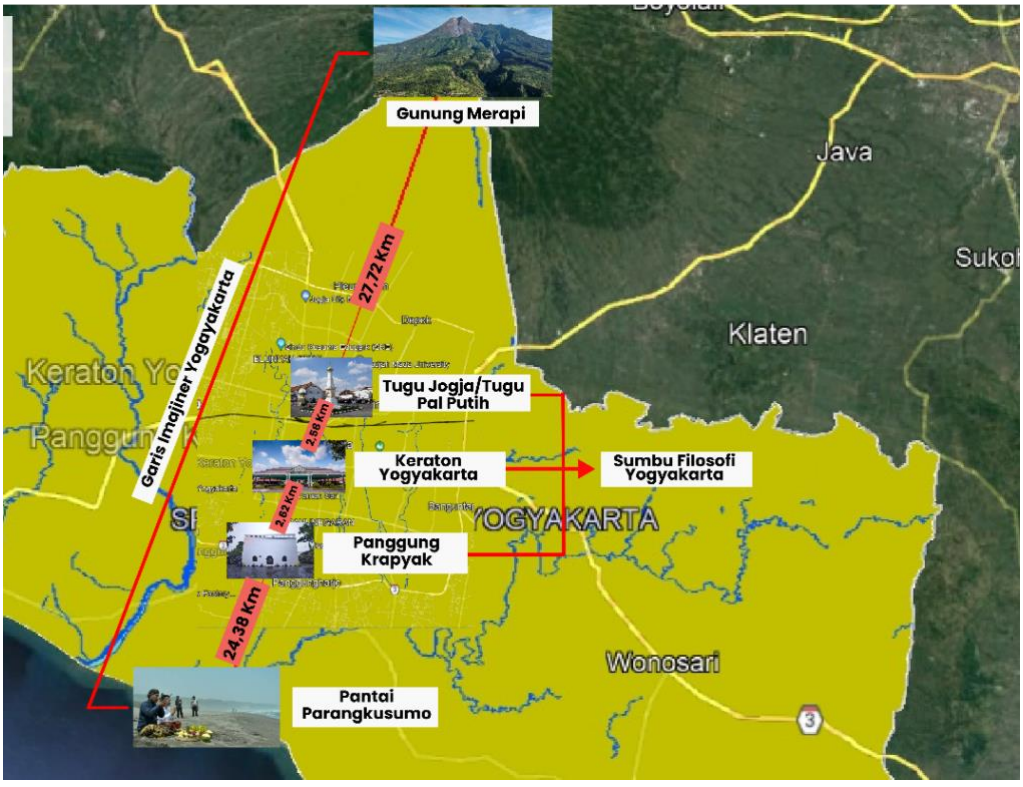

Figure 4. Distance between points along the Imaginary Line

The comparison can be seen in equations (1) and (2):

$$\frac{\text{Merapi Mountain- Yogyakarta Palace}}{\text{Yogyakarta Palace-Parangkusumo Beach}}=\frac{30.3}{24.38}=1.24, \quad (1)$$

and

$$\frac{\text{Pal Putih Monument-Yogyakarta Palace}}{\text{Yogyakarta Palace-Krapyak Stage}}=\frac{2.58}{2.62}=0.98. \quad (2)$$

Based on these results, it can be seen that the comparison results of equations (1) and (2) are around the value of 1. This shows that the location of the Yogyakarta Palace is in the middle of the imaginary line and the philosophical axis. This is in line with the philosophical meaning of the Yogyakarta Palace as the centre of world activities ranging from power, wealth, and also the centre of glory. Yogyakarta Palace is also the centre of the source of life with the eternal light that never dies. Yogyakarta Palace is also a place for Sultan Hamengkubuwono I - X who controls and owns Yogyakarata. The palace is a place for the Sultan to calm himself in the *Siti Hinggil* room and look at Mount Merapi (Syamsuddin et al, 2021). The palace became the centre of community activities ranging from religion, tradition, culture, and also government politics.

Expansion of Yogyakarta Imaginary Line

Based on the comparison of distances between points that have been obtained in equations (1) and (2), it is known that the resulting value is not exactly at the value of 1 but close to the value of 1. The researchers expand this notion by measuring the distance between points at the end of the Imaginary Line of Yogyakarta. Furthermore, the value and centre position of the line were sought. The value and centre position of the Imaginary Line are made as imaginary points. The mathematical process of the calculation can be seen in equations (3):

$$\text{Imaginary Point}=\frac{\text{Imaginary Line Distance}}{2}=\frac{54.68}{2}=27.34 \text{ km}. \quad (3)$$

Based on these calculations, the centre position of the imaginary line (imaginary point) can be obtained. The position is at the *Pal Putih* monument in Yogyakarta. This result can be seen in Figure 5 (red dot).

The centre point of the imaginary line located at *Tugu Pal Putih* is associated with the meaning of it. *Tugu Pal Putih* was formerly called *Tugu Golong-Gilig*. This monument symbolizes the unity of creation, taste, and *karsa* based on purity of the heart (white color) through *Margatama* (the path to virtue) to the south through Malioboro (using the torch or guidance of knowledge taught by the saints), continuing south through *Margamulya*, then through *Pangurakan* (expelling negative passions) (DIY Cultural

Office, 2016). So that this imaginary point can be interpreted as the centre of unity through its relation to the philosophical meaning of the *Tugu Pal Putih* Yogyakarta. Another meaning is that *Tugu Golong-Gilig* is the main point of view of the Sultan when carrying out meditation in *Bangsal Manguntur Tangkil* in North *Sitihinggil*. This is also corroborated by the following interview results:

"The Sultan looks towards the monument to concentrate on deciding things"- IS

This shows that it is possible for the imaginary point to be a source of unity and a source of calmness, hence making it possible to think with high concentration.

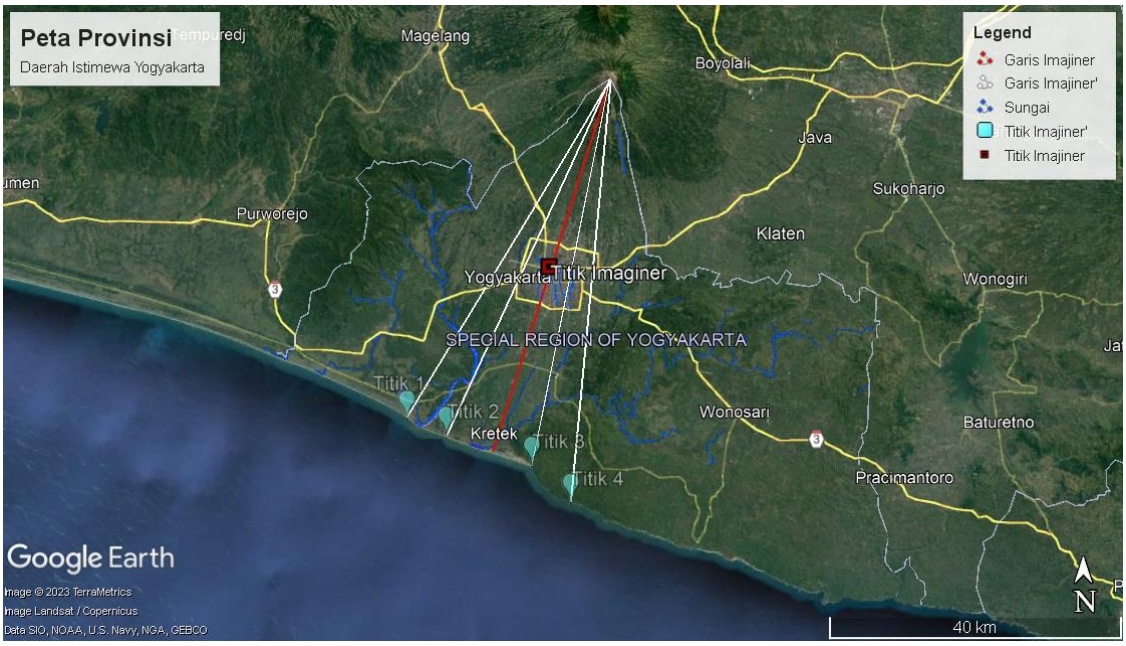

Figure 5. Expansion of the Yogyakarta Imaginary Line

Another extension is done by drawing other lines that begin from the same initial point (Mount Merapi) to the imaginary line. These lines are Line 1, Line 2, Line 3, and Line 4 (See Figure 5). An imaginary line from Mount Merapi to Parangkusumo Beach divides Yogyakarta Special Region into two parts with different environmental conditions (Adinugroho et al., 2016). DIY is flanked by three highlands: the Mount Merapi area, the Menoreh Mountain, and the Gunungsewu Mountain. Mountainous areas have difficult access, high costs, and many physical barriers. This condition causes facilities and infrastructures in the lowlands to be relatively more complete than in hilly or mountainous areas due to easier financing and access. The physical and geographical conditions between the Menoreh Mountain and the Sewu Mountain are dry, overgrown with deciduous plants, and lack of clean water (Rahmadi, Wiantoro, & Nugroho, 2018). Each region has a different level of geographical difficulty due to varying topography. The level of geographical difficulty will be higher the higher the area, such as the Menoreh and Sewu Mountains (Adinugroho et al., 2016).

The imaginary line is between the Menoreh Mountain on the west side and the Sewu Mountain on the east side. Kulonprogo and Gunungkidul Regencies have a high level of accessibility difficulty. Karst areas in Kulonprogo and Gunungkidul are characterized by hills with steep slopes and valleys (Rahmadi, Wiantoro, & Nugroho, 2018). The apex between these two mountain ranges makes low areas more developed such as Bantul Regency and Yogyakarta City (Adinugroho et al., 2016).

Along the imaginary line, dense tree vegetation is found. Vegetation from north (Mount Merapi) to south (Parangkusumo Beach) starts from sand vegetation due to the area of Mount Merapi, which regularly erupts and includes volcanic landscapes. Then it continues with dense forest vegetation towards Krapyak Stage to the beach. Towards the beach, it continues with black sand beach vegetation (BPS, 2019). The area crossed by the imaginary line from north to south has a higher population density, causing this area to be more fertile than other areas. This fertile area is in accordance with the philosophy of *Tugu Pal Putih* and Panggung Krapyak, which means phallus and yoni or male and female genitalias so that it symbolizes fertility or human origin (DIY Cultural Office, 2016). This is emphasized by the increasingly difficult and deserted population to the west and east of Yogyakarta (Adinugroho et al., 2016).

The imaginary line is followed by another line at points 1 to 4 (See Figure 5) that divides each imaginary line area into areas that are fertile or not. The lines closest to the imaginary line, points 2 and 3, enclose the urban area surrounded by the Yogyakarta ringroad. Meanwhile, lines 1 and 4 divide the fertile area bordering the beginning of Kulonprogo and Gunungkidul Regencies. This finding shows that philosophically, the imaginary line is not only used as a link between Mount Merapi and Parangkusumo Beach but also a source of life for the surrounding area. In addition, each line also divides the fertility area according to the rivers that border Yogyakarta such as the Code River, Gajahwong River, and Opak River in the east while in the west there are Winangan River, Bedong River, and Progo River (DIY Cultural Office, 2016). Rivers have always been a source of life in the surrounding area with higher biodiversity (LIPI, 2014).

The results found about the relationship between imaginary lines and mathematics have shown that each equation and area formed can show their respective characteristics differently. The results of the equation of the imaginary line may be applied in the mathematics curriculum. This finding assists an understanding the learning of mathematical may be developed from local reality. This can help students to build reason about patterns and properties, perform mathematical manipulations in making a generalized reality into a scientific proof or mathematical statement.

Imaginary lines and their mathematical equations can help the nature of understanding and applying mathematical model designed to find a new finding or solution by abstracting an irregular model or communicating a mathematical idea in a proof of an equation adapted or taken from a symbol, table, and diagram. More specifically, these findings can be utilized as the resource of school mathematics such when learning Algebra, Geometry, and Data Analysis. At a higher level, this finding can continue to be developed for Calculus material.The findings will train students to see unique phenomena and signs in the students' environment using mathematics view.

CONCLUSION

Connecting points into lines, measurements, and comparisons is learned in mathematics. This study shows that cultural landmark could be built based on mathematical considerations. The imaginary lines illustrated by the Tugu Pal Putih in Yogyakarta explored in this paper provide a mathematics learning resource. This imaginary line can give examples of the construction of points, straight lines, comparison of distances between points on the imaginary line and the extension of the imaginary line. This line reveals an imaginary point located at *Tugu Pal Putih* as the main point to concentrate on thinking. This line not only divides Yogyakarta imaginatively but also according to natural boundaries such as rivers. The extension of the imaginary line forms an area called the fertility area. The current study may only describe some facts of mathematical objects in real life, therefore following research should be extended on how these can be used in school instructional designs.

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